Clean Energy Communities

Energy Study

Prepared for:

Town of New Lebanon - Town Garage

14755 NY-22

New Lebanon, NY 12125

Audit No: CEC400101-1-S

Submitted by:
L&S Energy Services
58 Clifton Country Road, Suite 203
Clifton Park, NY 12065

Date: 3/25/2024

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.

NOTICE

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State of New York

Kathy Hochul, Governor

New York State Energy Research and Development Authority

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This report was prepared by:

L & S Energy Services

58 Clifton Country Road, Suite 203

Clifton Park, NY 12065

(518) 383-9405

Table of Contents

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 envelope and HVAC.

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

- Lighting - Install LED lights.
- Envelope - Install weatherstripping and replace insulation.
- Building Electrification - Install Air Source Heat Pumps

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.

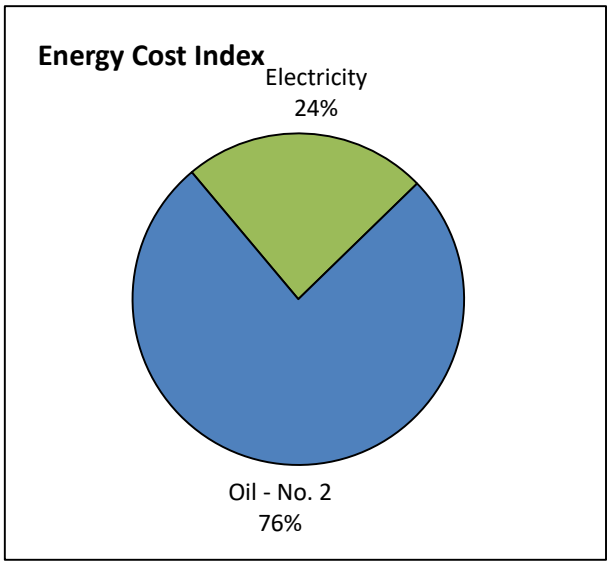
- The Energy Cost Index (ECI) is the total cost of energy divided by the conditioned floor area and is shown as dollars per square foot per year.
- The Energy Use Intensity (EUI) is the total heat content of energy divided by the conditioned floor area and is shown in units of one thousand Btus (kBtu)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

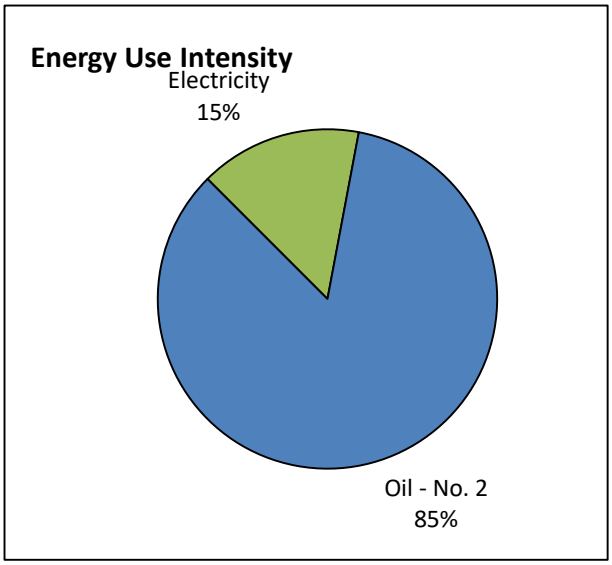
Energy Cost Index

Electricity	$ 1,189	$ 0.50	$/sq.ft./year
Oil - No. 2	$ 3,800	$ 1.58	$/sq.ft./year
Total Cost	$ 4,989	$ 2.08	$/sq.ft./year

Energy Use Intensity

Electricity	28	mmBtu	11.5	kBtu/sq.ft./year
Oil - No. 2	150	mmBtu	62.7	kBtu/sq.ft./year
Total Energy Use	178	mmBtu	74.1	kBtu/sq.ft./year





Energy Cost Index $ 2.08 /sf/yr. **Energy Use Intensity 74.1 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	673	$ 292	$ 934	3.2
EEM-2	R	Improve Temperature Control	4,713	$ 731	$ 199	0.3
EEM-3	R	Weather-Stripping And Caulking	857	$ 133	$ 500	3.8
EEM-4	R	Insulate Building Envelope	8,935	$ 1,386	$ 36,033	26.0
		All Energy Efficiency Measures:	**15,178**	**$ 2,543**	**$ 37,666**	**14.8**
		Total of Recommended Measures:	**15,178**	**$ 2,543**	**$ 37,666**	**14.8**

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	R	Install Clean Heating System - Air Source Heat Pump	10,262	$ 2,490	$ 34,491	13.9	$ 7,742	10.7
		All Measures:	**10,262**	**$ 2,490**	**$ 34,491**	**13.9**	**$ 7,742**	**10.7**
		Total of Recommended Measures:	**10,262**	**$ 2,490**	**$ 34,491**	**13.9**	**$ 7,742**	**10.7**

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	(11,782)	kWh =	(13,667)	pounds CO2 equivalent
Oil - No. 2	1,740	gal. =	39,107	pounds CO2 equivalent
			25,440	pounds CO2 equivalent
			75.2%	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:	$ 377	1,053	kWh per year
		2.3	kW demand
Fuel Savings:	($ 85)	(3.4)	MMBtu fuel per year
			Oil - No. 2
Total Annual Savings:	**$ 292**		
Project Cost:	**$ 934**		
Simple Payback:	**3.2**	**years**	

Introduction:

The office and garage have fluorescent fixtures, while the seldom used cold storage area has metal halide fixtures.

Recommendation:

Replace the fluorescents with LED equivalents. The new lamps should be self-driving and the ballasts should be replaced. Corn cob LEDs lamps should be able to directly replace the metal halide. It is assumed that the town can upgrade the lighting without labor costs.

EEM-2 Improve Temperature Control

Electric Savings:	$ 0	0	kWh per year
		0.0	kW demand
Fuel Savings:	$ 731	28.9	MMBtu fuel per year
			Oil - No. 2
Total Annual Savings:	**$ 731**		
Project Cost:	**$ 199**		
Simple Payback:	**0.3 years**		

Introduction:

The thermostat controlling the oil fired furnace is kept to 67 degrees. Many highway garage buildings and equivalent buildings like firehouses can keep their heating equipment between 58 and 62 degrees when unoccupied.

Recommendation:

Install a wi-fi rated thermostat that can reduce the temperature setpoint when the staff are not in the building and when the facility is unoccupied.

Alternatively, perhaps the base temperature in the garage can be low, and when the staff know that they will work in the garage they can engage a timer to increase the temperature.

EEM-3 Weather-Stripping And Caulking

Electric Savings:	$ 0	0	kWh per year
		0.0	kW demand
Fuel Savings:	$ 133	5.3	MMBtu fuel per year
			Oil - No. 2
Total Annual Savings:	**$ 133**		
Project Cost:	**$ 500**		
Simple Payback:	**3.8 years**		

Introduction:

Sealing the cracks between windows and wall openings will reduce the amount of unwanted outside air infiltration into conditioned spaces. The elimination of infiltration or drafts makes occupants feel more comfortable and reduces heating and cooling costs. Caulking and weather-stripping are cost effective ways to reduce infiltration and to tighten the building envelope.

All windows and doors must be caulked and weather-stripped. Clean and inspect surfaces for damage or moisture, in order to ensure that they are in good enough condition to accept weather-stripping or caulk. Tighten door or window hardware. Remove old weather-stripping and caulk. Cut weather-stripping carefully to length and apply it to the surface. New weather-stripping should be snug, and should completely fill gaps without buckling or otherwise deforming. Open and close window or door and inspect for interference, weather-stripping damage, or other problems. Windows and doors should be able to close without excessive force.

Recommendation:

In addition to the subsequent measure, a qualified contractor should evaluate the overhead doors and windows for air leaks. This measure provides estimates of savings for adding a new door sweep and weatherstripping for the overhead door closer to the office.

EEM-4 Insulate Building Envelope

Electric Savings:	$ 0	0	kWh per year
		0.0	kW demand
Fuel Savings:	$ 1,386	54.9	MMBtu fuel per year
			Oil - No. 2
Total Annual Savings:	**$ 1,386**		
Project Cost:	**$ 36,033**		
Simple Payback:	**26.0**	**years**	

Introduction:

Heat moves from areas of high temperature to areas of low temperature. As the temperature difference between a heated and an unheated space becomes greater, so does the rate of heat transfer. Insulation reduces the rate of heat transfer by filling the space with material that is less conductive than what is currently there. The effectiveness of insulation is measured by R-value, which is the resistance to heat transfer. As the R-value increases, the rate at which heat is transferred decreases.

Insulation can be installed in enclosed spaces, such as wall cavities, cathedral ceiling cavities, and floored attic cavities. It can also be installed in unfloored attics, which can accommodate greater thickness resulting in higher R-value. When insulation is combined with air sealing, convective air currents that circulate air within cavities and through insulation are reduced, which increases the effective R-value of the insulation.

Recommendation:

The existing insulation is at the end of its life and needs to be replaced with R-38 for the roof, and R-19 for the walls. Closed cell spray foam that is fire rated could be an option in this space, as well as a new liner system for the roof. New interior siding can also be installed as a thermal/vapor barrier for other types of insulation.

The estimated costs for a liner system and interior siding include removal and installation as well as the materials and labor.

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:	($ 1,412)		(12,835) 0.0	kWh per year kW demand
Fuel Savings:	$ 3,902		154.4	MMBtu fuel per year Oil - No. 2
Total Annual Savings:	**$ 2,490**			
Project Cost:	**$ 34,491**			
Simple Payback:	**13.9**	**years**	**10.7**	**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:

Replace the oil fired furnace with air source heat pumps. There is no air conditioning in the garage space, so any use would be added consumption. The calculation models the existing furnace consumption against the same efficiency (277%) of the heat pumps that are currently installed in the office/bathroom. Several larger units would need to be installed and can be mini-split systems with multiple heads. Other alternatives could be to install an air handler with ductwork.

Implement the insulation measures so that the heat pumps can be right-sized, which would save on capital costs. Further, the Energy Star rated units may be eligible for Clean Heat Program incentives through NYSEG. Installing solar panels on the roof would offset the electric costs.

Ground source heat pumps do not appear to be a good option for this building due to the large up-front cost. The highway garage may also move to a larger facility as the community grows where theoretically, the heat pumps and solar panels can follow - or be left there and leased to a local business.

Existing Conditions

The site is a highway garage. It was constructed in 1963 and is a metal building on slab. It has metal siding and a gabled metal roof. The walls are 13' high and peak at around 17'. Interior wall and ceiling insulation may be original per staff, but it may also have been installed around the 1980s as there has been several renovations over time to the heating and other systems through leftover equipment that was not removed (like ducts and chimney vents). The insulation is old and deteriorating along the walls. The roof liner system is likely compacted and needs to be replaced as well.

There are two sections 40' x 120' to the building. Half the building is cold storage and is largely unused, while the other half of the building is heated. Within the heated section is a built-up office for the Highway Supervisor, a storage closet, and a bathroom. This resides on the far wall, and the existing furnace is located on top of the storage space that is in the middle between the office in the front and the bathroom in the rear.

There are two side doors: one to the office and one to the cold storage. The office door seals fine but may need new weatherstripping eventually. The heated section has two 12' x 12' overhead garage doors. One appears to be predominately used and needs new seals and a door sweep. They have about one inch of interior foam in the core. The heated side also has six slider windows that have double pane glass for natural illumination.

The facility is open Monday through Friday from 6:30 am to 3 pm with for four total staff members.

Lighting Systems

The office has a T12 fluorescent fixture, while the garage has T5 high output fluorescent fixtures. The cold storage has 150 W Metal Halide pendants that are used seldomly. There is one side lamp over the cold storage door that doesn't appear to be used at all. All lights are on switches or pull chains.

Heating Ventilating and Air Conditioning Systems

Heating is provided by a Nortek, model OH-190 fuel oil fired furnace manufactured in 2020. It has an 81% efficiency and an output capacity of 186 Mbh. The fan blower motor is ¼ hp. It is controlled by a rotary dial thermostat and kept to a constant 67 degrees.

The office and bathroom share a Mitsubishi, model MXZ-2C20NAHZ2 mini-split, cold-climate, multi-head air source heat pump with a 22 MBh cooling and heating capacity manufactured in 2021. Its efficiency is 13.5 EER, 17 SEER, and between a 2.77 COP at 17 degrees. It can heat down to -13 degrees at ¾ capacity and is Energy Star Rated. The unit in the office is kept to 72 degrees, while the unit in the bathroom is kept to 80 degrees to prevent pipes from freezing. There is also a strip baseboard electrical heater that is also kept on supplementing the heat pump in pipe freezing prevention.

Water Heating System

The bathroom has an Ariston six gallon on demand unit with a 1.5 kW coil.

Other Energy-using Systems

The garage has a working shop with various plug loads, while the bathroom has a sump pump and a well water pump that serves the town hall. Lastly, the office has computer equipment.

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**
Furnace	1	Nortek OH-190	230	81%				Garage	2020
Heat Pump	1	Mitsubishi MXZ-2C20	22	277%	22	kbtuh	13.5	Office & Bathroom	2021
Baseboard	1	N/A	3	100%				Bathroom	1963

Domestic Hot Water									
Unit Type	**Qty**	**Make/Model**	**Capacity**	**Units**	**Fuel Type**	**Storage Capacity (gal.)**	**Eff.**	**Serves/Location**	**Year**
Tankless	1	Ariston	1.5	kW	Electricity	6	100%	Bathroom	

Motors									
Unit Type	**Qty**	**Make/Model**	**HP**	**Loading**	**Type**	**Hours/year**	**Eff.**	**Serves/Location**	**Year**
Furnace Blower	1		1/4						
Overhead Doors	2	Est.	1/2						

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	Office	1	4' 34w T12 Std. Mag. bal	2	80	No Change	LED Relamp	1	4' LED T8 2200 lu. 17W	2	34
2	Garage	8	4' 54w T5 HLO Elec. bal.	6	351	No Change	LED Relamp	8	4' LED T5HO 3300 lu. 25.5W	6	153
3	Cold Storage	4	150w M-H CWA bal.	1	190	No Change	LED Relamp	4	LED Corn Cob 27 Watt	1	27

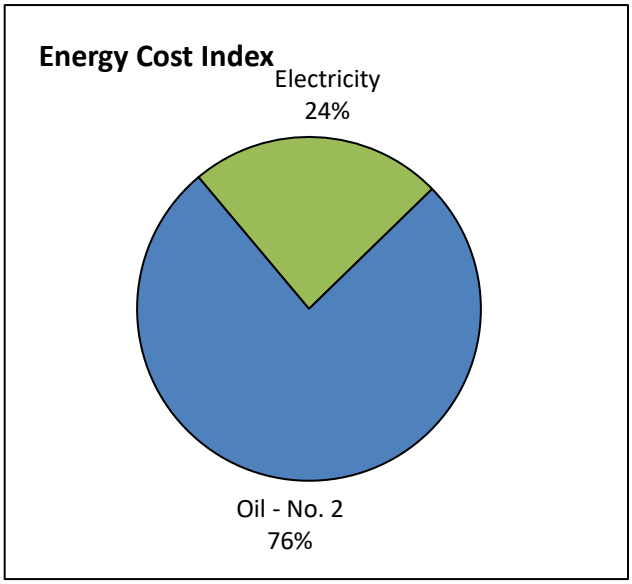
Exterior Lighting Fixtures											
Existing Fixtures						Recommended	Lighting Efficiency Improvements				
Line #	Area	Qty	Present Lighting Type	Lamps /fixt	Watts /Fixt	Control Type	Measure Type	Qty	Proposed Lighting Type	Lamps /fixt	Watts /Fixt
1	Storage Entrance	1	Unused I60	1	60	No Change	LED Area Light	0	0	0	0

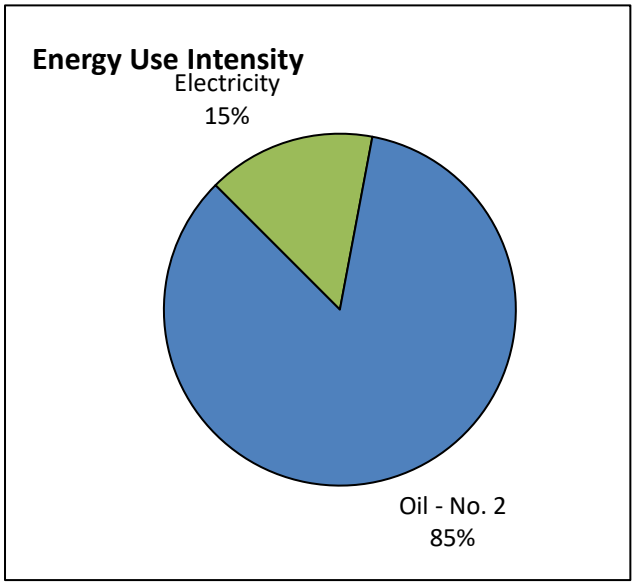
Appendix B

Energy Use and Cost Summary

Energy		Units Used		BTU/unit	mmBTU	% of total	kBtu/sq.ft./year
	Electricity	8,060	kwh	3,412	28	15%	11.5
	Oil - No. 2	1,090	gal.	138,000	150	85%	62.7
	Total				178		74.1

Cost		Energy Cost	Unit Costs		% of total	$/sq.ft./year
	Electricity	$ 1,189	$ 0.076	kwh	24%	$ 0.50
	Oil - No. 2	$ 3,800	$ 3.488	gal.	76%	$ 1.58
	Total	$ 4,989				$ 2.08





Energy Cost Index $ 2.08 /sf/yr. **Energy Use Intensity 74.1 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

Town of New Lebanon - Town Garage

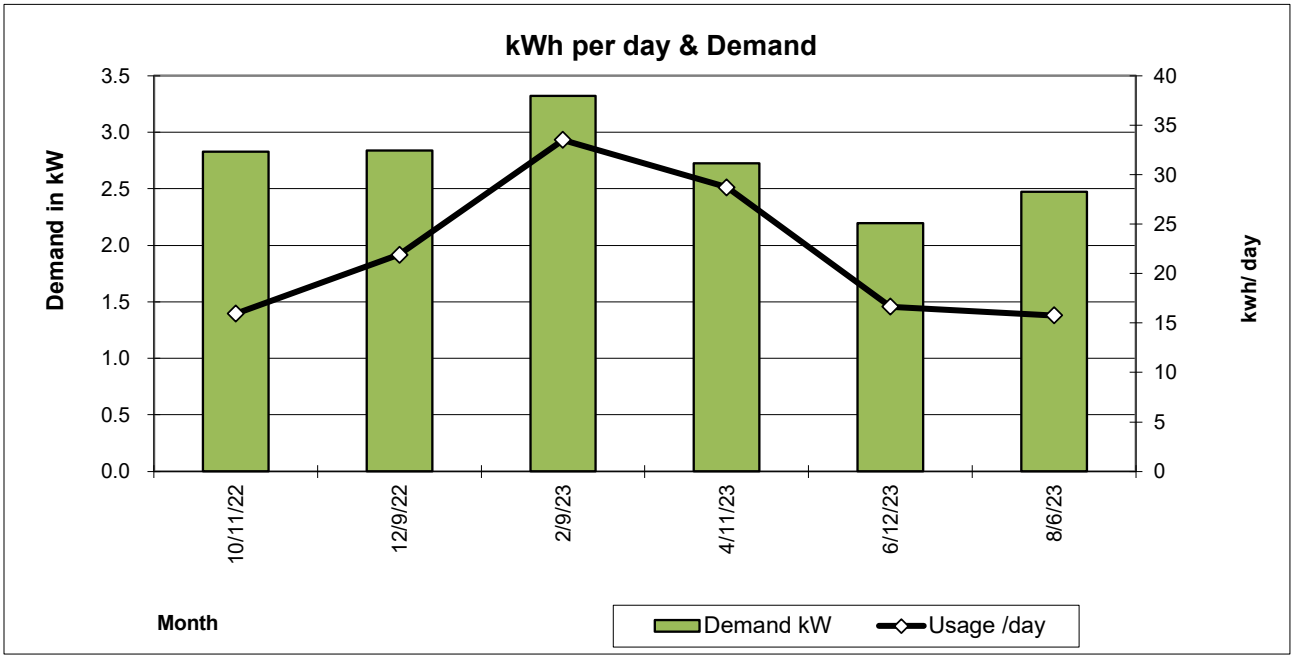
Gross Area:	2,400	s.f.
	11,458	Btu/s.f./Yr
	$ 0.50	/s.f.
	1.4	watts/s.f.

Utility:	NYSEG	
Account #	ends w/ -121	
Rate:	SC NonRes	
Meter Charge:	$ 33.00	/ month
Demand Charge:	$ 10.85	/ 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
10/11/22	60	957	2.8	$ 82	$ 110	$ 191	$ 31	$ 0.099	0.24	16
12/9/22	59	1,293	2.8	$ 82	$ 114	$ 196	$ 31	$ 0.077	0.32	22
2/9/23	62	2,078	3.3	$ 96	$ 227	$ 323	$ 36	$ 0.106	0.42	34
4/11/23	61	1,753	2.7	$ 84	$ 120	$ 204	$ 30	$ 0.062	0.44	29
6/12/23	62	1,033	2.2	$ 71	$ 63	$ 135	$ 24	$ 0.044	0.32	17
8/6/23	60	946	2.5	$ 76	$ 63	$ 139	$ 27	$ 0.049	0.27	16
	364	**8,060**	**16.4**	**$ 492**	**$ 697**	**$ 1,189**	**$ 178**	**$ 0.076**	**0.34**	**22**

Annual Energy:	**8,060**	**kWh / year**	**$ 1,189**	**/year**
Peak Demand:	**3**	**kW Peak**		
Average Demand:	**3**	**kW**		

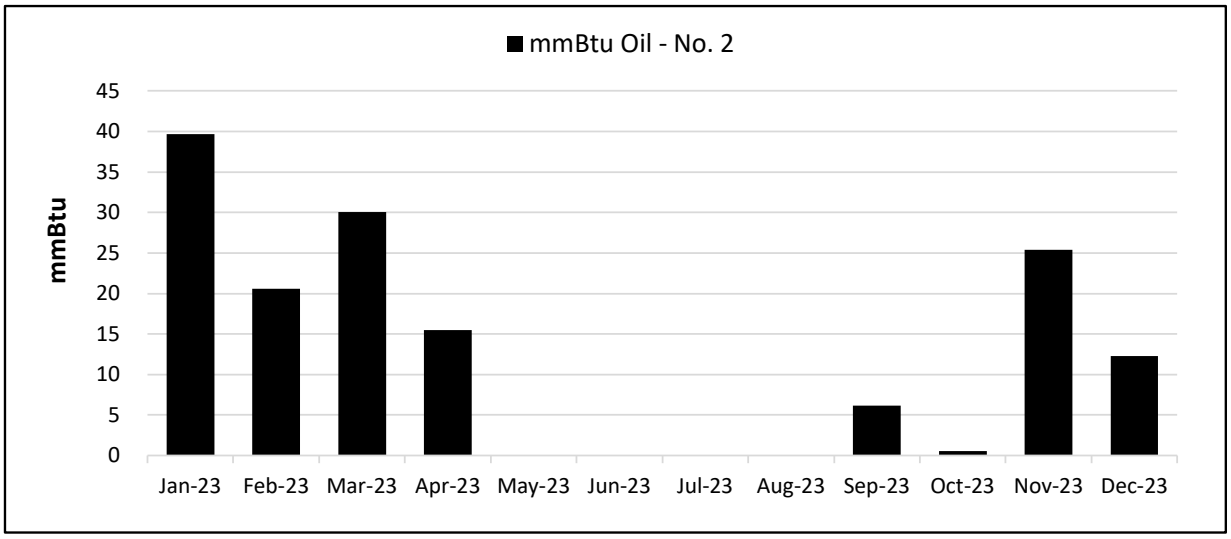
Unit Costs		
Demand	**$ 10.85**	**$/kW**
Energy	**$ 0.076**	**$/kWh Incremental**
Blended	**$ 0.147**	**$/kWh Blended**

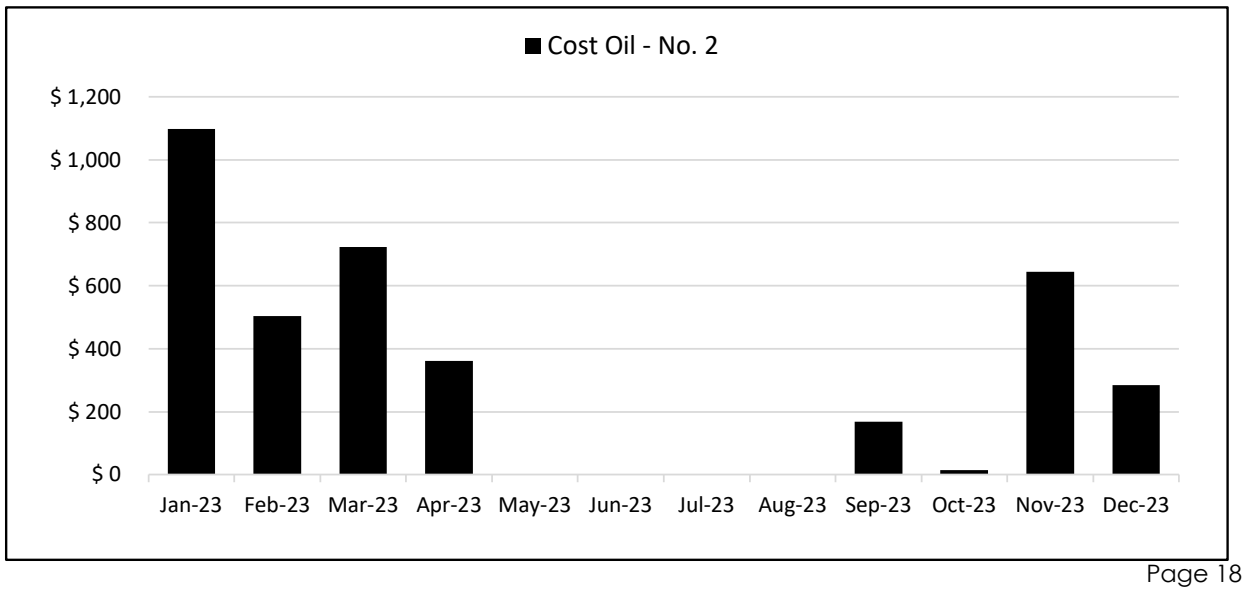


Note:
The Town Office shares a meter with this building, and the bills were prorated to 20% for this report. NYSEG also bills bi-monthly. Note that solar was installed towards the end of the billing period here, but according to the Enlightened software the panels had yet to start recording data until after the billing period.

ALL FUELS CONSUMPTION AND COST ANALYSIS **Town of New Lebanon - Town Garage**

Month	mmBtu Oil - No. 2	Cost Oil - No. 2
Jan-23	40	$ 1,099
Feb-23	21	$ 504
Mar-23	30	$ 722
Apr-23	16	$ 362
May-23	0	$ 0
Jun-23	0	$ 0
Jul-23	0	$ 0
Aug-23	0	$ 0
Sep-23	6	$ 169
Oct-23	1	$ 15
Nov-23	25	$ 645
Dec-23	12	$ 285
Total	150	$ 3,800
$/mmBtu	$ 25.27	
BTU/unit	138,000	1 mmBtu = 1,000,000 Btus
kBtu/SF/Yr.	62.7	1 kBtu = 1,000 Btus





Appendix C

EEM Calculations

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%.

CALCULATIONS FOR INTERIOR LIGHTING RETROFIT

EEM-1 **Town of New Lebanon - Town Garage**

	Type:	Units:	Unit cost:	BTU/unit	
	Oil - No. 2	gal.	$ 3.488	138,000	
	Electricity	kwh	$ 0.076	3,412	
	Demand	kW	$ 10.85	12	Months of demand savings/year

10% of building is air conditioned

HVAC Adjustment Factors		
Cooling	Demand	Fuel
HVACc	HVACd	HVACg
0.00%	0.00%	-3.20%

Existing Interior Lighting Systems					Recommended Lighting Controls					Recommended Interior Lighting Efficiency Improvements									Energy & Demand Calculations						
																			Demand			Total Use		Energy Savings	
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)	Present kW	Proposed kW	kW Saved	Present kwh/year	Proposed kwh/year	Controls kwh/year	Efficiency kwh/year
Office	1	4' 34w T12 Std. Mag. ba	2	80	No Change	0%	500	500	0	LED Relamp	1	4' LED T8 2200 lu. 17W	2		34	$ 24	$ 8	23	3.1	0.1	0.0	0.0	40	17	0	23
Garage	8	4' 54w T5 HLO Elec. bal.	6	351	No Change	0%	500	500	0	LED Relamp	8	4' LED T5HO 3300 lu. 25	6		153	$ 724	$ 266	792	2.7	2.8	1.2	1.6	1,404	612	0	792
Cold Storage	4	150w M-H CWA bal.	1	190	No Change	0%	365	365	0	LED Relamp	4	LED Corn Cob 27 Watt	1		27	$ 186	$ 103	238	1.8	0.8	0.1	0.7	277	39	0	238
	13		3.6	kW existing					0		13		1.4	kW proposed						3.6	1.4	2.3	1,721	668	0	1,053
																									1,053	kwh

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

SUMMARY OF SAVINGS BY MEASURE TYPE:

	Measure Type	Fixture Qty.	Energy Savings Controls kwh/year	Energy Savings Efficiency kwh/year	Demand kW Savings	Project Cost	Electric Savings	Payback (Years)	Measure Description
EEM-1C	LED Relamp	13		1,053	2.3	$ 934	$ 377	2.5	Screw-in or Socket based LED lamps
		13	0	1,053	2.3	$ 934	$ 377		
	Gross Energy Savings		1,053	kwh					
	Net Energy Savings		**1,053**	**kwh**	**2.3**	**-24**	**gal.**	**$ 292**	**net**

PAYBACK PERIOD:

Estimated Cost Interior Lighting:	$ 934	= 3.2 year payback
Annual Energy Savings (kWh + kW):	$ 292	

CALCULATIONS TO IMPROVE TEMPERATURE CONTROL

EEM-2 **Town of New Lebanon - Town Garage**

INPUT DATA: 100% of Building to be Setback

		Current	Proposed	
Heating T Setpoint:	Occupied	67	67	deg. F.
	Unoccupied	67	60	deg. F.
Cooling T Setpoint:	Occupied	85	85	deg. F.
	Unoccupied	85	85	deg. F.
HVAC Schedule	Occupied	42.5	42.5	Hours per week
	Unoccupied	125.5	125.5	Hours per week
Q internal gains:	Occupied	7,477	7,477	Btuh
	Unoccupied	1,629	1,629	Btuh
Q internal gains:	Schedule	43	43	Hours per week
BLC:	Occupied	1,118	1,118	Btuh/deg. F.
(excludes DOAS)	Unoccupied	708	708	Btuh/deg. F.

Fuel Data	Heating
Type:	Oil - No. 2
Units:	gal.
Unit cost:	$ 3.488
BTU/unit	138,000
Efficiency/ COP:	81.0%

CALCULATIONS:

Current — Albany, 43 hrs./week

Bin Mid Pt.	Occupied Hours	Unoccupied Hours	Occ Net Heat Loss BTUH	Unocc Net Heat Loss BTUH	Heating Fuel Use gal.
(2.5)	6	9	70,195	47,555	8
2.5	12	39	64,607	44,016	22
7.5	31	94	59,020	40,478	50
12.5	44	156	53,432	36,939	73
17.5	90	333	47,844	33,401	138
22.5	114	378	42,256	29,863	144
27.5	147	406	36,668	26,324	144
32.5	144	527	31,080	22,786	147
37.5	184	536	25,492	19,247	134
42.5	143	417	19,904	15,709	84
47.5	191	554	14,316	12,170	85
52.5	160	436	8,728	8,632	46
57.5	178	621	3,140	5,094	33
62.5	248	715	0	1,555	10
67.5	206	420	0	0	0
72.5	151	325	0	0	0
77.5	156	258	0	0	0
82.5	106	161	(4,683)	0	0
87.5	31	20	(10,271)	(3,399)	0
92.5	7	5	(15,859)	(6,937)	0
97.5	0	1	(21,447)	(10,475)	0
102.5	0	0	(27,035)	(14,014)	0
107.5	0	0	(32,623)	(17,552)	0
112.5	0	0	(38,211)	(21,091)	0
	8,760	hours			1,119

Proposed — Albany, 43 hrs./week

Bin Mid Pt.	Occupied Hours	Unoccupied Hours	Occ Net Heat Loss BTUH	Unocc Net Heat Loss BTUH	Heating Fuel Use gal.
(2.5)	6	9	70,195	42,601	7
2.5	12	39	64,607	39,062	21
7.5	31	94	59,020	35,524	46
12.5	44	156	53,432	31,986	66
17.5	90	333	47,844	28,447	123
22.5	114	378	42,256	24,909	127
27.5	147	406	36,668	21,370	126
32.5	144	527	31,080	17,832	124
37.5	184	536	25,492	14,294	111
42.5	143	417	19,904	10,755	66
47.5	191	554	14,316	7,217	60
52.5	160	436	8,728	3,678	27
57.5	178	621	3,140	140	6
62.5	248	715	0	0	0
67.5	206	420	0	0	0
72.5	151	325	0	0	0
77.5	156	258	0	0	0
82.5	106	161	(4,683)	0	0
87.5	31	20	(10,271)	(3,399)	0
92.5	7	5	(15,859)	(6,937)	0
97.5	0	1	(21,447)	(10,475)	0
102.5	0	0	(27,035)	(14,014)	0
107.5	0	0	(32,623)	(17,552)	0
112.5	0	0	(38,211)	(21,091)	0
	8,760	hours			909

	Present	Proposed	Savings
Heating	1,119	909	210
Annual Energy $			$ 731

IMPLEMENTATION COST & PAYBACK PERIOD:

Item	Material $/unit	Labor $/unit	Quantity	Total
Wi-fi thermostat	$ 144	$ 56	1	$ 199
				$ 0
				$ 199

Implementation Cost:		$ 199	= 0.3 year pay
Annual Energy Savings:		$731	

CALCULATIONS FOR WEATHER-STRIPPING AND CAULKING

EEM-3 **Town of New Lebanon - Town Garage**

INPUT DATA:

Bldg. Volume	31,200	cubic feet		Present infiltration		
		ACH	Period	Cu. ft./hr.	CFM	btuh/deg.
Baseline infiltration rate		1.00	Occupied	31,200	520	562
from heat loss study		0.25	Unoccupied	7,800	130	140
Proposed Reductions	Crack Length	Leakage Rate - cfh		Leakage - net cfh		
Cubic feet per hour	lineal feet	Present	New	Present	Proposed	Savings
Roof - Wall Joint				0	0	0
Window Jamb to Wall				0	0	0
Operable Window WS				0	0	0
Door Sweeps & WS	48	60	5	1,440	120	1,320
Fireplace				0	0	0
				1,440	120	1,320

Proposed Reductions	Air changes/Hour			Proposed infiltration		
Air changes/hour	% reduction	Proposed	Period	Cu. ft./hr.	CFM	btuh/deg.
	4%	0.96	Occupied	29,880	498	538
	17%	0.21	Unoccupied	6,480	108	117
Total Infiltration & Reductior	**Occupied**	**31,200**	**29,880**	**1,320**	cfh savings	
Cu.Ft./hour	**Unoccupied**	**7,800**	**6,480**	**1,320**	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:	67	67	°F
Q internal gains:	7,477	1,629	Btuh
BLC:	1,118	708	Btuh/°F
T Balance:	60.3	64.7	°F. T Balance = T Setpoint - (Q internal gains / BLC)
Bin Data for Albany, 43 hrs./week			
Accumulated Hours	1,444	5,221	below balance temp.
Avg. OAT	37.6	40.8	°F below balance temp.
(T Set- Avg OAT)	29.4	26.2	°F difference

Type:	Oil - No. 2	
Units:	gal.	
Unit cost:	$ 3.488	/gal.
CF1	138,000	Btu/gal.
Efficiency:	81.0%	
CF2	0.018	Btu/hr-°F-cfh

	Energy Use - Btu/year			Fuel Use	
	Occupied	Unoccupied	Total	gal. / yr	
Baseline infiltration rate	23,813,500	19,238,900	43,052,400	385	
Proposed infiltration rate	22,806,000	15,983,100	38,789,100	347	
			Total Savings	38	$ 133

IMPLEMENTATION COST & PAYBACK PERIOD:

Item	Matl. & Labor ($ / lin ft)	Quantity (lin ft)	Total	
Weather-stripping			$ 0	
Caulking			$ 0	
Air Sealing	$ 500.00	1	$ 500	
	Implementation Cost:		$ 500	= 3.8 year payback
	Annual Energy Savings:		$ 133	

CALCULATIONS TO INSULATE BUILDING ENVELOPE

EEM-4 **Town of New Lebanon - Town Garage**

INPUT DATA:

Surface to be insulated:	Roof	Walls		
Area:	2,530	2,147	sq ft	
Present R value:	21.0	7.0		
Revised R value	38.0	19.0		
Present U factor::	0.048	0.143	Btuh/sq ft-deg F	
Revised U factor:	0.026	0.053	Btuh/sq ft-deg F	
Present U x Area	120	307	427	UA Total presen
Proposed U x Area	67	113	180	UA Total propos

CALCULATIONS:	Occupied	Unoccupied	**Fuel Data**	Heating
Heating Setpoint:	67	67	Type:	Oil - No. 2
Cooling Setpoint:	85	85	Units:	gal.
Q internal gains (Btuh):	7,477	1,629	Unit cost:	$ 3.488
BLC (Btuh/degree F):	1,118	708	BTU/unit	138,000
T Balance (°F.):	60.3	64.7	Efficiency/ COP:	81.0%
T Balance = T Setpoint - (Q internal gains / BLC)			EER:	

Bin Mid-Pt.	Occupied Hours	Unoccupied Hours	Change in Occupied Heat Loss	Change in Unoccupied Heat Loss	Heating Savings gal.
(2.5)	6	9	17,209	17,209	2
2.5	12	39	15,971	15,971	7
7.5	31	94	14,733	14,733	16
12.5	44	156	13,495	13,495	24
17.5	90	333	12,257	12,257	46
22.5	114	378	11,019	11,019	48
27.5	147	406	9,781	9,781	48
32.5	144	527	8,542	8,542	51
37.5	184	536	7,304	7,304	47
42.5	143	417	6,066	6,066	30
47.5	191	554	4,828	4,828	32
52.5	160	436	3,590	3,590	19
57.5	178	621	2,352	2,352	17
62.5	248	715	0	1,114	7
67.5	206	420	0	0	0
72.5	151	325	0	0	0
77.5	156	258	0	0	0
82.5	106	161	0	0	0
87.5	31	20	(619)	(619)	0
92.5	7	5	(1,857)	(1,857)	0
97.5	0	1	(3,095)	(3,095)	0
102.5	0	0	(4,333)	(4,333)	0
107.5	0	0	(5,571)	(5,571)	0
112.5	0	0	(6,809)	(6,809)	0
	8,760	hours		Energy Savings:	397
					$ 1,386

IMPLEMENTATION COST & PAYBACK PERIOD:

	Material & Labor		
Item	($ / sq ft)	Quantity	Total
Roof	$ 10.00	2,530	$ 25,298
Walls	$ 5.00	2,147	$ 10,735
	$ 0.00	4,677	$ 0

Implementation Cost:	$ 36,033	= 26 year payback
Annual Energy Savings:	$ 1,386	

CALCULATIONS TO INSTALL CLEAN HEATING SYSTEM - AIR SOURCE HEAT PUMP						
BE-1	**Town of New Lebanon - Town Garage**					
			Fuel Information			
Building Information	Auto Repair			Heating	Cooling	
Location	Albany	Climate Zone 5	Type:	Oil - No. 2	Electricity	
Portion of Building HP will serve:	100%		Units:	gal.	kwh	
Building Heating Load (BHL)	78,457	BTU/h	Unit cost:	$ 3.488	$ 0.076	/kwh
Building Cooling Load (BCL)			BTU/unit	138,000	3,412	/kwh
BEFLHheating	1,594	Hours	Heating Eff.	81%	$ 10.85	/kW
			CO2	22.48	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?		N				
Present Heating System	Warm Air Furnace, Oil Fired < 225 kBTU/h					
Present Cooling System						
% of Portion to be served by ASHP that is presently cooled						
Proposed System						
Does proposed ASHP require supplemental resistance heat?		N				
ASHP Type	Multi Zone Ductless					
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		EERee				
Seasonal Energy Efficiency Ratio		SEER				
Heating Season Performance Factor	12.0	HSPF				
Resulting system to be modeled	**Scenario**	**3c**				
	Multi-Zone Ductless Multi-split with Integrated/ Modulating controls sized to 100%					

Adjusted Efficiency Values	Baseline	Energy Efficient				
SEERbaseline			EERseason,ee	10.850	c	cooling offset
EERbaseline			EERee	0.255	d	cooling slope
COPseason,baseline	1.00	2.77	COPseason,ee	-2.823	a	heating offset
FElecHeat	0.00	0.00	FElecHeat,new	1.775	b	heating slope
EFFbaseline	0.81	1.00	Fload,cooling			
FFuelHeat	1.00	0.97	Fload,heating			
		1.00	Fload,heating,FuelHeat		0.69	CF
		0.97	Fload,heating,ElecHeat			

					Savings	Savings
	Baseline	Energy Efficient	Savings	Units	$	CO2 Lbs/yr.
Cooling Electric Use (kWh/yr.)				kWh		
Heating Electric Use (kWh/yr.)	0	12,835	(12,835)	kWh		
Total Electric Use (kWh/yr.)	**0**	**12,835**	**(12,835)**	**kWh**	**($ 975)**	**(14,889)**
Peak Demand (kW)			(8.3)	kW	($ 437)	
Fossil Fuel Energy Use (MMBTU)	154	0	154	MMBtu		
Fossil Fuel Energy Use : gal.	**1,119**	**0**	**1,119**	**gal.**	**$ 3,902**	**25,151**
Annual Energy Costs	**$ 3,902**	**$ 1,412**	**$ 2,490**		$ 2,490	10,262
Estimated Project Cost	**$ 5,275**	**per ton =**	**$ 34,491**	**14**	**year payback**	

Appendix D

Assumptions/Data Used to Develop Energy and Dollar Savings Figures

Building and Occupancy Information

			Avg. # of occupants	Heating Setpoint	Cooling Setpoint		% of base electricity use resulting in internal heat gains
Floor Area:	2,400	square feet					
		days /occupied	4	67	85	days	100%
		nights/unoccupied	0	67	85	nights	100%
		# of computer	1				

Interior lighting, people and occupied levels of internal loads occur for 42.5 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 70% of the peak metered kW)

Heating System Information

			% of bldg. served	COP heat	EER	Heat kBTUH	Heating Fuel	Efficiency	
Primary system:	Forced Air		90%	0.81		186	Oil - No. 2	81.0%	Et
Secondary:	Forced Air		10%	2.77	10.00	22		277.0%	Et
	10%	of building is air conditioned	Does the cooling system have economizer?				No		

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

cfm outside air, running hours / week | 0% heat recovery efficiency

Domestic Hot Water

	Fuel	Efficiency						
DHW system energy type	Electricity	1%	Is there a pump to circulate DHW?			No		
Hot Water usage is	0.5	gallons per	person	/ day for	4	persons on	250	days/year

Weather & Schedule Information:

Select nearest weather station for bin data:	ALBANY			for TRM:	Albany
Base temperature for heating degree days:	65	°F. yields	6,929 HDD base65	for TRM:	Auto Repair
Base temperature for cooling degree days:	70	°F. yields	348 CDD base70	for TRM:	Gas Heat Only

Present Schedule for Occupied/Day HVAC setpoints

Day of week		Start	End	Hours
Sun	1	12:00 AM	12:00 AM	-
Mon	2	6:30 AM	3:00 PM	8.5
Tue	3	6:30 AM	3:00 PM	8.5
Wed	4	6:30 AM	3:00 PM	8.5
Thu	5	6:30 AM	3:00 PM	8.5
Fri	6	6:30 AM	3:00 PM	8.5
Sat	7	12:00 AM	12:00 AM	-
Albany, 43 hrs./week				42.5
				125.5

Proposed Schedule for Occupied/Day HVAC setpoints

Day of week	Start	End	Hours
1	12:00 AM	12:00 AM	-
2	6:30 AM	3:00 PM	8.5
3	6:30 AM	3:00 PM	8.5
4	6:30 AM	3:00 PM	8.5
5	6:30 AM	3:00 PM	8.5
6	6:30 AM	3:00 PM	8.5
7	12:00 AM	12:00 AM	-
Albany, 43 hrs./week			42.5

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

Town of New Lebanon - Town Garage
14755 NY-22
New Lebanon, NY 12125

Building Information

Width (typical)	40	feet	Building Floor Area	2,400	sq. ft.
Equivalent Length	60	feet	Roof Area	2,530	sq. ft.
Number of Floors	1.0	floors	Gross Wall Area	2,600	sq. ft.
Avg. Floor to Floor Height	13	feet per floor	Building Volume	31,200	cubic feet
Roof or Ceiling rise is	4	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		2,530	21.0	0.048	120	11%
Walls	82.6%	of GWA	2,147	7.0	0.143	307	27%
Glazing 1	5.5%	of GWA	144	2.0	0.500	72	6%
Glazing 2	0.0%	of GWA	0	0.9	1.111	0	0%
Doors 1	1	3x7 doors	21	2.0	0.500	11	1%
Overhead	2	12x12	288	5.0	0.200	58	5%
Total Exterior Surface Area			5,130	sq.ft.		567	50%

		ACH	equiv. cfm	Btuh/deg. F.	BLC (without ventilation)	
Est. Infiltration Rate	Occupied	1.00	520	562	1,118	Btuh/deg. F. Occupied
Est. Infiltration Rate	Unoccupied	0.25	130	140	708	Btuh/deg. F. Unoccupied

		cfm	Fraction	Btuh/deg. F.	**Total BLC with Ventilation**	
Est. Ventilation Rate	Occupied	0	100%	0	**1,118**	**Btuh/deg. F. Occupied**
Est. Ventilation Rate	Unoccupied		100%	0	**708**	**Btuh/deg. F. Unoccupied**

Heat Gain Estimation

Estimated Solar Gain 1% of building heat loss during occupied periods will be met by solar gains

		kW	# People	Total BTUH	Hours/wk.
Loads & People	Occupied	**1.9**	**4**	7,477	42.5
	Unoccupied	**0.5**	**0**	1,629	125.5

Heat Loss Study - continued

Town of New Lebanon - Town Garage
14755 NY-22
New Lebanon, NY 12125

Fuel Data	Heating	Cooling	
Type:	Oil - No. 2	Electricity	Economizer?
Units:	gal.	kwh	No
Unit cost:	$ 3.488	$ 0.076	
BTU/unit	138,000	3,412	
Nom. Eff, COP	0.810	0.000	COP
Avg. Eff, COP	0.810	4.15	Avg. COP
		14.2	Avg. EER
		10%	of bldg. cooled

		Current	
Heating T Setpoint:	Occupied	67	deg. F.
	Unoccupied	67	deg. F.
Cooling T Setpoint:	Occupied	85	deg. F.
	Unoccupied	85	deg. F.
HVAC Schedule	Occupied	43	Hrs. per week
	Unoccupied	126	Hrs. per week
Q internal gains:	Occupied	7,477	Btuh
	Unoccupied	1,629	Btuh
Q internal gains:	Schedule	43	Hrs. per week
BLC:	Occupied	1,118	Btuh/deg. F.
	Unoccupied	708	Btuh/deg. F.

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

Current Albany, 43 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.
(2.5)	6	9	70,195	47,555	8	0	0	0
2.5	12	39	64,607	44,016	22	0	0	0
7.5	31	94	59,020	40,478	50	0	0	0
12.5	44	156	53,432	36,939	73	0	0	0
17.5	90	333	47,844	33,401	138	0	0	0
22.5	114	378	42,256	29,863	144	0	0	0
27.5	147	406	36,668	26,324	144	0	0	0
32.5	144	527	31,080	22,786	147	0	0	0
37.5	184	536	25,492	19,247	134	0	0	0
42.5	143	417	19,904	15,709	84	0	0	0
47.5	191	554	14,316	12,170	85	0	0	0
52.5	160	436	8,728	8,632	46	0	0	0
57.5	178	621	3,140	5,094	33	0	0	0
62.5	248	715	0	1,555	10	0	0	0
67.5	206	420	0	0	0	0	0	0
72.5	151	325	0	0	0	0	0	0
77.5	156	258	0	0	0	0	0	0
82.5	106	161	(4,683)	0	0	3	0	0
87.5	31	20	(10,271)	(3,399)	0	3	0	0
92.5	7	5	(17,513)	(7,350)	0	1	0	0
97.5	0	1	(21,789)	(10,561)	0	0	0	0
102.5	0	0	(27,035)	(14,014)	0	0	0	0
107.5	0	0	(32,623)	(17,552)	0	0	0	0
112.5	0	0	(38,211)	(21,091)	0	0	0	0
	8,760	hours			1,119	7	DOAS fuel use	0
							DOAS cool use	0

Cross Check Against Historic Consumption

	Historic		Calculated	Difference
Present Annual Heating Fuel Use is	155	mmBTU	154	100% 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.

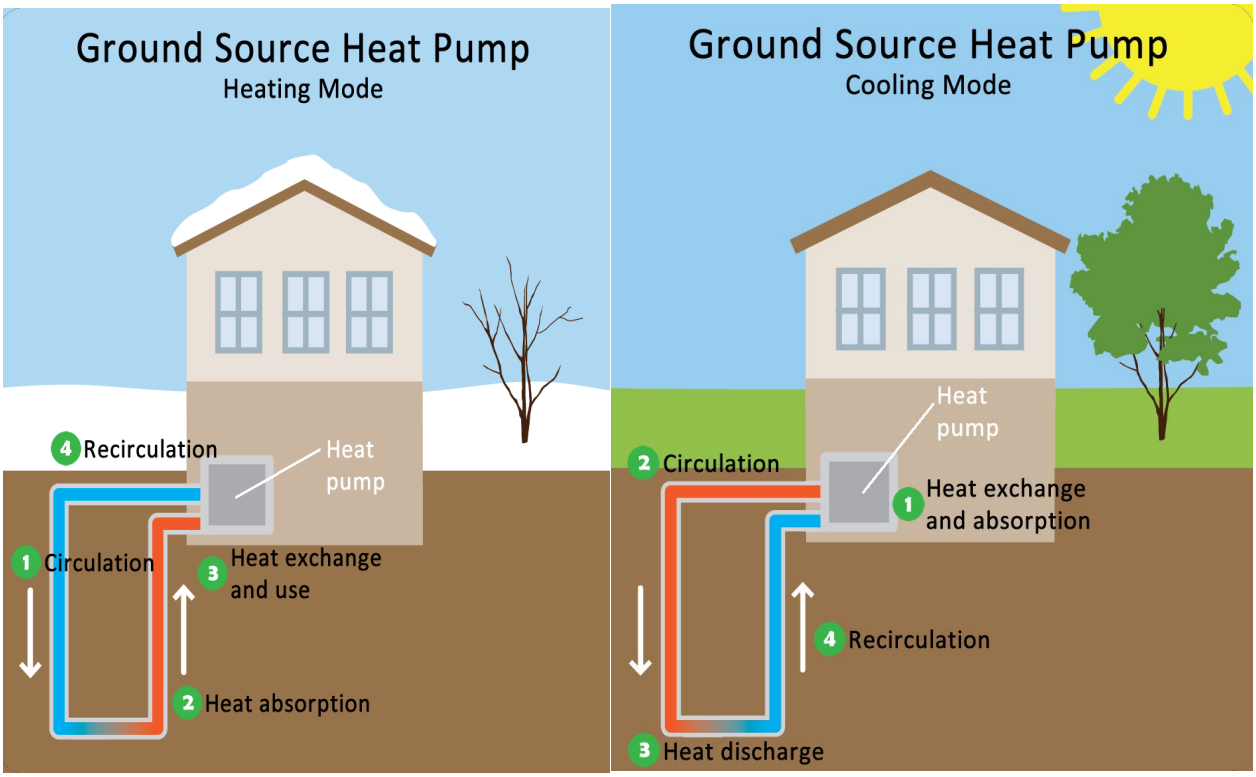
TYPES OF CLEAN HEATING AND COOLING (CHC) TECHNOLOGIES

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).

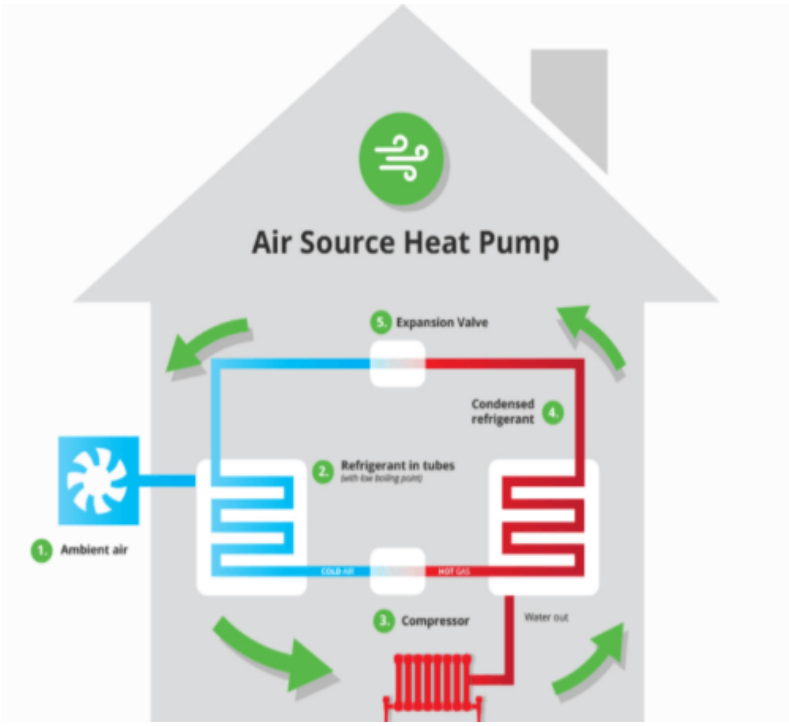
The system reverses during cooling, where the energy is absorbed by the ground loop.



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

What is an Air Source Heat Pump (ASHP)?

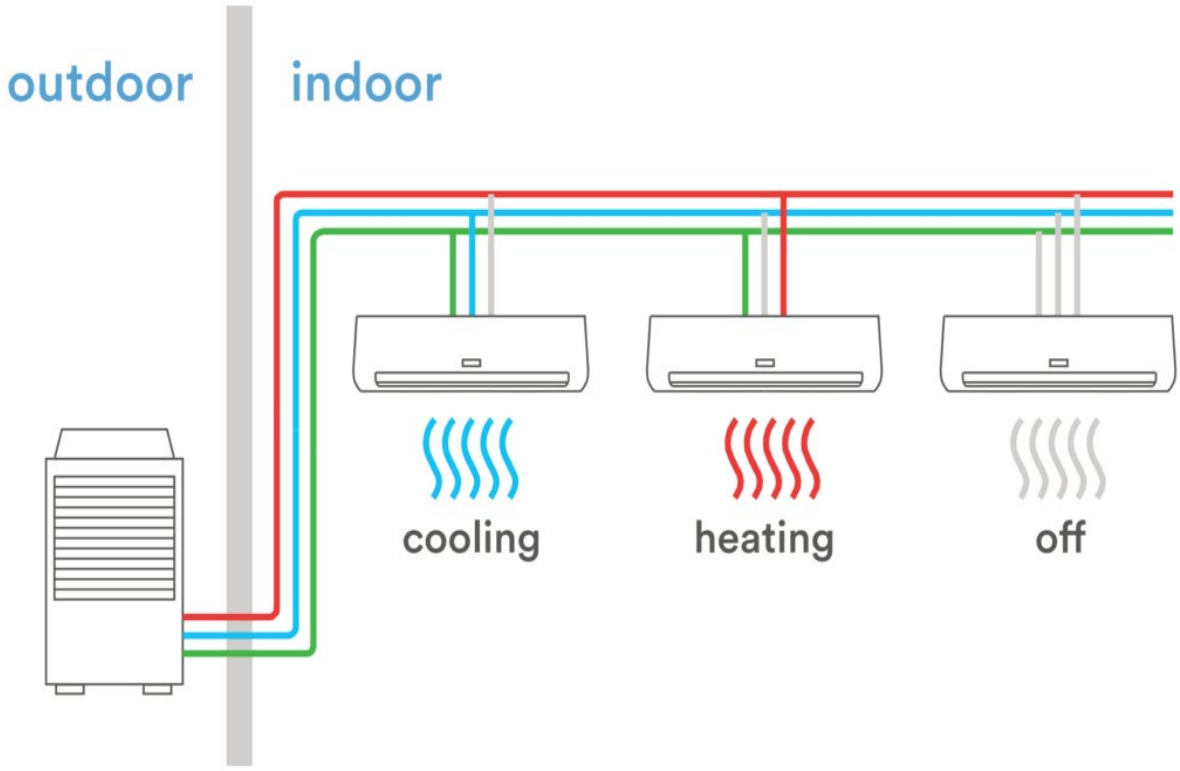
An air source heat pump works much like a refrigerator operating in reverse. Outside air is blown over a network of tubes filled with a refrigerant. This warms up the refrigerant, and it turns from a liquid into a gas. This gas passes through a compressor, which increases the pressure. Compression also 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	673	1,053	2.3	$ 377	Oil - No. 2	(3.4)	($ 85)	$ 292	$ 934	3.2
EEM-2	R	Controls	Improve Temperature Control	4,713	0	0.0	$ 0	Oil - No. 2	28.9	$ 731	$ 731	$ 199	0.3
EEM-3	R	Envelope	Weather-Stripping And Caulking	857	0	0.0	$ 0	Oil - No. 2	5.3	$ 133	$ 133	$ 500	3.8
EEM-4	R	Envelope	Insulate Building Envelope	8,935	0	0.0	$ 0	Oil - No. 2	54.9	$ 1,386	$ 1,386	$ 36,033	26.0
Total of Recommended Measures:				**15,178**	**1,053**	**2.3**	**$ 377**		**85.7**	**$ 2,165**	**$ 2,543**	**$ 37,666**	**14.8**

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	R	VRF	Install Clean Heating System - Air Source Heat Pump	10,262	(12,835)	0.0	($ 1,412)	Oil - No. 2	154.4	$ 3,902	$ 2,490	$ 34,491	13.9
Total of Recommended Measures:				**10,262**	**(12,835)**	**0.0**	**($ 1,412)**		**154.4**	**$ 3,902**	**$ 2,490**	**$ 34,491**	13.9