Clean Energy Communities

Energy Study

Prepared for:

Town of Groton - Municipal Building

101 Conger Boulevard

Groton, NY 13073

Audit No: CEC001236-1-S

Submitted by:

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Date: 3/17/2025

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.

NOTICE

State of New York

Kathy Hochul, Governor

New York State Energy Research and Development Authority

Consultant Disclaimer

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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.

Specific areas of concern that were identified by the owner for evaluation include HVAC controls, lighting, and envelope.

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

- Lighting – Replace all the fluorescent lights with LEDs.
- Controls – Install Wi-Fi enabled thermostats so that the facility manager has remote control of the building heating and cooling zones.
- Envelope –
    - The overhead garage doors need new weatherstripping and door sweeps.
    - The garage walls and ceiling should be fully insulated with spray foam.
    - The Town Offices should have insulation above the dropped ceiling.
    - The front and rear door in the mechanic's bay need to be replaced.
    - The paint room single pane windows need to be replaced.
- Pipes – Insulate the hot water heating and domestic hot water pipes in the boiler room.
- Domestic Hot Water – Replace the gas fired storage tank for a small, on demand electric unit.
- Heat Pumps – Install air source or ground source heat pumps in for the Court/Offices section of the building.

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.

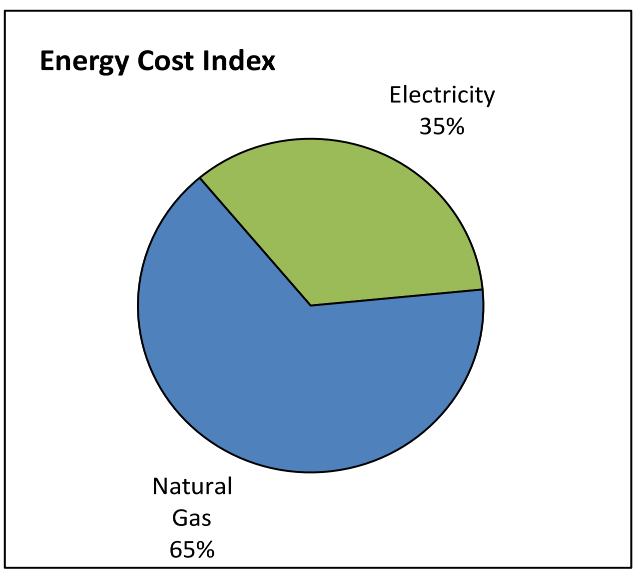
- The Energy Cost Index (ECI) is the total cost of energy divided by the conditioned floor area and is shown as dollars per square foot per year.
- The Energy Use Intensity (EUI) is the total heat content of energy divided by the conditioned floor area and is shown in units of one thousand Btus (kBtu)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

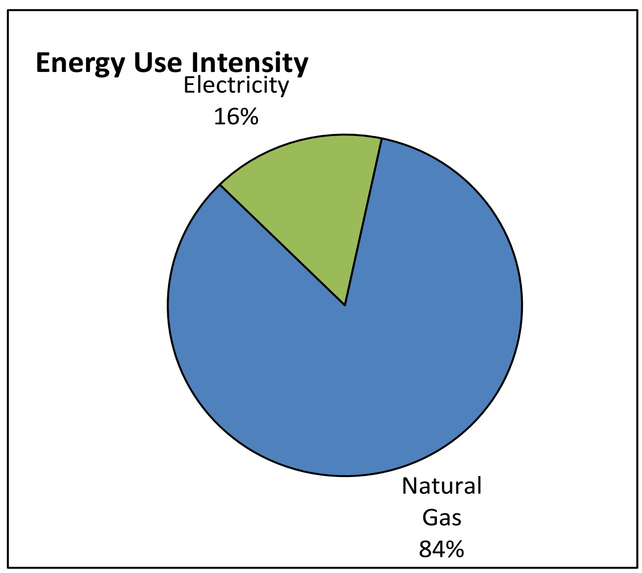
Energy Cost Index

Electricity	$ 7,221	$ 0.31	$/sq.ft./year
Natural Gas	$ 13,664	$ 0.59	$/sq.ft./year
Total Cost	$ 20,885	$ 0.91	$/sq.ft./year

Energy Use Intensity

Electricity	278	mmBtu	12.1	kBtu/sq.ft./year
Natural Gas	1,476	mmBtu	64.2	kBtu/sq.ft./year
Total Energy Use	1,754	mmBtu	76.3	kBtu/sq.ft./year





Energy Cost Index $ 0.91 /sf/yr. **Energy Use Intensity 76.3 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	16,630	$ 1,276	$ 17,632	13.8
EEM-2	R	Improve Temperature Control	21,756	$ 1,680	$ 787	0.5
EEM-3	R	Weather-Stripping And Caulking	7,212	$ 557	$ 3,072	5.5
EEM-4	R	Insulate Building Envelope - Garage	35,995	$ 2,779	$ 74,906	26.9
EEM-5	R	Insulate Building Envelope - Town Office	3,242	$ 250	$ 7,500	30.0
EEM-6	NR	Install Insulated Doors	584	$ 45	$ 1,905	42.2
EEM-7	NR	Install Double Glazing	5,561	$ 421	$ 23,040	54.7
EEM-8	R	Insulate Heating And Domestic Hot Water Pipes	245	$ 19	$ 145	7.7
EEM-9	NR	Install A Tankless Water Heater	(22)	($ 2)	$ 450	(287.2)
		All Energy Efficiency Measures:	**91,202**	**$ 7,026**	**$ 129,437**	**18.4**
		Total of Recommended Measures:	**85,079**	**$ 6,561**	**$ 104,042**	**15.9**

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.
(RBE) – Recommended Beneficial Electrification: Measures that should be considered based on greenhouse gas reductions, eliminating on-site use of fossil fuels, and/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	6,364	$ 500	$ 52,753	105.5	$ 10,658	84.2
BE-2	RBE	Install Clean Heating System - Ground Source Heat Pump	14,140	$ 1,096	$ 136,683	124.7	$ 12,093	113.6
		All Measures:	**20,503**	**$ 1,596**	**$ 189,436**	**118.7**	**$ 22,751**	**104.4**
		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	14,356	kWh =	16,653	pounds CO2 equivalent
Natural Gas	5,838	therm =	68,426	pounds CO2 equivalent
			85,079	pounds CO2 equivalent
			31.8%	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.

Existing Conditions

The site is a municipal complex comprising three different sections between two connected buildings. The original building from 1961 consists of the Town Office, which hosts the Clerk and other departments, as well as the highway garage. The newer section, constructed in 1990, was built for the Town Court. There are five full-time staff who work in the Office from 8am to 4pm on weekdays. The Court has a single clerk who works from 7am to 4pm Monday through Thursday. Court is in session on Mondays at 5pm. The highway department has nine staff, who work from 6am to 3pm Monday through Thursday and 6am to 12pm on Fridays in the winter (as well as overtime). During the summer, they work from 6am to 4pm Monday through Thursday. The highway staff are usually out of the building.

The Court space consists of 3,480 ft^2 per drawings that were available. It is a block and brick building that has 20' walls and a flat roof with a grey EPDM membrane. According to the drawings there are 3" of rigid board insulation above metal deck at R-38 levels. The interior walls in the Court are framed and likely insulated. The rear storage space of the building is neither framed, nor insulated. There are two entrances, each with heated vestibules that have double pane glass doors with metal frames. The Court also has a side entrance with a fire rated metal door. The windows are all double pane glass with metal frames and are either fixed or have pull handles.

The Town Office is part of the original building structure, which is a poured concrete building. This section has standard 10' walls, and a gabled roof with a corrugated metal exterior and a dropped ceiling. There is unlikely to be insulation along the ceiling or interior walls. The highway garage is a concrete framed building with block side and rear walls at 15'. The concrete roof is inverted, and the drains feed directly into the sewer line. There does not appear to be any insulation in this section of the building. The front and rear walls consist primarily of insulated 14'x18' overhead garage doors. The side wall has two large single pane glass metal framed windows. One has plastic sheathing over it. The rear wall used to have single pane windows, but these were boarded up and replaced with smaller double pane glass windows. The entrances are fire rated metal doors. This section is around 19,520 ft^2.

Lighting Systems

The lights in the Court are a combination of T8, T12, and compact fluorescent fixtures. The offices in the original building have T8 fluorescent fixtures. The garage has T5 highbay fixtures in all bays except for the paint room, which has LED fixtures. These lights all operate via switches. The exterior lights are all LED with photocells.

Heating Ventilating and Air Conditioning Systems

The Court and Office have two different heating systems. The boiler plant heats via baseboard heat along the perimeter, while gas fired packaged rooftop units heat and cool the space. Staff state that the rooftop units operate primarily in the shoulder periods before the boiler plant comes on to heat. It was observed that the rooftop unit was set to cooling, despite the boiler being on, which indicates that the staff often are fighting to keep the building comfortable, and even simultaneously heating and cooling the space. The juror room has an electric heater and a dehumidifier which are on to protect files from potential damage. Note that the Courtroom is almost exclusively unoccupied.

The Town Office uses the boiler and its rooftop unit to heat and cool, while the highway garage office has a PTAC for cooling with a hot water coil tied into the boiler for heating. The garage breakroom and bathroom are heated exclusively by the boiler, as well as the furthest garage bay, which is the paint room. The paint room cannot have an open flame, so unit ventilators are supplied by the boiler. The rest of the garage bays use ceiling mounted gas fired unit heaters. They recently installed destratification fans, which allows the staff to reduce the thermostat setpoints.

- Boiler
    - Weil McLain, model LGB-2 cast iron six sectional gas fired boiler from 2024.
    - 650 Mbh capacity and a rated efficiency of 80.7%.
    - Most pipes are insulated.
    - Three zones with Grundfos 215 W circulator pumps.
        - Court/Office – Digital thermostat in kitchen area is set to 75 degrees
        - Highway – Digital thermostat installed in 2024 in the breakroom is set to 65 degrees
        - Paint Room – Slider thermostat set to 50 degrees.
        - The thermostats used to be pneumatic but were converted to digital with the new zones/boiler.
- Rooftop Units
    - Carrier, models 48TCED08 units. One from 2012 and one from 2014.
    - Two stage cooling at 7.5 Ton with an 11 EER and 11.7 IEER.
    - 180 Mbh heating capacity at 82% efficiency.
    - Units appear to have outside air intakes, but per model number description there is no damper.
    - The Court programmable thermostat was set to cool to 73 degrees (which may simultaneously heat and cool the space). Typical heating setpoint are 70 degrees with a 5 degree setback.
    - The Town Office programmable thermostat is set to hold to 74 degrees in heating and 77 degrees in cooling.
- Electric Baseboard
    - The juror room is kept heated with a 6’ baseboard to 75 degrees.
- Unit Heaters
    - The highway garage has eight total Reznor unit heaters.
        - Two in the mechanic’s bay are 140 Mbh with a rated efficiency of 77% from 1984.
        - The other six are in the main garage, and these are estimated to have 200 Mbh capacity.
            - Four are older, likely from 1984 with 77% efficiencies.
            - Two are new, likely from 2023 with 82% efficiencies.
    - Each has their own rotary dial thermostats that staff keep between 55 and 60 degrees.

Water Heating System

Hot water is provided by an A.O. Smith, model FCG-75-300 gas fired hot water storage heater from 2014. It has capacities of 75 Mbh and 75 gallons. The combustion efficiency is 80%. The pipes are not insulated, and the hot water temperature was not able to be measured as the pipe run took a long time to get to the Clerk's bathroom. Staff state that the only use is for handwashing.

Other Energy-using Systems

Other than office equipment and kitchen appliances, the highway garage has an air compressor, and other process equipment.

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

Energy Efficiency Measure Descriptions

EEM-1 Interior Lighting Retrofit

Electric Savings:	$ 1,276	14,336	kWh per year
		7.6	kW demand
Fuel Savings:	$ 0	0.0	MMBtu fuel per year
Total Annual Savings:	**$ 1,276**		
Project Cost:	**$ 17,632**		
Simple Payback:	**13.8**	**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:

There are several different types of fluorescent fixtures consisting of T5, T8, and T12 tubes of various lengths. Replace the office lights with flat panel LEDs. Replace the high bay lights with new LED tubes. Install occupancy sensors in the offices, breakrooms, bathrooms, and highway garage.

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 Improve Temperature Control

Electric Savings:	$ 0		0	kWh per year
			0.0	kW demand
Fuel Savings:	$ 1,680		185.6	MMBtu fuel per year
				Natural Gas
Total Annual Savings:	**$ 1,680**			
Project Cost:	**$ 787**			
Simple Payback:	**0.5**	**years**		

Introduction:

Proper temperature control is important in order to minimize energy costs. Maintaining space temperatures within a reasonable range during occupied periods and reliably reducing the amount of heating and cooling energy during unoccupied periods should be the goal for your temperature control system.

Facilities that are occupied only on weekdays can maintain a lower space temperature setpoint on weekends. Programmable thermostats are available that permit full 7 day schedules to be defined. 5-2 or 5-1-1 thermostats use the same schedule for all weekdays and provide one or two schedules for weekend days.

Recommendation:

The boiler plant has two thermostats serving the entire court/office complex with one installed in the kitchen, and the other installed in the breakroom. There are also two rooftop unit thermostats located in the court and clerk's office. The facility manager indicates that staff adjust the temperatures as they please in different areas to address different comfort levels. However, this leads to simultaneous heating and cooling in the court.

New Wi-Fi enabled thermostats need to be installed to replace the four thermostats so that the facility manager can control the temperatures during occupied times and set programs up for unoccupied times. For instance, the court is unoccupied most of the week, and the staff should not be using the rooftop units for heating (or cooling) in the winter unless the boiler is offline. This measure provides an estimate of savings for introducing a night setback of 5 degrees in the heating season. Contact the mechanical contractor to inquire about adding more zones and thermostats, which will limit imbalances within the system.

EEM-3 Weather-Stripping And Caulking

Electric Savings:	$ 0		0	kWh per year
			0.0	kW demand
Fuel Savings:	$ 557		61.5	MMBtu fuel per year Natural Gas
Total Annual Savings:	**$ 557**			
Project Cost:	**$ 3,072**			
Simple Payback:	**5.5**	**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:

The overhead garage doors need new weatherstripping and door sweeps.

EEM-4 Insulate Building Envelope - Garage

Electric Savings:	$ 0		0	kWh per year
			0.0	kW demand
Fuel Savings:	$ 2,779		307.1	MMBtu fuel per year Natural Gas
Total Annual Savings:	**$ 2,779**			
Project Cost:	**$ 74,906**			
Simple Payback:	**26.9**	**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 garage should be insulated with spray foam along the walls and ceiling. Also spray foam the walls between the overhead doors and the rear areas below the windows. Savings are estimated for adding at least 2" of spray foam on the walls and 4" on the ceiling. A fire retardant paint or similar coating may need to be added to the spray foam depending on local codes. Costs are estimated at $\$1/inch/ft^2$ of spray foam.

EEM-5 Insulate Building Envelope - Town Office

Electric Savings:	$ 2		20	kWh per year
			0.0	kW demand
Fuel Savings:	$ 249		27.5	MMBtu fuel per year
				Natural Gas
Total Annual Savings:	**$ 250**			
Project Cost:	**$ 7,500**			
Simple Payback:	**30.0**	**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 Town Office should install fiberglass or equivalent insulation above the drop ceiling. Savings are estimated for adding 4" of R-19 insulation at a cost of $\$3/ft^2$.

EEM-6 Install Insulated Doors

Electric Savings:	$ 0		0	kWh per year
			0.0	kW demand
Fuel Savings:	$ 45		5.0	MMBtu fuel per year Natural Gas
Total Annual Savings:	**$ 45**			
Project Cost:	**$ 1,905**			
Simple Payback:	**42.2**	**years**		

Introduction:

Single pane wooden frame or metal frame doors can be very inefficient. Heat loss due to conduction through single pane glass can be very high. Also heat loss due to air infiltration past loose fitting or worn out frames can increase the cost of energy to heat this air. Drafts can also occur causing discomfort to occupants. The installation of insulated replacement doors will reduce these heating loads.

Energy efficient doors are built with thermal breaks and insulated cores to reduce conduction heat losses. Weather stripping along the perimeter of the door minimizes the infiltration of unconditioned air.

Recommendation:

The metal entrance doors in the front and rear of the garage have reached the end of their useful lives and need to be replaced. Unfortunately, since this space is not heated like a typical office, the potential savings from an energy efficiency standpoint do not have a good payback relative to the cost for high efficiency doors. However, since they need to be replaced, this measured is recommended for non-energy reasons.

EEM-7 Install Double Glazing

Electric Savings:	($ 8)	0	kWh per year
		0.0	kW demand
Fuel Savings:	$ 429	47.4	MMBtu fuel per year Natural Gas
Total Annual Savings:	**$ 421**		
Project Cost:	**$ 23,040**		
Simple Payback:	**54.7**	**years**	

Introduction:

Single pane wooden or metal frame windows can be very inefficient. Heat loss due to conduction through single pane windows can be very high. New windows utilize two panes of glass instead of one. Glass performance is measured in two ways Solar Heat Gain Co-efficient (SHGC) or Visible Transmittance (VT). SHGC is the amount of solar gain transmitted through a window into the building. VT refers to the amount of visible light that moves through the glass from exterior to interior. These two factors can be altered for a higher performing window by adding Low-E coatings and spacers with gas. The overall thermal performance of windows is generally assigned a u-value. This measurement considers all parts of a window. These parts include the frame, sash, and glass. The installation of windows with double glazing will reduce infiltration and conduction losses.

Recommendation:

The paint shop windows are single pane glass and need to be replaced with similar windows in the rear of the garage. However, further consideration should be given to removing the windows altogether and installing block and spray foam over the holes.

Savings are based on installing new double pane windows, but since they will be prohibitively expensive, this measure is not recommended.

EEM-8 Insulate Heating And Domestic Hot Water Pipes

Electric Savings:	$ 0		0	kWh per year
			0.0	kW demand
Fuel Savings:	$ 19		2.1	MMBtu fuel per year Natural Gas
Total Annual Savings:	**$ 19**			
Project Cost:	**$ 145**			
Simple Payback:	**7.7**	**years**		

Introduction:

Heat is distributed through the building by pipes containing hot water or steam. Heating distribution system pipes lose heat to the surrounding space. If the heat is lost to an area that does not require heating, the drop in system efficiency can be significant. Un-insulated pipes in conditioned space may also overheat the space, wasting energy and causing comfort problems. All heating distribution system pipes located in unconditioned space should be insulated.

Domestic hot water (DHW) is water that is heated for hand washing, showering, dish washing, laundry, etc. Domestic hot water pipes lose heat to the surrounding space. This loss is significant in facilities with recirculating hot water systems, or in facilities that use hot water for a large portion of the day. In a recirculating system, all domestic hot water pipes should be insulated. In a non-recirculating system, domestic hot water pipes within eight feet of the water heater should be insulated.

Recommendation:

Insulate all exposed heating pipes that are located in unconditioned space. Insulate the first eight feet of domestic hot water piping after the water heater. Insulation thickness should be per the New York State Energy Conservation Construction Code, and should be pre-formed fiberglass pipe insulation with protective jacketing.

Install 1 in. insulation on (12 ft.) of 1 in. Dull Copper Hot Water pipe and 1 in. insulation on (8 ft.) of 0.75 in. Dull Copper DHW pipe.

EEM-9 Install A Tankless Water Heater

Electric Savings:	($ 26)		(294)	kWh per year
			(0.1)	kW demand
Fuel Savings:	$ 25		2.7	MMBtu fuel per year Natural Gas
Total Annual Savings:	**($ 2)**			
Project Cost:	**$ 450**			
Simple Payback:	**(287.2)**	**years**		

Introduction:

Storage type water heaters maintain a tank of hot water continuously, so that hot water is available when it is needed. These storage tanks continuously lose heat through the outer surfaces of the tank, even though they are insulated. Water heaters with gas, oil or propane burners also lose heat through the flue when the burner is not firing.

Tankless water heaters produce hot water only when there is a demand for it. They sense the flow of water and quickly heat the water as long as there is flow, or demand, for hot water. Tankless water heaters are available with electricity, natural gas or propane as energy sources. They are best located close to the point where hot water is used.

Recommendation:

The existing hot water maker has a 75 gallon tank. The hot water loads in the facility are limited to handwashing. The storage tank can be replaced when it reaches the end of its useful life with a small, four gallon unit with a 1.65 kW coil that can be found at any local retailer inexpensively. It also may be more practical to install in-line on demand units in the furthest bathrooms since hot water takes a long time to travel across the building to reach this space.

The cost of gas is cheaper than that of electricity, but this measure is expected to be cost neutral since the storage tank losses are mostly eliminated. This measure is not recommended currently, but when the existing tank reaches the end of its life, consider a different option.

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:	($ 1,344)		(15,105)	kWh per year
			2.3	kW demand
Fuel Savings:	$ 1,844		203.8	MMBtu fuel per year
				Natural Gas
Total Annual Savings:	**$ 500**			
Project Cost:	**$ 52,753**			
Simple Payback:	**105.5**	**years**	**84.2**	**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:

The rooftop units serving the Court and Offices can be replaced with heat pump rooftop units. It is assumed that the existing units are sized sufficiently for all the heating needs for redundancy. They are sized to 180 Mbh, which is equivalent to 15 Tons. Heat pumps have reduced capacity at lower temperatures, so they may need to be oversized. Alternatively, the boiler plant can be used to supplement some of the heating loads using a hybrid heating solution.

The heat pumps are assumed to be rated at 15 EER full load cooling, 19 SEER. The heat pumps are assumed to be rated at 10 HSPF for heating, which may be adjusted to 2.58 COP, which is the average seasonal heating efficiency. 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 is recommended for beneficial electrification purposes, despite the long payback. Contact a qualified contractor to receive quotes. Further study is required for the Town to make an informed decision to implement either air source or ground source heat pump upgrades as discussed in the subsequent measure.

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

Electric Savings:	($ 715)		(8,034)	kWh per year
			3.3	kW demand
Fuel Savings:	$ 1,811		200.2	MMBtu fuel per year Natural Gas
Total Annual Savings:	**$ 1,096**			
Project Cost:	**$ 136,683**			
Simple Payback:	**124.7**	**years**	**113.6**	**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:

Like the previous measure, ground source heat pumps can be installed to heat and cool the Town Office and Court section using rooftop water source heat pumps. This measure is more efficient than air source heat pumps but is more costly.

Install a closed loop heat pump system with variable-speed compressors and variable pumping. The heat pumps are assumed to be rated at 18 EER full load cooling, 25 EER part load. The heat pumps are assumed to be rated at 4 COP full load heating, 4.5 COP part load.

This measure is recommended for beneficial electrification purposes, despite the long payback. Contact a qualified contractor to receive quotes. Further study is required for the Town to make an informed decision to implement either air source or ground source heat pump upgrades as discussed in the subsequent measure

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
Boiler	1	Weil McLain LGB-2	650	80.7%				Offices & Paint Room	2024
Rooftop Units	2	Carrier 48TCED08	180	82%	7 1/2	tons	11.0	Offices	'12/'14
Electric Baseboard	1	N/A	7	100%				Juror Room	N/A
Unit Heater	2	Reznor	140	77%				Mechanic's Bay	1984
Unit Heater	2	Reznor	200	82%				Garage	2024
Unit Heater	6	Reznor	200	77%				Garage	1984
PTAC	1	N/A heating from boiler			1	tons	9.0	Highway Office	1984

Domestic Hot Water									
Unit Type	Qty	Make/Model	Capacity	Units	Fuel Type	Storage Capacity (gal.)	Eff.	Serves/Location	Year
Storage	1	A.O. Smith FCG-75-300	75	kBtu/h	Natural Gas	75	80%	Bathrooms	2014

Motors									
Unit Type	Qty	Make/Model	HP	Loading	Type	Hours/year	Eff.	Serves/Location	Year
Zone Circulator	3	Grundfos	215 W					Offices & Paint Room	2024
Rooftop Blower	2	Carrier	8.4 A					Offices	'12/'14
Rooftop Condenser	4	Carrier	1.5 A					Offices	'12/'14
Unit Heater Blower	10	Reznor - Est.	1/6					Garage	

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	Court	9	4' 34w T12 Std. Mag. bal	2	80	No Change	New LED Fixture	9	4' LED fixture 4500 lu. 42w	1	42
2	Court	17	13w CFL Quad Elec. bal.	1	15	No Change	LED Relamp	17	A19 LED, 9W	1	9
3	Court	11	13w CFL Quad Elec. bal.	2	28	No Change	LED Relamp	11	A19 LED, 9W	2	18
4	Juror	4	4' 32w T8 Elec. bal.	3	89	No Change	New LED Fixture	4	4' LED fixture 4500 lu. 42w	1	42
5	Court Clerk	3	4' 32w T8 Elec. bal.	3	89	Occ. Sensor Switch	New LED Fixture	3	4' LED fixture 4500 lu. 42w	1	42
6	Halls	8	4' 32w T8 Elec. bal.	2	59	No Change	New LED Fixture	8	4' LED fixture 4500 lu. 42w	1	42
7	File Storage	4	4' 32w T8 Elec. bal.	2	59	No Change	New LED Fixture	4	4' LED fixture 4500 lu. 42w	1	42
8	Bathrooms	2	4' 32w T8 Elec. bal.	2	59	Remote Occ Sensor	New LED Fixture	2	4' LED fixture 4500 lu. 42w	1	42
9	Rear Storage	7	4' 34w T12 Std. Mag. bal	2	80	No Change	New LED Fixture	7	4' LED fixture 4500 lu. 42w	1	42
10	Codes	3	4' 32w T8 Elec. bal.	3	89	No Change	New LED Fixture	3	4' LED fixture 4500 lu. 42w	1	42
11	Kitchen	6	4' 32w T8 Elec. bal.	2	59	Remote Occ Sensor	New LED Fixture	6	4' LED fixture 4500 lu. 42w	1	42
12	Clerk	6	4' 32w T8 Elec. bal.	2	59	No Change	New LED Fixture	6	4' LED fixture 4500 lu. 42w	1	42
13	Lobby	2	4' 32w T8 Elec. bal.	2	59	No Change	New LED Fixture	2	4' LED fixture 4500 lu. 42w	1	42
14	Highway Office	6	60 watt Incandescent	1	60	Occ. Sensor Switch	LED Relamp	6	A19 LED, 9W	1	9
15	Highway Office	2	4' 32w T8 Elec. bal.	3	89	Occ. Sensor Switch	New LED Fixture	2	4' LED fixture 4500 lu. 42w	1	42
16	Mechanics Bay	1	4' 34w T12 Std. Mag. bal	2	80	Remote Occ Sensor	New LED Fixture	1	4' LED fixture 4500 lu. 42w	1	42
17	Mechanics Bay	1	8' 60w T12 IS Std. Mag. b	2	138	Remote Occ Sensor	New LED Fixture	1	8' LED fixture, 8645 lu., 65W	1	65
18	Mechanics Bay	17	4' 54w T5 HLO Elec. bal.	4	234	Remote Occ Sensor	LED Relamp	17	4' LED T5HO 3300 lu. 25.5W	4	102
19	Breakroom	4	4' 32w T8 Elec. bal.	2	59	Remote Occ Sensor	New LED Fixture	4	4' LED fixture 4500 lu. 42w	1	42
20	Parts Room	4	4' 32w T8 Elec. bal.	2	59	Remote Occ Sensor	New LED Fixture	4	4' LED fixture 4500 lu. 42w	1	42
21	Garage	10	4' 54w T5 HLO Elec. bal.	6	351	Remote Occ Sensor	LED Relamp	10	4' LED T5HO 3300 lu. 25.5W	6	153
22	Garage	6	4' 54w T5 HLO Elec. bal.	4	234	Remote Occ Sensor	LED Relamp	6	4' LED T5HO 3300 lu. 25.5W	4	102
23	Garage	8	4' 32w T8 Elec. bal.	2	59	Remote Occ Sensor	New LED Fixture	8	4' LED fixture 4500 lu. 42w	1	42

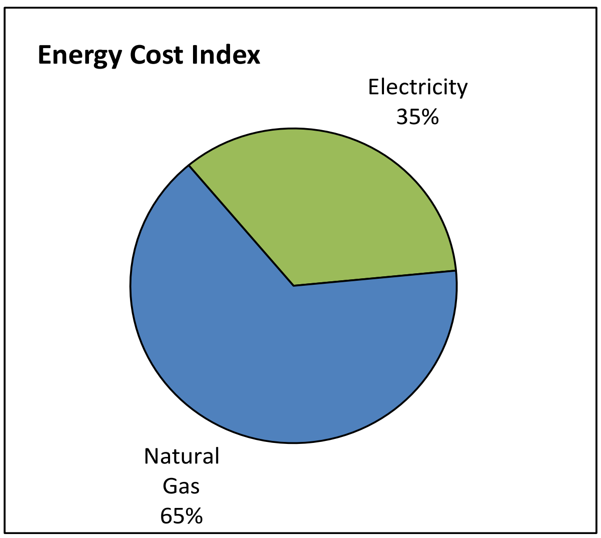
All other lights are LED.

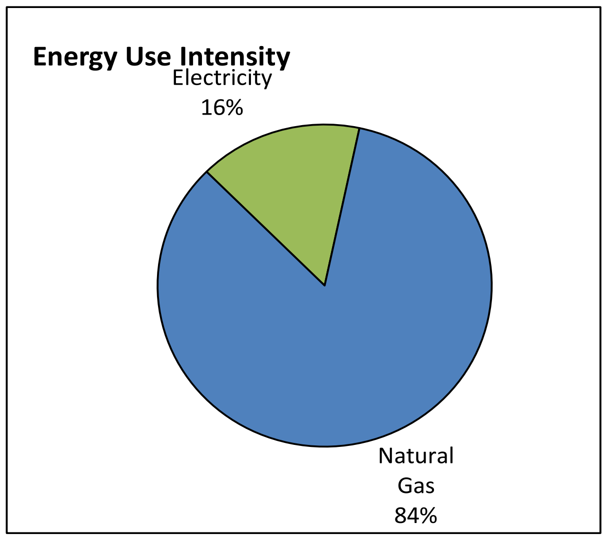
Appendix B

Energy Use and Cost Summary

Energy		Units Used		BTU/unit	mmBTU	% of total	kBtu/sq.ft./year
	Electricity	81,440	kwh	3,412	278	16%	12.1
	Natural Gas	14,759	therm	100,000	1,476	84%	64.2
	Total				1,754		76.3

Cost		Energy Cost	Unit Costs		% of total	$/sq.ft./year
	Electricity	$ 7,221	$ 0.089	kwh	35%	$ 0.31
	Natural Gas	$ 13,664	$ 0.905	therm	65%	$ 0.59
	Total	$ 20,885				$ 0.91





Energy Cost Index $ 0.91 /sf/yr. **Energy Use Intensity 76.3 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 Groton - Municipal Building

Gross Area:	23,000	s.f.
	12,081	Btu/s.f./Yr
	$ 0.31	/s.f.

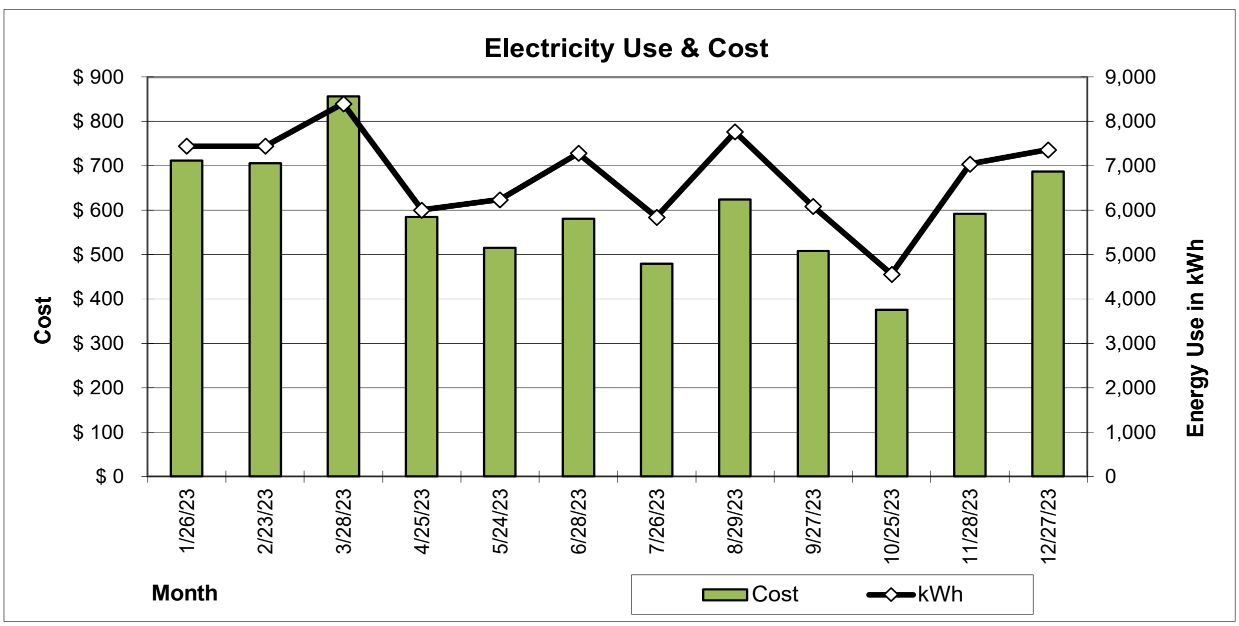
Utility:	Village of Groton		
Account #	ends w/ 30-0		
Rate:	SC		
Meter Charge:		$ 0.00	/ month
Demand Charge:		$ 0.00	/ kW
Supplier:			

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
1/26/23	30	7,440				$ 712	$ 0	$ 0.096	N/A	248
2/23/23	28	7,440				$ 706	$ 0	$ 0.095	N/A	266
3/28/23	33	8,400				$ 856	$ 0	$ 0.102	N/A	255
4/25/23	28	6,000				$ 585	$ 0	$ 0.097	N/A	214
5/24/23	29	6,240				$ 515	$ 0	$ 0.083	N/A	215
6/28/23	35	7,280				$ 581	$ 0	$ 0.080	N/A	208
7/26/23	28	5,840				$ 480	$ 0	$ 0.082	N/A	209
8/29/23	34	7,760				$ 624	$ 0	$ 0.080	N/A	228
9/27/23	29	6,080				$ 508	$ 0	$ 0.084	N/A	210
10/25/23	28	4,560				$ 375	$ 0	$ 0.082	N/A	163
11/28/23	34	7,040				$ 592	$ 0	$ 0.084	N/A	207
12/27/23	29	7,360				$ 687	$ 0	$ 0.093	N/A	254
	365	**81,440**				**$ 7,221**	**$ 0**	**$ 0.089**	**N/A**	**223**

Annual Energy:	**81,440**	**kWh / year**	**$ 7,221**	**/year**
Peak Demand:		**kW Peak**		
Average Demand:		**kW**		

Unit Costs

Demand		**$/kW**
Energy	**$ 0.089**	**$/kWh Incremental**
Blended	**$ 0.089**	**$/kWh Blended**



NATURAL GAS CONSUMPTION AND COST ANALYSIS

Town of Groton - Municipal Building

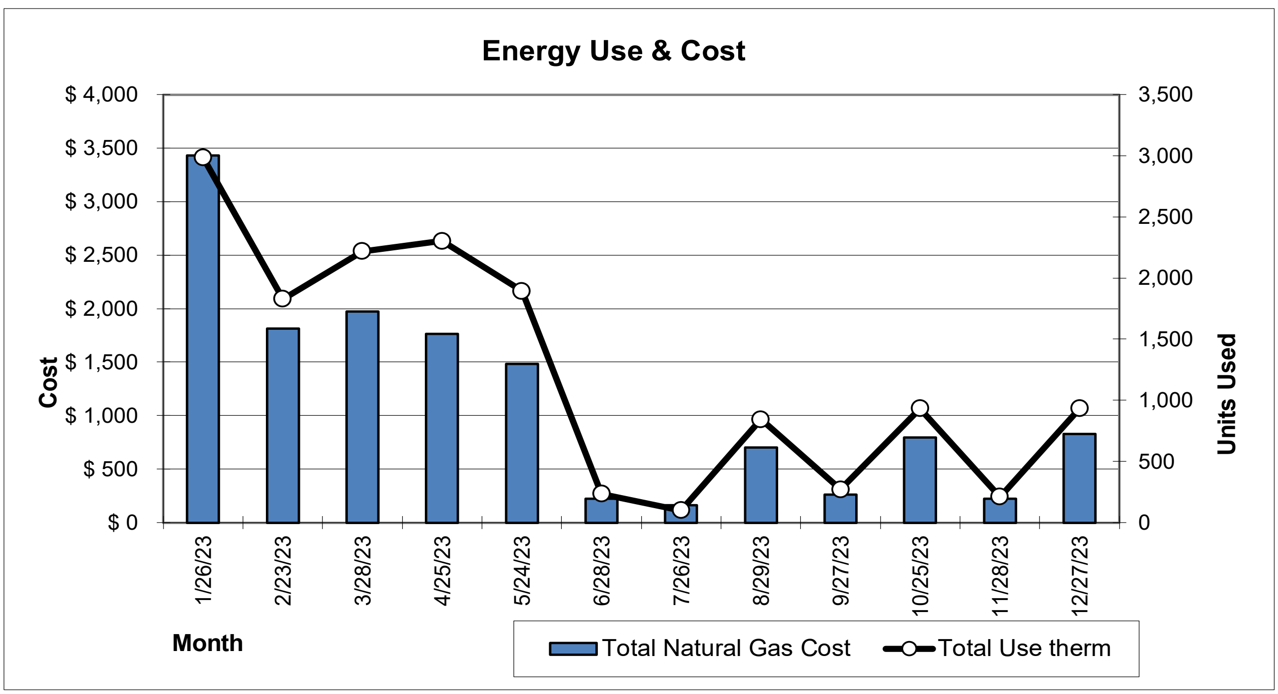
Utility: **NYSEG**
Account # : ends w/ -580,
Rate: SC Non-Residential
Billing unit: therm
BTU/Unit: **100,000**
Meter Charge: **$ 25.60** / month
Supplier: **Direct Energy**

23,000 s.f.
64,170 Btu/s.f./Yr
$ 0.59 /s.f.

Natural Gas
Use & Cost Summary:

Month	#	Utility Charges		Supplier Charges		**Total Use**	**Total Natural**	Average
Ending	Days	therm	Cost	therm	Cost	**therm**	**Gas Cost**	$/therm
1/26/23	30	2,987	$ 925	2,987	$ 2,504	2,987	$ 3,429	$ 1.14
2/23/23	28	1,829	$ 621	1,829	$ 1,193	1,829	$ 1,814	$ 0.98
3/28/23	33	2,219	$ 830	2,219	$ 1,146	2,219	$ 1,975	$ 0.88
4/25/23	28	2,302	$ 737	2,302	$ 1,029	2,302	$ 1,766	$ 0.76
5/24/23	29	1,895	$ 688	1,895	$ 794	1,895	$ 1,482	$ 0.77
6/28/23	35	235	$ 127	235	$ 99	235	$ 225	$ 0.85
7/26/23	28	101	$ 118	101	$ 42	101	$ 160	$ 1.34
8/29/23	34	844	$ 330	844	$ 373	844	$ 703	$ 0.80
9/27/23	29	271	$ 142	271	$ 118	271	$ 260	$ 0.87
10/25/23	28	933	$ 382	933	$ 415	933	$ 797	$ 0.83
11/28/23	34	211	$ 121	211	$ 100	211	$ 222	$ 0.93
12/27/23	29	933	$ 387	933	$ 444	933	$ 830	$ 0.86
	365	**14,759**	**$ 5,407**	**14,759**	**$ 8,257**	**14,759**	**$ 13,664**	$ 0.90

Annual Natural Gas Cost	**$ 13,664**	**/year**		
Annual Natural Gas Consumption	**14,759**	**therm**		
Average Unit Cost per therm:	**$ 0.905**		**$ 9.05**	**/ mmBtu**



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 Groton - Municipal Building**

Type:	Units:	Unit cost:	BTU/unit	
Natural Gas	therm	$ 0.905	100,000	
Electricity	kwh	$ 0.089	3,412	
Demand	kW	$ 0.00	12	Months of demand savings/year

15% of building is air conditioned

HVAC Adjustment Factors		
Cooling	Demand	Fuel
HVACc	HVACd	HVACg

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
Court	9	4' 34w T12 Std. Mag. ba	2	80	No Change	0%	400	400	0	New LED Fixture	9	4' LED fixture 4500 lu. 4	1		42	$ 1,404	$ 12	137	115.3	0.7	0.4	0.3	288	151	0	137
Court	17	13w CFL Quad Elec. bal	1	15	No Change	0%	400	400	0	LED Relamp	17	A19 LED, 9W	1		9	$ 61	$ 4	41	16.9	0.3	0.2	0.1	102	61	0	41
Court	11	13w CFL Quad Elec. bal	2	28	No Change	0%	400	400	0	LED Relamp	11	A19 LED, 9W	2		18	$ 79	$ 4	44	20.2	0.3	0.2	0.1	123	79	0	44
Juror	4	4' 32w T8 Elec. bal.	3	89	No Change	0%	400	400	0	New LED Fixture	4	4' LED fixture 4500 lu. 4	1		42	$ 624	$ 7	75	93.2	0.4	0.2	0.2	142	67	0	75
Court Clerk	3	4' 32w T8 Elec. bal.	3	89	Occ. Sensor S	10%	2,000	1,800	1	New LED Fixture	3	4' LED fixture 4500 lu. 4	1		42	$ 558	$ 27	307	20.4	0.3	0.1	0.1	534	227	53	254
Halls	8	4' 32w T8 Elec. bal.	2	59	No Change	0%	2,000	2,000	0	New LED Fixture	8	4' LED fixture 4500 lu. 4	1		42	$ 1,248	$ 24	272	51.6	0.5	0.3	0.1	944	672	0	272
File Storage	4	4' 32w T8 Elec. bal.	2	59	No Change	0%	200	200	0	New LED Fixture	4	4' LED fixture 4500 lu. 4	1		42	$ 624	$ 1	14	515.5	0.2	0.2	0.1	47	34	0	14
Bathrooms	2	4' 32w T8 Elec. bal.	2	59	Remote Occ	25%	1,000	750	1	New LED Fixture	2	4' LED fixture 4500 lu. 4	1		42	$ 552	$ 5	55	112.8	0.1	0.1	0.0	118	63	30	26
Rear Storage	7	4' 34w T12 Std. Mag. ba	2	80	No Change	0%	100	100	0	New LED Fixture	7	4' LED fixture 4500 lu. 4	1		42	$ 1,092	$ 2	27	461.3	0.6	0.3	0.3	56	29	0	27
Codes	3	4' 32w T8 Elec. bal.	3	89	No Change	0%	2,000	2,000	0	New LED Fixture	3	4' LED fixture 4500 lu. 4	1		42	$ 468	$ 25	282	18.6	0.3	0.1	0.1	534	252	0	282
Kitchen	6	4' 32w T8 Elec. bal.	2	59	Remote Occ	10%	2,000	1,800	1	New LED Fixture	6	4' LED fixture 4500 lu. 4	1		42	$ 1,176	$ 23	254	51.9	0.4	0.3	0.1	708	454	71	184
Clerk	6	4' 32w T8 Elec. bal.	2	59	No Change	0%	2,000	2,000	0	New LED Fixture	6	4' LED fixture 4500 lu. 4	1		42	$ 936	$ 18	204	51.6	0.4	0.3	0.1	708	504	0	204
Lobby	2	4' 32w T8 Elec. bal.	2	59	No Change	0%	2,000	2,000	0	New LED Fixture	2	4' LED fixture 4500 lu. 4	1		42	$ 312	$ 6	68	51.6	0.1	0.1	0.0	236	168	0	68
Highway Office	6	60 watt Incandescent	1	60	Occ. Sensor S	10%	2,000	1,800	1	LED Relamp	6	A19 LED, 9W	1		9	$ 112	$ 55	623	2.0	0.4	0.1	0.3	720	97	72	551
Highway Office	2	4' 32w T8 Elec. bal.	3	89	Occ. Sensor S	10%	2,000	1,800	1	New LED Fixture	2	4' LED fixture 4500 lu. 4	1		42	$ 402	$ 18	205	22.1	0.2	0.1	0.1	356	151	36	169
Mechanics Bay	1	4' 34w T12 Std. Mag. ba	2	80	Remote Occ	10%	2,000	1,800	1	New LED Fixture	1	4' LED fixture 4500 lu. 4	1		42	$ 396	$ 8	84	52.7	0.1	0.0	0.0	160	76	16	68
Mechanics Bay	1	8' 60w T12 IS Std. Mag.	2	138	Remote Occ	10%	2,000	1,800	1	New LED Fixture	1	8' LED fixture, 8645 lu.,	1		65	$ 400	$ 14	159	28.2	0.1	0.1	0.1	276	117	28	131
Mechanics Bay	17	4' 54w T5 HLO Elec. bal.	4	234	Remote Occ	10%	2,000	1,800	inc.	LED Relamp	17	4' LED T5HO 3300 lu. 25	4		102	$ 1,026	$ 430	4,835	2.4	4.0	1.7	2.2	7,956	3,121	796	4,039
Breakroom	4	4' 32w T8 Elec. bal.	2	59	Remote Occ	10%	2,000	1,800	1	New LED Fixture	4	4' LED fixture 4500 lu. 4	1		42	$ 864	$ 15	170	57.2	0.2	0.2	0.1	472	302	47	122
Parts Room	4	4' 32w T8 Elec. bal.	2	59	Remote Occ	10%	2,000	1,800	1	New LED Fixture	4	4' LED fixture 4500 lu. 4	1		42	$ 864	$ 15	170	57.2	0.2	0.2	0.1	472	302	47	122
Garage	10	4' 54w T5 HLO Elec. bal.	6	351	Remote Occ	10%	2,000	1,800	4	LED Relamp	10	4' LED T5HO 3300 lu. 25	6		153	$ 1,865	$ 380	4,266	4.9	3.5	1.5	2.0	7,020	2,754	702	3,564
Garage	6	4' 54w T5 HLO Elec. bal.	4	234	Remote Occ	10%	2,000	1,800	2	LED Relamp	6	4' LED T5HO 3300 lu. 25	4		102	$ 842	$ 152	1,706	5.5	1.4	0.6	0.8	2,808	1,102	281	1,426
Garage	8	4' 32w T8 Elec. bal.	2	59	Remote Occ	10%	2,000	1,800	2	New LED Fixture	8	4' LED fixture 4500 lu. 4	1		42	$ 1,728	$ 30	339	57.2	0.5	0.3	0.1	944	605	94	245
	141			15.0	kW existing				17		141			7.4	kW proposed					15.0	7.4	7.6	25,725	11,389	2,272	12,064
																									14,336	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	67		9,664	5.5	$ 2,455	$ 860	2.9	Screw-in or Socket based LED lamps
EEM-1G	New LED Fixture	74		2,400	2.0	$ 11,548	$ 214	54.1	New LED fixture for surface mounting
EEM-1M	Occ. Sensor Switch	3	161			$ 270	$ 14	18.8	Wall Mounted Occupancy Sensor
EEM-1O	Remote Occ Sensor	14	2,111			$ 3,360	$ 188	17.9	Remote Mounted Occupancy Sensor
		141	2,272	12,064	7.6	$ 17,632	$ 1,276		

Gross Energy Savings	14,336	kwh			
Net Energy Savings	**14,336**	**kwh**	**7.6**	**0 therm**	**$ 1,276 net**

PAYBACK PERIOD:

Estimated Cost Interior Lighting: $ 17,632 = 13.8 year payback

Annual Energy Savings (kWh + kW): $ 1,276

CALCULATIONS TO IMPROVE TEMPERATURE CONTROL

EEM-2 **Town of Groton - Municipal Building**

INPUT DATA:		100%	of Building to be Setback		
			Current	Proposed	
Heating T Setpoint:	Occupied		70	70	deg. F.
	Unoccupied		70	65	deg. F.
Cooling T Setpoint:	Occupied		74	74	deg. F.
	Unoccupied		77	77	deg. F.
HVAC Schedule	Occupied		40.0	40.0	Hours per week
	Unoccupied		128.0	128.0	Hours per week
Q internal gains:	Occupied		21,281	21,281	Btuh
	Unoccupied		4,720	4,720	Btuh
Q internal gains:	Schedule		40	40	Hours per week
BLC:	Occupied		6,970	6,970	Btuh/deg. F.
(excludes DOAS)	Unoccupied		4,973	4,973	Btuh/deg. F.
	Fuel Data		Heating		
	Type:		Natural Gas		
	Units:		therm		
	Unit cost:		$ 0.905		
	BTU/unit		100,000		
	Efficiency/ COP:		78.6%		

CALCULATIONS:

Current — Binghamton, 40 hrs./week

Bin Mid Pt.	Occupied Hours	Unoccupied Hours	Occ Net Heat Loss BTUH	Unocc Net Heat Loss BTUH	Heating Fuel Use therm
(7.5)	0	6	518,901	380,681	29
(2.5)	2	17	484,050	355,816	89
2.5	5	44	449,200	330,951	214
7.5	6	98	414,349	306,087	413
12.5	24	169	379,499	281,222	721
17.5	82	341	344,648	256,358	1,472
22.5	128	323	309,798	231,493	1,456
27.5	80	384	274,947	206,629	1,290
32.5	203	635	240,097	181,764	2,089
37.5	158	636	205,247	156,899	1,683
42.5	123	533	170,396	132,035	1,162
47.5	199	619	135,546	107,170	1,188
52.5	160	446	100,695	82,306	672
57.5	165	702	65,845	57,441	651
62.5	228	774	30,994	32,576	411
67.5	147	448	0	7,712	44
	8,760	hours			13,585

Proposed — Binghamton, 40 hrs./week

Bin Mid Pt.	Occupied Hours	Unoccupied Hours	Occ Net Heat Loss BTUH	Unocc Net Heat Loss BTUH	Heating Fuel Use therm
(7.5)	0	6	518,901	355,816	27
(2.5)	2	17	484,050	330,951	84
2.5	5	44	449,200	306,087	200
7.5	6	98	414,349	281,222	382
12.5	24	169	379,499	256,358	667
17.5	82	341	344,648	231,493	1,364
22.5	128	323	309,798	206,629	1,354
27.5	80	384	274,947	181,764	1,168
32.5	203	635	240,097	156,899	1,888
37.5	158	636	205,247	132,035	1,481
42.5	123	533	170,396	107,170	994
47.5	199	619	135,546	82,306	992
52.5	160	446	100,695	57,441	531
57.5	165	702	65,845	32,576	429
62.5	228	774	30,994	7,712	166
	8,760	hours			11,729

	Present	Proposed	Savings	
Heating	13,585	11,729	1,856	therm
Cooling	0	0	0	0
Annual Energy $			$ 1,680	

IMPLEMENTATION COST & PAYBACK PERIOD:

Item	Material $/unit	Labor $/unit	Quantity	Total
Wi-fi thermostat	$ 146	$ 51	4	$ 787
7-day thermostat	$ 97	$ 51		$ 0
				$ 787

Implementation Cost:	$ 787	= 0.5 year payback
Annual Energy Savings:	$1,680	

CALCULATIONS FOR WEATHER-STRIPPING AND CAULKING

EEM-3 **Town of Groton - Municipal Building**

INPUT DATA:

Bldg. Volume	321,993	cubic feet		Present infiltration		
		ACH	Period	Cu. ft./hr.	CFM	btuh/deg.
Baseline infiltration rate		0.60	Occupied	193,196	3,220	3,478
from heat loss study		0.30	Unoccupied	96,598	1,610	1,739
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	1,024	30	5	15,360	2,560	12,800
Fireplace				0	0	0
				15,360	2,560	12,800
Proposed Reductions	Air changes/Hour			Proposed infiltration		
Air changes/hour	% reduction	Proposed	Period	Cu. ft./hr.	CFM	btuh/deg.
	7%	0.56	Occupied	180,396	3,007	3,247
	13%	0.26	Unoccupied	83,798	1,397	1,508
Total Infiltration & Reductior	**Occupied**	**193,196**	**180,396**	**12,800**	cfh savings	
Cu.Ft./hour	**Unoccupied**	**96,598**	**83,798**	**12,800**	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:	70	70	°F
Q internal gains:	21,281	4,720	Btuh
BLC:	6,970	4,973	Btuh/°F
T Balance:	66.9	69.1	°F. T Balance = T Setpoint - (Q internal gains / BLC)
Bin Data for Binghamton, 40 hrs./week			
Accumulated Hours	1,563	6,175	below balance temp.
Avg. OAT	42.4	43.0	°F below balance temp.
(T Set- Avg OAT)	27.6	27.0	°F difference

Type:	Natural Gas	
Units:	therm	
Unit cost:	$ 0.905	/therm
CF1	100,000	Btu/therm
Efficiency:	78.6%	
CF2	0.018	Btu/hr-°F-cfh

	Energy Use - Btu/year			Fuel Use	
	Occupied	Unoccupied	Total	therm / yr	
Baseline infiltration rate	150,237,700	289,760,400	439,998,100	5,600	
Proposed infiltration rate	140,283,900	251,364,800	391,648,700	4,985	
			Total Savings	615	$ 557

IMPLEMENTATION COST & PAYBACK PERIOD:

Item	Matl. & Labor ($ / lin ft)	Quantity (lin ft)	Total	
Weather-stripping	$ 3.00	1,024	$ 3,072	
Caulking			$ 0	
Air Sealing			$ 0	
	Implementation Cost:		$ 3,072	= 5.5 year payback
	Annual Energy Savings:		$ 557	

CALCULATIONS TO INSULATE BUILDING ENVELOPE - GARAGE

EEM-4 Town of Groton - Municipal Building

INPUT DATA:

Surface to be insulated:	Roof	Walls		
Area:	17,725	2,002	sq ft	
Present R value:	10.0	3.7		
Revised R value	38.0	17.7		
Present U factor::	0.100	0.272	Btuh/sq ft-deg F	
Revised U factor:	0.026	0.057	Btuh/sq ft-deg F	
Present U x Area	1,773	544	2,317	UA Total presen
Proposed U x Area	466	113	580	UA Total propos

CALCULATIONS:	Occupied	Unoccupied	**Fuel Data**	Heating
Heating Setpoint:	60	60	Type:	Natural Gas
Cooling Setpoint:			Units:	therm
Q internal gains (Btuh):	21,281	4,720	Unit cost:	$ 0.905
BLC (Btuh/degree F):	6,970	4,973	BTU/unit	100,000
T Balance (°F.):	56.9	59.1	Efficiency/ COP:	78.0%
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 therm
(7.5)	0	6	117,239	117,239	9
(2.5)	2	17	108,555	108,555	26
2.5	5	44	99,870	99,870	63
7.5	6	98	91,186	91,186	122
12.5	24	169	82,502	82,502	204
17.5	82	341	73,817	73,817	400
22.5	128	323	65,133	65,133	377
27.5	80	384	56,448	56,448	336
32.5	203	635	47,764	47,764	513
37.5	158	636	39,080	39,080	398
42.5	123	533	30,395	30,395	256
47.5	199	619	21,711	21,711	228
52.5	160	446	13,027	13,027	101
57.5	165	702	(99,870)	4,342	39
62.5	228	774	(108,555)	(108,555)	0
67.5	147	448	(117,239)	(117,239)	0
	8,760	hours		Energy Savings:	3,071
					$ 2,779

IMPLEMENTATION COST & PAYBACK PERIOD:

Item	Material & Labor ($ / sq ft)	Quantity	Total
Roof	$ 4.00	17,725	$ 70,902
Walls	$ 2.00	2,002	$ 4,004
	$ 0.00	19,727	$ 0

Implementation Cost:	$ 74,906	= 26.9 year payback
Annual Energy Savings:	$ 2,779	

CALCULATIONS TO INSULATE BUILDING ENVELOPE - TOWN OFFICE

EEM-5 **Town of Groton - Municipal Building**

INPUT DATA:

Surface to be insulated:	Roof			
Area:	2,500	sq ft		
Present R value:	14.0			
Revised R value	33.0			
Present U factor::	0.071	Btuh/sq ft-deg F		
Revised U factor:	0.030	Btuh/sq ft-deg F		
Present U x Area	179		179	UA Total present
Proposed U x Area	76		76	UA Total proposed

CALCULATIONS:	Occupied	Unoccupied	**Fuel Data**	Heating	Cooling
Heating Setpoint:	70	70	Type:	Natural Gas	Electricity
Cooling Setpoint:	74	77	Units:	therm	kwh
Q internal gains (Btuh):	21,281	4,720	Unit cost:	$ 0.905	$ 0.089
BLC (Btuh/degree F):	6,970	4,973	BTU/unit	100,000	3,412
T Balance (°F.):	66.9	69.1	Efficiency/ COP:	78.6%	322.4%
T Balance = T Setpoint - (Q internal gains / BLC)			EER:		11.0

Bin Mid-Pt.	Occupied Hours	Unoccupied Hours	Change in Occupied Heat Loss	Change in Unoccupied Heat Loss	Heating Savings therm	Cooling Savings kwh
(7.5)	0	6	7,968	7,968	1	0
(2.5)	2	17	7,454	7,454	2	0
2.5	5	44	6,940	6,940	4	0
7.5	6	98	6,426	6,426	9	0
12.5	24	169	5,912	5,912	15	0
17.5	82	341	5,398	5,398	29	0
22.5	128	323	4,884	4,884	28	0
27.5	80	384	4,370	4,370	26	0
32.5	203	635	3,856	3,856	41	0
37.5	158	636	3,341	3,341	34	0
42.5	123	533	2,827	2,827	24	0
47.5	199	619	2,313	2,313	24	0
52.5	160	446	1,799	1,799	14	0
57.5	165	702	1,285	1,285	14	0
62.5	228	774	771	771	10	0
67.5	147	448	0	257	1	0
72.5	147	231	0	0	0	0
77.5	126	176	(360)	(51)	0	5
82.5	81	67	(874)	(565)	0	10
87.5	21	23	(1,388)	(1,080)	0	5
92.5	3	0	(1,902)	(1,594)	0	1
97.5	0	0	(2,416)	(2,108)	0	0
102.5	0	0	(2,930)	(2,622)	0	0
107.5	0	0	(3,444)	(3,136)	0	0
	8,760	hours		Energy Savings:	275	20
					$ 249	$ 2

IMPLEMENTATION COST & PAYBACK PERIOD:

Item	Material & Labor ($ / sq ft)	Quantity	Total
Roof	$ 3.00	2,500	$ 7,500
			$ 0
			$ 0

Implementation Cost:	$ 7,500	= 30 year payback
Annual Energy Savings:	$ 250	

CALCULATIONS TO INSTALL INSULATED DOORS

EEM-6 Town of Groton - Municipal Building

INPUT DATA:

Type & Qty.	Garage			
	Present	Proposed		
Area:	40	sq ft total		
Perimeter:	38	38		
Infilt. rate:	40	5		
R value:	3.0	6.0		
U factor:	0.333	0.167		
U x Area	13	7		

	Present	Proposed	Change	
Total UA	13	7	7	Btuh/deg F
Infiltration Load	14	2	12	Btuh/deg F
	27	8	19	Btuh/deg F

CALCULATIONS:

	Occupied	Unoccupied	Fuel Data	Heating
Heating Setpoint:	70	70	Type:	Natural Gas
Cooling Setpoint:	74	77	Units:	therm
Q internal gains (Btuh):	21,281	4,720	Unit cost:	$ 0.905
BLC (Btuh/degree F):	6,970	4,973	BTU/unit	100,000
T Balance (°F.):	66.9	69.1	Efficiency/ COP:	78.6%
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 therm
(7.5)	0	6	1,447	1,447	0
(2.5)	2	17	1,353	1,353	0
2.5	5	44	1,260	1,260	1
7.5	6	98	1,167	1,167	2
12.5	24	169	1,073	1,073	3
17.5	82	341	980	980	5
22.5	128	323	887	887	5
27.5	80	384	793	793	5
32.5	203	635	700	700	7
37.5	158	636	607	607	6
42.5	123	533	513	513	4
47.5	199	619	420	420	4
52.5	160	446	327	327	3
57.5	165	702	233	233	3
62.5	228	774	140	140	2
67.5	147	448	0	47	0
	8,760	hours		Energy Savings:	50
					$ 45

IMPLEMENTATION COST & PAYBACK PERIOD:

Item	Material & Labor ($ / each)	Quantity	Total
Garage	$ 1,000	2	$ 1,905
			$ 0
			$ 0

Implementation Cost:	$ 1,905	= 42.2 year payback
Annual Energy Savings:	$ 45	

CALCULATIONS TO INSTALL DOUBLE GLAZING

EEM-7 Town of Groton - Municipal Building

Type:	Natural Gas
Units:	**therm**
Unit cost:	**$ 0.905** /therm
Heat Content of Fuel	**100,000** Btu/therm
Combustion Efficiency:	79%

DATA:

	Occupied	Unoccupied	
T Setpoint:	**70**	**70**	degrees F
Q internal gains:	**21,281**	**4,720**	Btuh
BLC:	**6,970**	**4,973**	Btuh/degree F
T Balance:	66.9	69.1	degrees F

T Balance = T Setpoint - (Q internal gains / BLC)

Glazing Information

			Glazing 2	
Present Conditions			Single glazed windows	
Present Area:			**288**	sq ft
U factor:			**1.00**	Btuh/sq ft-deg F
Crack Length:			96	feet
Present Infiltration:			40	cfh
Proposed Condition			Double glazed casement windows	
Proposed Area:			**288**	sq ft
New U factor:			0.50	Btuh/sq ft-deg F
New Crack Length:			96	feet
Proposed Infiltration:			5	cfh

Bin Data for Binghamton, 40 hrs./week

	T Setpoint	T Balance	Accum Hours	Average O.A. Temp below T Balance	Temp Difference (T Set- Avg OAT)
Occupied	70	66.9	**1,563**	**42.4**	27.6
Unoccupied	70	69.1	**6,175**	**43.0**	27.0

CALCULATIONS:

Conduction Savings = (AreaPr x Upr) - (AreaRev x Urev + AreaInfill x Uinfill) x Accum Hours x Temp Diffe

Infiltration Savings = 1/2 x 0.018 x {(LengthPr x Ipr) - (Length Rev x Irev)} x Accum Hours x Temp Differen

Energy Cost Savings = (Energy Savings / Conversion Factor) x (Unit cost / Efficiency)

Winter	Conduction Savings (Btu/year)	Infiltration Savings (Btu/year)	Total Savings (Btu/year)	Total Annual Fuel Savings (therm/year)	Energy Cost Savings ($/year)
Occupied	6,221,000	1,306,000	7,527,000	96	$ 87
Unoccupied	23,997,000	5,039,000	29,036,000	370	$ 334
Annual Savings:	30,218,000	6,345,000	36,563,000	465	$ 421

IMPLEMENTATION COST & PAYBACK PERIOD:

Item	Material & Labor $ / sq. ft.	Quantity	Total	
		0	$ 0	
	$ 80	288	$ 23,040	
	Implementation Cost:		$ 23,040	= 54.7 year payback
	Annual Energy Savings:		$ 421	

CALCULATIONS TO INSULATE HEATING AND DOMESTIC HOT WATER PIPES

EEM-8 Town of Groton - Municipal Building

Input Data

	Type:	Units:	Unit cost:	BTU/unit	Efficiency
Fuel Information					
Heating System	Natural Gas	therm	$ 0.905	100,000	79%
DHW System	Natural Gas	therm	$ 0.905	100,000	80%

		Type #1	Type #2			
Fluid		Hot Water	DHW			
Pipe Material		Dull Copper	Dull Copper			
O.D., inches (d)		1.00	0.75			
Total Length, ft		12	8			
Fluid Temperature Inside Pipe, °F (Ts)		160	110			
Ambient Temperature, °F (Ta)		65	65			
Annual Operating Hours		1,885	8,760			
New Insulation Thickness, inches		1.0	1.0			
Thermal Conductivity - "k" (Btu-in/hr-sq ft-°F)		0.270	0.250			
Heat Loss - Bare Pipe						
C factor		1.016	1.016			
emissivity based on pipe material		0.44	0.44			
Outside Radius Pipe, inches (Ri)		0.50	0.38			
h convection, Btu/hr - s.f. pipe surface area -°F		1.45	1.32			
h radiation, Btu/hr - s.f. pipe surface area - °F		0.57	0.50			
h total		2.02	1.81			
Pipe area, sq ft/lin ft of pipe		0.262	0.196			
Q bare, Btu/hr-lin ft		**50**	**16**			
Heat Loss - Insulated Pipe						
Outside Radius Insulation, inches (Rs)		1.50	1.38			
Q i, Btu/hr-sq ft of outer area of insulation		15.6	6.3			
Insulation Area - sq ft/lin ft of pipe		0.8	0.7			
Q insul, Btu/hr-lin ft		**12.2**	**4.5**			
Avoided Energy Loss						
Existing Loss - mmBtu/year		1.1	1.1			
Proposed Loss - mmBtu/year		0.3	0.3			
Avoided Loss - mmBtu/year		0.9	0.8			
Annual Fuel Consumption	existing	14	14			
	proposed	3	4			
21	Units Saved	11	10			
Natural Gas	Fuel Type	Natural Gas	Natural Gas			
$ 19	$/year	**$ 10**	**$ 9**			

Formulae:

Based on ASHRAE 1993 Fundamentals Handbook pages 20.9 and 22.17

h convection = C x {(1 / d) ^ 0.2} x { (1 / ((Ts + Ta)/2)) ^ 0.181 } x { (Ts - Ta) ^ 0.266 }

h radiation = { emissivity x 0.1713 x 10 ^ -8 x [(Ta + 460) ^ 4 - (Ts +460) ^ 4]} / (Ta - Ts)

Q bare = h total x Pipe Area x (Ts - Ta)

Q i = (Ts - Ta) / { [Rs x (ln (Rs / Ri)] / k }

Q insul = Q i x Insul Area

Total Avoided Consumption = (Q bare - Q insul) x Total length of pipe x Annual Operating Hours

Payback Period:

Implementation Cost:	$ 145	= 7.7 years payback
Annual Energy Savings:	$ 19	

CALCULATIONS TO INSTALL A TANKLESS WATER HEATER

EEM-9 Town of Groton - Municipal Building

INPUT DATA:					
		Present Fuel		Proposed Fuel	
	Fuel:	**Natural Gas**		Electricity	
	Units:	therm		kwh	
	Fuel Cost:	$ 0.91	per therm	$ 0.09	per kwh
	BTU / unit:	100,000	Btu per therm	3,412	Btu per kwh
Annual DHW Consumption:		Present		Proposed	
	Hot Water Usage:	**0.5**	Gallons/person	0.5	Gallons/person
	Number of persons:	**10**	(estimate)	10	(estimate)
	Days of Usage:	**250**	per year	250	per year
	Hours of Usage per Day:	8	hours	8	hours
	Average inlet water Temp	53	degrees F	53	degrees F
	Average hot water temp:	125	degrees F	125	degrees F
Storage Tank Losses:		Present Tank		Proposed Tank	
	Tank U factor:	0.08	Btu/SF/Hour	0.08	Btu/SF/Hour
	Height of Tank:	56.5	inches	20.0	inches
	Diameter of Tank:	22.0	inches	10.0	inches
		75	gallons/tank	4	gallons/tank
	# of Tanks	1	Qty.	1	Qty.
	Hours Tank is Hot:	8,760	Hours	8,760	
	Water Temperature:	125	Deg. F.	125	
	Ambient Temperature:	65	Deg. F.	65	
Recirculation Losses:		0.0%	of boiler capacity =	0	BTUh
		0	hours/year	8,760	hours/year =
Boiler Jacket & Flue Losses:					
	Burner Input	75,000	BTUH	5,631	BTUH
	COP:	**0.80**		0.99	COP
	Boiler Output Capacity	60,000	BTU output	5,575	BTU output
	Jacket & Flue Losses:		of boiler capacity	0.0%	of boiler capacity
	Boiler is Hot:	8,760	hours/year	8,760	hours/year =
CALCULATIONS:					
		Present		Proposed	
	Consumption Energy:	753,120	BTU output rqd/yr	753,120	BTU output rqd/yr
	Tank Energy Losses:	1,418,750	BTU/year	238,847	BTU/year
	Recirculation Losses:	0	BTU/year	0	BTU/year
	Boiler Jacket Losses:	0	BTU/year	0	BTU/year
	Output BTU/Year	2,171,871		991,967	
	Annual Fuel Consumption	27	therm	294	kwh
	Demand	0	billed kW /yr.	1	kW
	Annual Fuel Cost	$ 25		$ 26	
	Annual Savings:	**27**	**therm**	**($ 2)**	**per year**
		(294)	**kwh**		
		(1)	billed kW /yr.		
IMPLEMENTATION COST & PAYBACK PERIOD:					
Item		Quantity	Matl. & Labor Cost	Total	
		1	$ 450	$ 450	
		Implementation Cost:		**$ 450**	= **-287.2 year pa**
		Annual Energy Savings:		**($ 2)**	

CALCULATIONS TO INSTALL CLEAN HEATING SYSTEM - AIR SOURCE HEAT PUMP

BE-1	**Town of Groton - Municipal Building**					
			Fuel Information			
Building Information	Small Office			Heating	Cooling	
Location	Binghamton	Climate Zone 6	Type:	Natural Gas	Electricity	
Portion of Building HP will serve:	15%		Units:	therm	kwh	
Building Heating Load (BHL)	180,000	BTU/h	Unit cost:	$ 0.905	$ 0.089	/kwh
Building Cooling Load (BCL)	135,000	BTU/h	BTU/unit	100,000	3,412	/kwh
BEFLHheating	890	Hours	Heating Eff.	79%	$ 0.00	/kW
BEFLHcooling	756	Hours	CO2	11.72	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, 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	180,000	BTU/h at 5°F	1.0	HP Sizing Ratio		
Energy Efficiency Ratio	15.0	EERee				
Seasonal Energy Efficiency Ratio	19.0	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	11.7	18.2	EERseason,ee	-0.140	c	cooling offset
EERbaseline	11.0	15.0	EERee	0.966	d	cooling slope
COPseason,baseline	1.00	2.58	COPseason,ee	-0.003	a	heating offset
FElecHeat	0.00	1.00	FElecHeat,new	0.879	b	heating slope
EFFbaseline	0.79	1.00	Fload,cooling			
FFuelHeat	1.00	1.00	Fload,heating			
		1.00	Fload,heating,FuelHeat		0.69	CF
		1.00	Fload,heating,ElecHeat			
					Savings	Savings
	Baseline	Energy Efficient	Savings	Units	$	CO2 Lbs/yr.
Cooling Electric Use (kWh/yr.)	8,720	5,601	3,119	kWh		
Heating Electric Use (kWh/yr.)	0	18,224	(18,224)	kWh		
Total Electric Use (kWh/yr.)	**8,720**	**23,825**	**(15,105)**	**kWh**	**($ 1,344)**	**(17,522)**
Peak Demand (kW)	8.5	6.2	2.3	kW	$ 0	
Fossil Fuel Energy Use (MMBTU)	204	0	204	MMBtu		
Fossil Fuel Energy Use : therm	**2,038**	**0**	**2,038**	**therm**	**$ 1,844**	**23,885**
Annual Energy Costs	**$ 2,620**	**$ 2,120**	**$ 500**		$ 500	6,364
Estimated Project Cost	**$ 3,517**	**per ton =**	**$ 52,753**	**105**	**year payback**	

CALCULATIONS TO INSTALL CLEAN HEATING SYSTEM - GROUND SOURCE HEAT PUMP

BE-2	**Town of Groton - Municipal Building**					
			Fuel Information			
Building Information	Small Office			Heating	Cooling	
Location	Binghamton	Climate Zone 6	Type:	Natural Gas	Electricity	
Portion of Building HP will serve:	15%		Units:	therm	kwh	
Building Heating Load (BHL)	180,000	BTU/h	Unit cost:	$ 0.905	$ 0.089	/kwh
Building Cooling Load (BCL)	135,000	BTU/h	BTU/unit	100,000	3,412	/kwh
BEFLHheating	890	Hours	Heating Eff.	79%	$ 0.00	/kW
BEFLHcooling	756	Hours	CO2	11.72	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	Variable-Speed	0.40	Capacity Ratio			
Estimated Pump Power	60 watts per ton					
Pumping Control Strategy	Variable					
Heating Capacity	180,000	BTU	rating condition			
Energy Efficiency Ratio Full Load	18.0	EER GLHP,full	77	° EWT		
Energy Efficiency Ratio Part Load	25.0	EER GLHP,par	68	° EWT		
Heating COP Full Load	4.0	COP GLHP,full	32	° EWT		
Heating COP Part Load	4.5	COP GLHP,pai	41	° EWT		
Adjusted Efficiency Values	Baseline	Energy Efficient				
EERseason,baseline	11.7	20.72	EERseason,ee			
EERpeak,baseline	11.0	18.0	EER GSHP, full,ee			
COPseason,baseline	1.00	3.97	COPseason,ee			
FElecHeat	0.00					
EFFbaseline	0.80	0.69	CF			
FFuelHeat	1.00					
					Savings	Savings
	Baseline	Energy Efficient	Savings	Units	$	CO2 Lbs/yr.
Cooling Electric Use (kWh/yr.)	8,720	4,924	3,796	kWh		
Heating Electric Use (kWh/yr.)	0	11,830	(11,830)	kWh		
Total Electric Use (kWh/yr.)	**8,720**	**16,754**	**(8,034)**	**kWh**	**($ 715)**	**(9,319)**
Peak Demand (kW)	8.5	5.2	3.3	kW	$ 0	
Fossil Fuel Energy Use (MMBTU)	200	0	200	MMBtu		
Fossil Fuel Energy Use : therm	**2,002**	**0**	**2,002**	**therm**	**$ 1,811**	**23,459**
Annual Energy Costs	**$ 2,588**	**$ 1,491**	**$ 1,096**		$ 1,096	14,140
Estimated Project Cost	**$ 9,112**	**per ton =**	**$ 136,683**	**125**	**year payback**	

Appendix D

Assumptions/Data Used to Develop Energy and Dollar Savings Figures

Building and Occupancy Information

Floor Area: 23,000 square feet

	Avg. # of occupants	Heating Setpoint	Cooling Setpoint	% of base electricity use resulting in internal heat gains	
days /occupied	10	70	74	days	25%
nights/unoccupied	0	70	77	nights	25%
# of computer	10				

Interior lighting, people and occupied levels of internal loads occur for 40 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 N/A of the peak metered kW)

Heating System Information

		% of bldg. served	COP heat	EER	Heat kBTUH	Heating Fuel	Efficiency	
Primary system:	Non-Condensing Boiler	23%	0.81	11.00	525	Natural Gas	80.7%	Et
Secondary:	Forced Air	77%	0.79	11.00	1,763	Natural Gas	78.7%	Et

15% 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 ___ heat recovery efficiency

Domestic Hot Water

	Fuel	Efficiency	
DHW system energy type	Natural Gas	80%	Is there a pump to circulate DHW? No

Hot Water usage is 0.5 gallons per person / day for 10 persons on 250 days/year

Weather & Schedule Information:

Select nearest weather station for bin data:	BINGHAMTON	for TRM:	Binghamton
Base temperature for heating degree days:	65 °F. yields 7,180 HDD base65	for TRM:	Auto Repair
Base temperature for cooling degree days:	70 °F. yields 234 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	8:00 AM	4:00 PM	8.0
Tue	3	8:00 AM	4:00 PM	8.0
Wed	4	8:00 AM	4:00 PM	8.0
Thu	5	8:00 AM	4:00 PM	8.0
Fri	6	8:00 AM	4:00 PM	8.0
Sat	7	12:00 AM	12:00 AM	-
Binghamton, 40 hrs./week				40.0
				128.0

Proposed Schedule for Occupied/Day HVAC setpoints

Day of week	Start	End	Hours
1	12:00 AM	12:00 AM	-
2	8:00 AM	4:00 PM	8.0
3	8:00 AM	4:00 PM	8.0
4	8:00 AM	4:00 PM	8.0
5	8:00 AM	4:00 PM	8.0
6	8:00 AM	4:00 PM	8.0
7	12:00 AM	12:00 AM	-
Binghamton, 40 hrs./week			40.0

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

Town of Groton - Municipal Building
101 Conger Boulevard
Groton, NY 13073

Building Information

Width (typical)	90	feet	Building Floor Area	23,000	sq. ft.
Equivalent Length	256	feet	Roof Area	23,000	sq. ft.
Number of Floors	1.0	floors	Gross Wall Area	9,675	sq. ft.
Avg. Floor to Floor Height	14	feet per floor	Building Volume	321,993	cubic feet
Roof or Ceiling rise is	0	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		23,000	21.1	0.047	1,092	16%
Walls	47.4%	of GWA	4,587	3.7	0.272	1,247	19%
Glazing 1	6.2%	of GWA	600	2.0	0.500	300	4%
Glazing 2	3.0%	of GWA	288	1.0	1.000	288	4%
Entry Doors	8	3x7 doors	168	3.0	0.333	56	1%
Overhead Do	16	14'x18'	4,032	16.0	0.063	252	4%
		Total Exterior Surface Area	32,675	sq.ft.		3,234	48%

		ACH	equiv. cfm	Btuh/deg. F.	BLC (without ventilation)	
Est. Infiltration Rate	Occupied	0.60	3,220	3,478	6,376	Btuh/deg. F. Occupied
Est. Infiltration Rate	Unoccupied	0.30	1,610	1,739	4,973	Btuh/deg. F. Unoccupied

		cfm	Fraction	Btuh/deg. F.	**Total BLC with Ventilation**	
Est. Ventilation Rate	Occupied	1,100	50%	594	**6,970**	**Btuh/deg. F. Occupied**
Est. Ventilation Rate	Unoccupied		100%	0	**4,973**	**Btuh/deg. F. Unoccupied**

Heat Gain Estimation

Estimated Solar Gain 5% of building heat loss during occupied periods will be met by solar gains

		kW	# People	Total BTUH	Hours/wk.
Loads & People	Occupied	**5.5**	**10**	21,281	40.0
	Unoccupied	**1.4**	**0**	4,720	128.0

Heat Loss Study - continued

Town of Groton - Municipal Building
101 Conger Boulevard
Groton, NY 13073

		Current	
Heating T Setpoint:	Occupied	70	deg. F.
	Unoccupied	70	deg. F.
Cooling T Setpoint:	Occupied	74	deg. F.
	Unoccupied	77	deg. F.
HVAC Schedule	Occupied	40	Hrs. per week
	Unoccupied	128	Hrs. per week
Q internal gains:	Occupied	21,281	Btuh
	Unoccupied	4,720	Btuh
Q internal gains:	Schedule	40	Hrs. per week
BLC:	Occupied	6,970	Btuh/deg. F.
	Unoccupied	4,973	Btuh/deg. F.

Fuel Data	Heating	Cooling	
Type:	Natural Gas	Electricity	Economizer?
Units:	therm	kwh	No
Unit cost:	$ 0.905	$ 0.089	
BTU/unit	100,000	3,412	
Nom. Eff, COP	0.792	3.224	COP
Avg. Eff, COP	0.786	3.22	Avg. COP
		11.0	Avg. EER
		15%	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 — Binghamton, 40 hrs./week

Bin Mid Pt.	Occupied Hours	Unoccupied Hours	Occ Net Heat Loss BTUH	Unocc Net Heat Loss BTUH	Heating Fuel Use therm	Cooling Energy kwh	DOAS Hours	DOAS Heating kBtu/yr.
(7.5)	0	6	518,901	380,681	29	0	0	0
(2.5)	2	17	484,050	355,816	89	0	0	0
2.5	5	44	449,200	330,951	214	0	0	0
7.5	6	98	414,349	306,087	413	0	0	0
12.5	24	169	379,499	281,222	721	0	0	0
17.5	82	341	344,648	256,358	1,472	0	0	0
22.5	128	323	309,798	231,493	1,456	0	0	0
27.5	80	384	274,947	206,629	1,290	0	0	0
32.5	203	635	240,097	181,764	2,089	0	0	0
37.5	158	636	205,247	156,899	1,683	0	0	0
42.5	123	533	170,396	132,035	1,162	0	0	0
47.5	199	619	135,546	107,170	1,188	0	0	0
52.5	160	446	100,695	82,306	672	0	0	0
57.5	165	702	65,845	57,441	651	0	0	0
62.5	228	774	30,994	32,576	411	0	0	0
67.5	147	448	0	7,712	44	0	0	0
72.5	147	231	(18,725)	(8,589)	0	65	0	0
77.5	126	176	(64,445)	(20,438)	0	161	0	0
82.5	81	67	(126,907)	(57,094)	0	194	0	0
87.5	21	23	(202,754)	(99,467)	0	90	0	0
92.5	3	0	(259,966)	(133,881)	0	11	0	0
97.5	0	0	(185,079)	(106,665)	0	0	0	0
102.5	0	0	(219,929)	(131,530)	0	0	0	0
107.5	0	0	(254,780)	(156,394)	0	0	0	0
	8,760	hours			13,585	521	DOAS fuel use	0
							DOAS cool use	0

Cross Check Against Historic Consumption

	Historic		Calculated	Difference
Present Annual Heating Fuel Use is	1,355	mmBTU	1,359	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.

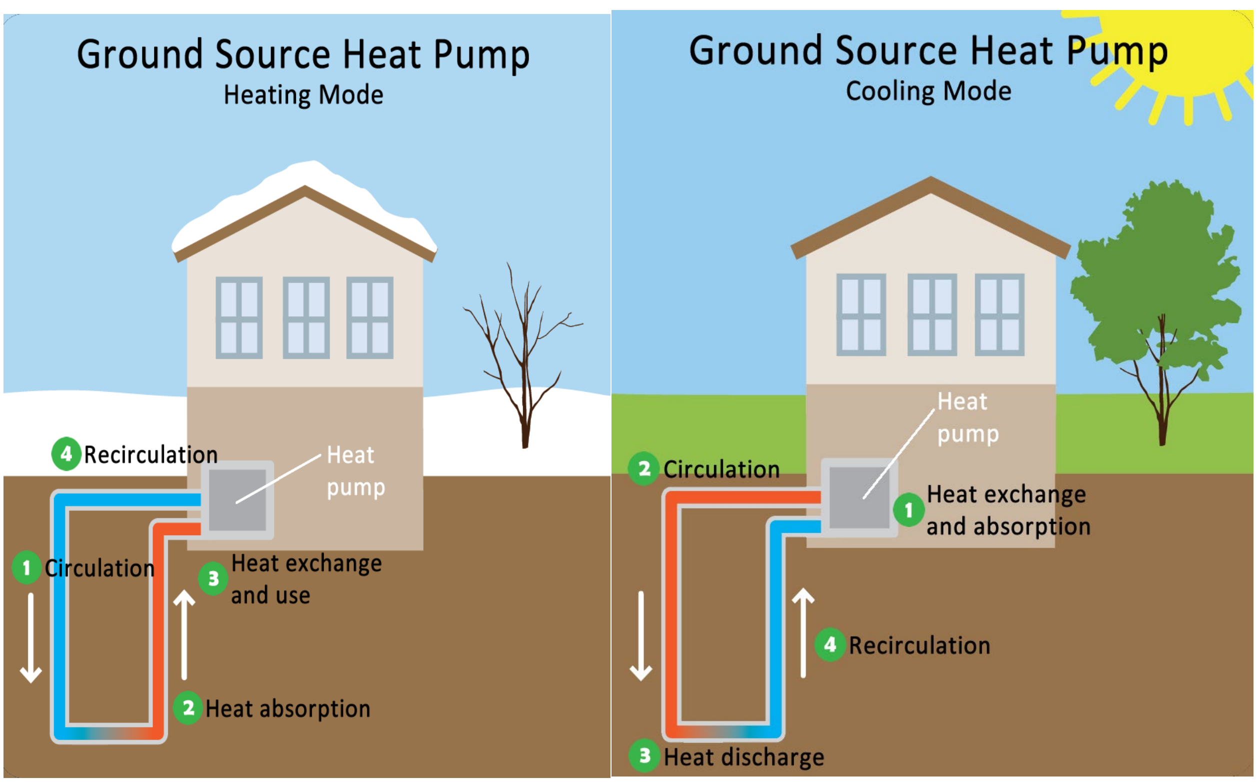
TYPES OF CLEAN HEATING AND COOLING (CHC) TECHNOLOGIES

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).

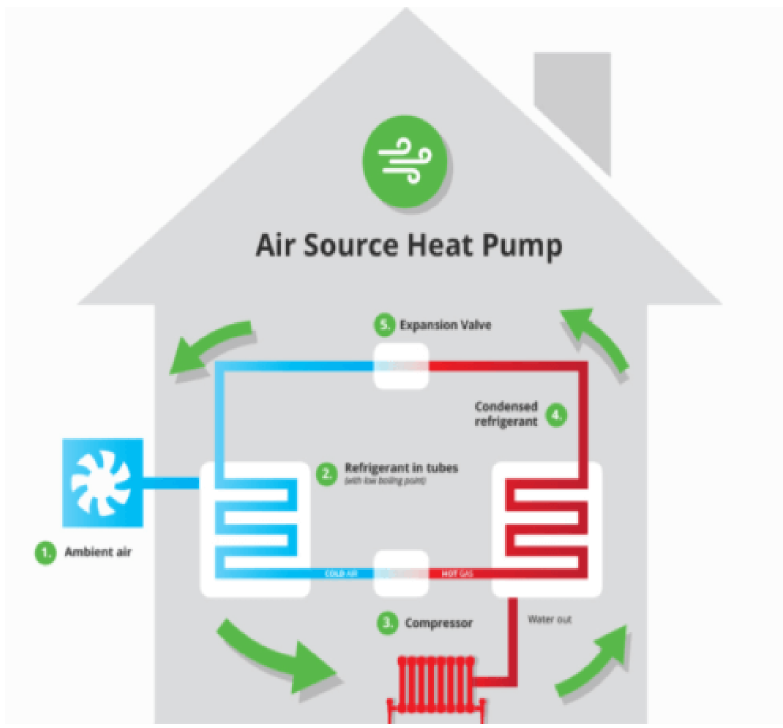
The system reverses during cooling, where the energy is absorbed by the ground loop.



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

What is an Air Source Heat Pump (ASHP)?

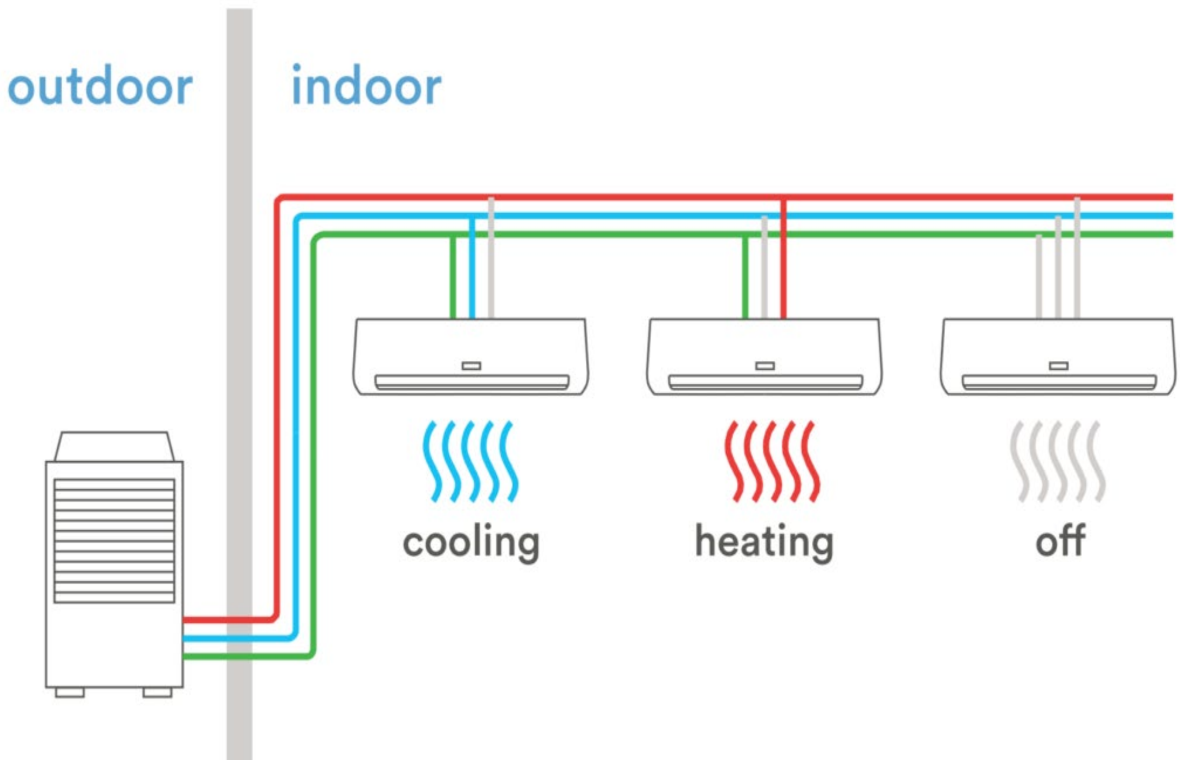
An air source heat pump works much like a refrigerator operating in reverse. Outside air is blown over a network of tubes filled with a refrigerant. This warms up the refrigerant, and it turns from a liquid into a gas. This gas passes through a compressor, which increases the pressure. Compression also 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	16,630	14,336	7.6	$ 1,276		0.0	$ 0	$ 1,276	$ 17,632	13.8
EEM-2	R	Controls	Improve Temperature Control	21,756	0	0.0	$ 0	Natural Gas	185.6	$ 1,680	$ 1,680	$ 787	0.5
EEM-3	R	Envelope	Weather-Stripping And Caulking	7,212	0	0.0	$ 0	Natural Gas	61.5	$ 557	$ 557	$ 3,072	5.5
EEM-4	R	Envelope	Insulate Building Envelope - Garage	35,995	0	0.0	$ 0	Natural Gas	307.1	$ 2,779	$ 2,779	$ 74,906	26.9
EEM-5	R	Envelope	Insulate Building Envelope - Town Office	3,242	20	0.0	$ 2	Natural Gas	27.5	$ 249	$ 250	$ 7,500	30.0
EEM-6	NR	Envelope	Install Insulated Doors	584	0	0.0	$ 0	Natural Gas	5.0	$ 45	$ 45	$ 1,905	42.2
EEM-7	NR	Envelope	Install Double Glazing	5,561	0	0.0	($ 8)	Natural Gas	47.4	$ 429	$ 421	$ 23,040	54.7
EEM-8	R	HVAC	Insulate Heating And Domestic Hot Water Pipes	245	0	0.0	$ 0	Natural Gas	2.1	$ 19	$ 19	$ 145	7.7
EEM-9	NR	DHW	Install A Tankless Water Heater	(22)	(294)	(0.1)	($ 26)	Natural Gas	2.7	$ 25	($ 2)	$ 450	(287.2)
Total of Recommended Measures:				**85,079**	**14,356**	**7.6**	**$ 1,278**		**583.8**	**$ 5,284**	**$ 6,561**	**$ 104,042**	**15.9**

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	6,364	(15,105)	2.3	($ 1,344)	Natural Gas	203.8	$ 1,844	$ 500	$ 52,753	105.5
BE-2	RBE	GSHP	Install Clean Heating System - Ground Source Heat Pump	14,140	(8,034)	3.3	($ 715)	Natural Gas	200.2	$ 1,811	$ 1,096	$ 136,683	124.7
Total of Recommended Measures:				**0**	**0**	**0.0**	**$ 0**		**0.0**	**$ 0**	**$ 0**	**$ 0**	