energy & resource solutions

ENERGY AUDIT REPORT

Energy Efficiency Audit: 425 Cherry Street

prepared for

Town of Bedford Hills

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1 Executive Summary

1.1 Introduction

This report details the recommendations and conclusions of an energy efficiency audit prepared for the town of Bedford Hills, New York. The town of Bedford Hills has shown tremendous initiative in promoting sustainability, spreading awareness of incented energy efficiency measures, and leading by example by upgrading their municipal buildings to reach optimal efficiency. As part of this study, four of the town's municipal buildings – 74 Main Street, 425 Cherry Street, 321 Bedford Road, and 21 Park Avenue – will be audited and studied to identify capital projects to improve the facilities' energy efficiency. In addition, the town requested a feasibility study to evaluate upgrading its HVAC systems to ground and/or air source heat pumps, in an effort to electrify its facilities in response to the Westchester gas moratorium.

ERS will submit the study findings of each building separately. The following report details ERS's findings at the 425 Cherry Street.

Mr. Alain Tayoun of ERS conducted a site visit at 425 Cherry Street on November 26, 2019. He met with Mr. Frank Zipp. During the site visit, Mr. Tayoun collected information on the building's operation, schedules, envelope, mechanical systems, and maintenance. In addition, Mr. Tayoun deployed logging equipment to develop operating profiles for some of the mechanical and lighting systems at the facility.

Details of our findings and recommendations for the facility are contained in this report, including a summary of recommended measures, facility details, and a detailed discussion on each measure. Supporting analyses and information can be found in the appendices at the end of this report.

1.2 Summary of Current Energy Use

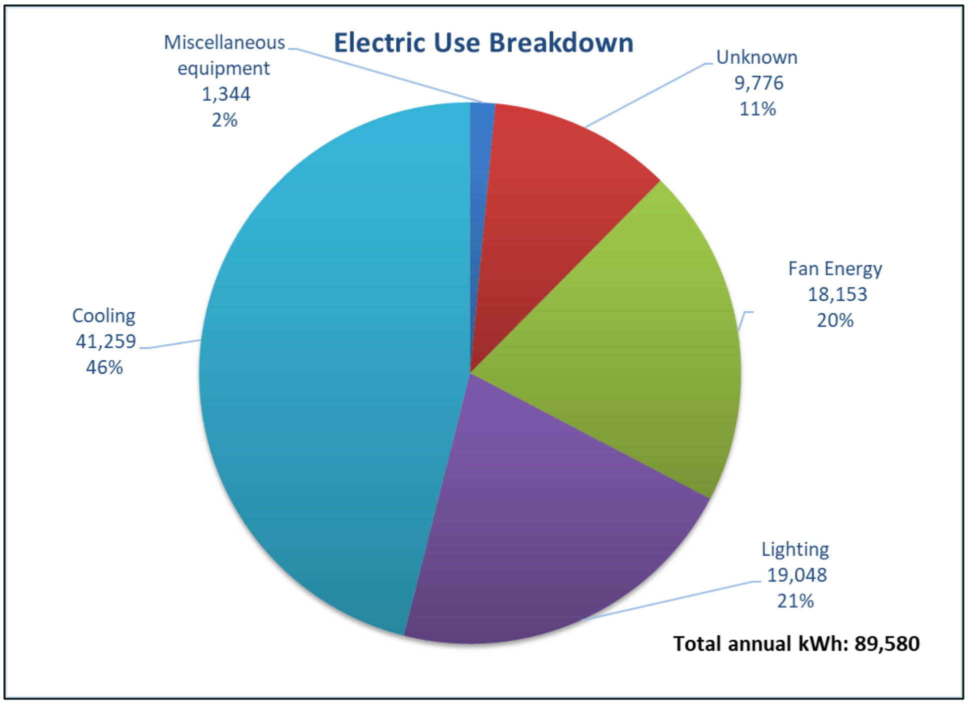
The municipal building at 425 Cherry Street was built in the 1990s and houses several of the town's departments: Parks and Recreation, Water and Finance, Building Department and Wetlands. The building has a total of three floors with a total floor area of approximately 10,000 square feet. Open and enclosed offices make up most of the square footage. Other areas include conference rooms, breakrooms, and restrooms.

The utilities at this facility include electricity and natural gas. The following discussion presents electric and natural gas billing and usage information for the facility. A detailed energy profile is presented in Section 2.

1.2.1 Electric Energy Use Breakdown

In preparing this energy report, ERS studied the current (baseline) electricity use at the facility. ERS estimated the lighting energy use by doing an inventory of the facility's lighting, collecting the various fixture and lamp nameplates, and using the operating profiles we developed through meter deployment. We determined the energy usage of the cooling equipment by collecting nameplate information (make, model, capacity, and efficiency) and calculating the estimated energy usage throughout the year. Since the study timeframe took place in the winter, ERS could not collect summer performance data. As a result, we developed a bin analysis to determine the baseline cooling energy usage. There is a spike in the energy usage during the summer months that was not identified by ERS. This portion of the energy use is referenced as "Unknown" in the figure below and discussed further in Section 2.2. The other miscellaneous end users represent the various office and kitchen equipment at the facility. Figure 1-1 presents the electric energy end-use breakdown plot.

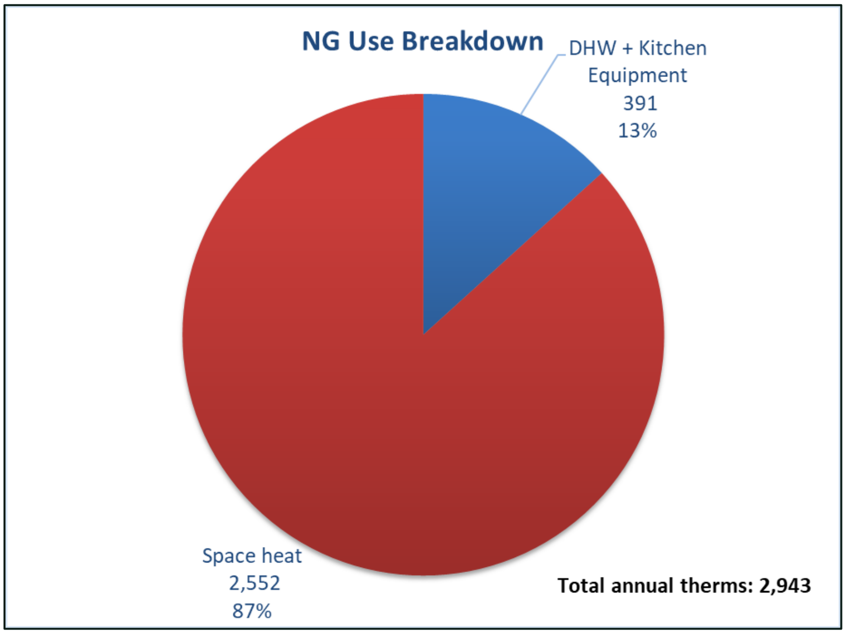
Figure 1-1. Facility Electricity End-Use Breakdown (kWh)



1.2.2 Natural Gas Energy Use Breakdown

In preparing this energy report, ERS also studied the current (baseline) natural gas use at the facility. As anticipated, space heating makes up the greater portion of gas use at 87% of the facility consumption. Figure 1-2 presents the natural gas energy end-use breakdown plot.

Figure 1-2. Facility Natural Gas End-Use Breakdown (Therms)



1.3 Summary of Recommended Energy Efficiency Measures

ERS recommends two energy efficiency measures (EEMs) for implementation and an additional informational measure. Details on the EEMs are shown in Table 1-1, below.

Table 1-1. Summary of Recommended Energy Efficiency Measures

Measure	Peak Demand Reduction (kW)*	Electrical Energy Savings (kWh/yr)	Thermal Energy Savings (therms/yr)	Cost Savings ($/yr)	CO2 Reduction (Metric Ton)	Measure Cost ($)	Simple Payback (years)	Potential Incentive ($)	Simple Payback w/ Incentive (years)
EEM-1: Install energy efficient lighting and lighting controls	6.2	12,849	N/A	$1,362.63	1.72	$14,854.00	11	$1,440	9.8
EEM-2-a: Retrofit current RTUs with controls	0.0	26,069	119	$2,854.53	4.12	$30,000.00	11	$0	10.5
EEM-2-b: Replace current HVAC system with air source heat pumps (ASHP)	16.6	18,201	2,954	$4,157	18.12	$87,500	21	N/A	N/A
EEM-2-c: Replace current HVAC system with variable refrigerant flow (VRF) systems	29.9	28,167	2,954	$5,214	19.45	$122,500	23	N/A	N/A
EEM-2-d: Replace current HVAC system with ground source heat pumps (GSHP)	29.0	29,643	2,954	$5,371	19.65	$280,000	52	$52,500	42.4
EEM-2-e: Replace current HVAC system with variable refrigerant flow GSHPs	34.7	36,742	2,954	$6,124	20.60	$350,000	57	$52,500	48.6

[1]Peak demand reduction reflects kW savings during the Summer. The overall demand increases in the winter for EEM-2 due to electric heating

N/A= Not applicable

As mentioned before, the town of Bedford Hills has shown interest in clean heating and cooling technologies. Therefore, five options were studied. The first often involves a retrofit to the current system and the remaining four options involve various heat pump technology alternatives. All five options are further described in section 3. We have also included an estimated NYSERDA and utility incentive for each measure where applicable. Please note that these incentive levels are based on the current utility and state offerings. For an update on the utility and state offerings available at the time of equipment purchase, we recommend contacting ERS before implementing any recommended measures.

1.3.1 EEM-1: Install Energy Efficient Lighting and Controls in Entire Facility

The lights at the facility typically operate during business hours. The interior lighting technologies observed in the facility include linear and U-tube T8 fixtures with electronic ballasts and CFL biax lamps. Light-emitting diode (LED) lamps and fixtures can offer significantly improved light quality with greater system efficiency and options for better control. We recommend replacing all of the existing lights with equivalent LED designs with lighting controls in designated areas.

1.3.2 EEM-2: Replace Current HVAC System – Five Options

The town of Bedford Hills is interested in evaluating several options to serve heating and cooling loads at its facility. Currently, the building is heated and cooled with six gas-fired rooftop units (RTUs). All six units are original to the building's construction.

The town is interested in both conventional and clean energy options to satisfy the building's cooling and heating loads, and as such, it is considering converting its HVAC systems to either air source or ground source heat pump if the study is found to be economically viable. The electrification of the heating sytem provides multiple non-energy benefits including a. reduction in greenhouse gas emmissions and an increase occupant comfort.

Below is a brief technology description of the five different options that ERS studied as part of this project.

EEM-2-a Retrofit Rooftop Units with Variable Frequency Drives (VFDs)

The existing RTUs have constant-volume supply fans and compressors, meaning that they only run at a fixed speed. The fans run during both the heating and cooling seasons and constantly recirculate air throughout the building, resulting in significant energy consumption from fan operation. The compressors run at full capacity when there's a need for cooling, even if it is minimal, resulting in higher energy usage than required. The facility does not, however, always require the full heating, cooling, or ventilation capacity that the RTUs are capable of providing. VFD retrofit packages, specifically for RTUs, are a smart control add-on that regulate the speed of both the fan and the compressor to meet the appropriate or pre-set load. When installed on the RTUs with proper controls, those packages allow the units to adjust their speed according to a reset schedule controlled by a thermostat in the space. This measure, however, is not applicable to all RTUs and should be considered on a case-by-case basis.

EEM-2-b Air Source Heat Pump (ASHP)

An ASHP uses a refrigerant system involving a compressor and a condenser to absorb heat at one place and release it at another. Unlike water source heat pumps, ASHP refrigerants exchange heat with the ambient air. ASHPs are, at most, a two-speed system; therefore, the unit's compressor can only operate at one of two different levels depending on the load it has to provide. They are a low-cost electric space heater or cooler. A high-efficiency heat pump can provide up to four times as much heat as an electric resistance heater using the same amount of electricity.

EEM-2-c: Variable Refrigerant Flow Air Source Heat Pump (VRF)

A VRF is a more efficient air source heat pump with variable speed compressors and a modulating refrigerant fluid valve. Depending on the load a unit has to provide, its built-in logic controls the compressor's speed (0% to 100%) and modulates the refrigerant valve (0% to 100%) to optimize the energy usage. VRFs are a great solution for multi-zone facilities since the units adapt and optimize for the required overall load in all zones and are not restricted to one or two levels of operation.

EEM-2-d: Ground Source Heat Pumps (GSHPs)

GSHPs are similar in concept to ASHPs; however, the refrigerant exchanges heat with the underground soil instead of the air. The advantage of having an underground system is that in most cases, the geological properties of the ground allow for optimal temperatures that favor efficient heat transfer.

EEM-2-e: Variable Refrigerant Flow Ground Source Heat Pump (VRF GSHP)

VRF GSHP is a GSHP that operates under a similar manner to a VRF. Depending on the load a unit has to provide, the compressor's speed along with the refrigerant valve modulate (0% to 100%) to optimize the energy usage. In addition, with small loads, a reduced volume of refrigerant has to be circulating through the underground loop resulting in additional energy savings.

1.4 Summary of Informational Measures

Below is a summary the informational measures.

1.4.1 IM-1: Replace the Existing Gas-Fired Domestic Hot Water Heater with a Heat Pump Hot Water Heater

The facility currently has a 40-gallon, gas-fired domestic hot water heater with a 66% efficiency. Heat pump hot water heaters are an electric alternative to providing domestic hot water in a facility at a comparable price to gas (varies based on electric and natural gas costs). ERS is listing this upgrade as an informational measure since it has no cost savings associated with it. However, this measure is being reported since the town of Bedford Hills has shown interest in electrifying their facility in response to the Westchester gas moratorium.

2 Facility Description

This section discusses the facility and energy-consuming systems present at 425 Cherry Street in Bedford Hills, New York. Details on the annual energy consumption and end-use breakdowns are presented in the following subsections.

The municipal building at 425 Cherry Street was built in the 1990s and houses several of the town's departments: Parks and Recreation, 1st Floor – Water and Finance, 2nd Floor – Building Department and Wetlands, 3rd Floor. The building has a total of three floors with a total floor area of approximately 10,000 square feet. Open and enclosed offices make-up most of the square footage. Other areas include conference rooms, breakrooms and restrooms. Heating and cooling are provided by a total of six gas-fired RTUs. Photo 2-1, below, shows the facility at 425 Cherry Street.

Photo 2-1. View of 425 Cherry Street

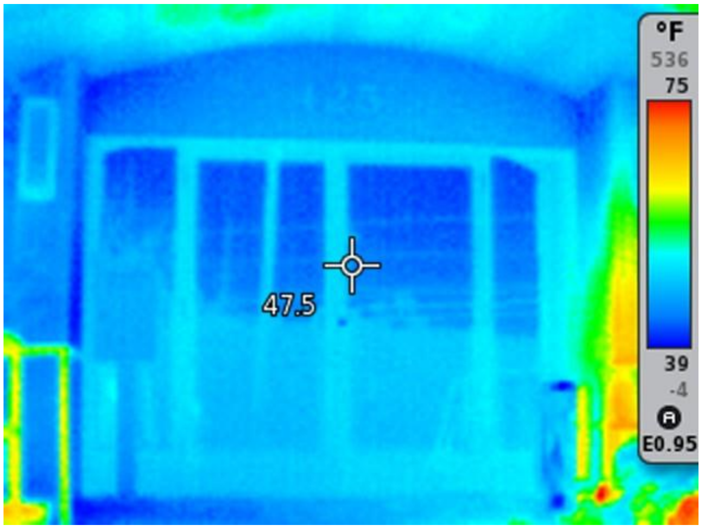
Image courtesy of Google Maps

2.1 Building Envelope, Roof, Crawl Space, and Windows

The facility's exterior walls consist of wood framing with concrete masonry and a brick outer shell. The building's roof is flat and covered with thermal and water insulation and coated with a white reflective material. The windows are double paned with aluminum frames.

The overall envelope of the building is in good condition and is well maintained. Photos 2-2 and 2-3 are thermal images taken by ERS on the day of the site visit.

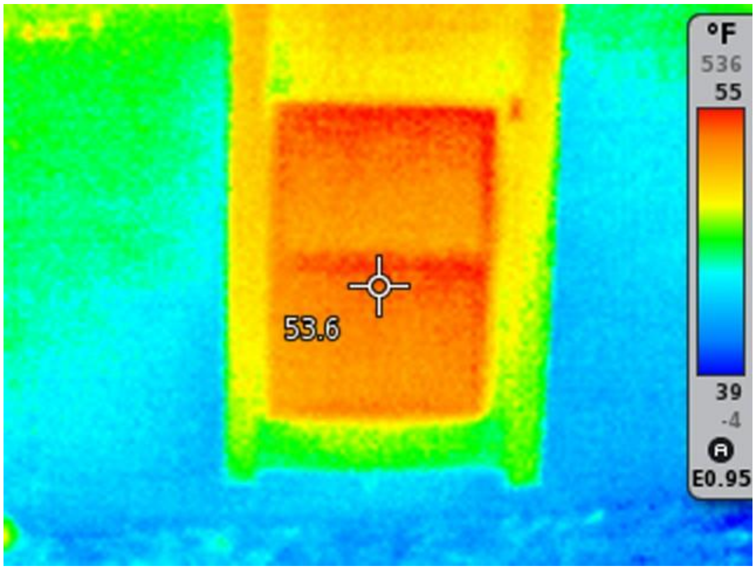
Photo 2-2. Front Entrance Door at 425 Cherry Street



The outdoor temperature was around 35°F on the day of the site visit, and heating was taking place at the facility. The thermal image, above, shows that the front door temperature is at 47.5°F, which indicates that little heat is escaping the inside of the building that is maintained at 72°F. In general, if an exterior surface (wall, window, door, roof, etc.) was poorly sealed or insulated, the temperature of the surface would be close to the building's interior temperature. Therefore, the image indicates that the front door of the facility is well sealed.

Photo 2-3 shows a side window at the facility that is shaded from the sun. The thermal camera shows that the surface temperature of the window is at 53.6°F, which indicates that some heat is leaking. This is to be expected since windows cannot be insulated as well as exterior walls. Even though the leakage does not warrant a window replacement, however, upgrading to triple-pane windows can improve the thermal resistance of the window and contain the facility better.

Photo 2-3. Side Window at 425 Cherry Street



2.2 Facility Lighting

Current lighting consists predominantly of 4-foot fluorescent three-lamp T8 fixtures rated at 89W per fixture, which can mostly be found in hallways, offices, and conference rooms. Some of the storage rooms, bathrooms, and hallways are equipped with 60W incandescent lamps, 26W CFL biax and U-tube T8 fixtures. All of the facility lighting is manually controlled by wall switches.

2.3 Heating and Cooling Systems

The building is heated and cooled with six gas-fired RTUs. All six units are original to the building's construction. All six units are single speed and run constantly when the unit is called for heating, cooling, or ventilation.

Table 2-1 summarizes the HVAC equipment information. Photos 2-4 and 2-5, below Table 2-1, show the 5- and 7.3-ton RTUs that are installed at the facility.

Table 2-1. Current HVAC Equipment at 425 Cherry Street

General Info					Specs			
RTU	Floor Served	Make	Model	Approximate Age	Heating Capacity (Btu/hr)	Heating Efficiency	Cooling Capacity (Tons)	SEER
1	2nd	Lennox	GCS16 - 060 - 120 - 1Y	+20 years	96,000	80%	5	10
2	2nd	Lennox	GCS16 - 060 - 120 - 1Y	+20 years	96,000	80%	5	10
3	1st	Lennox	GCS16 - 060 - 120 - 1Y	+20 years	96,000	80%	5	10
4	1st	Lennox	GCS16 - 060 - 120 - 1Y	+20 years	96,000	80%	5	10
5	3rd	Lennox	GCS24 - 953 - 200 - 1Y	+20 years	160,000	80%	7.3	10
6	3rd	Lennox	GCS24 - 953 - 200 - 1Y	+20 years	160,000	80%	7.3	10

Photo 2-4. 5-Ton Lennox GCS16 - 060 - 120 - 1Y

Photo 2-5. 7.3-Ton Lennox GCS24 - 953 - 200 - 1Y

2.4 Miscellaneous Equipment

The miscellaneous electric energy-consuming items at the facility include office equipment (computers, monitors, TVs, etc.) and kitchen appliances (refrigerators, microwaves, toaster ovens, etc.).

The facility's domestic hot water is provided by a natural gas fired hot water heater with a 66% efficiency.

2.5 Energy Source Use Profile

The following subsections provide a detailed look at each resource, including past billing information and a breakdown of end use.

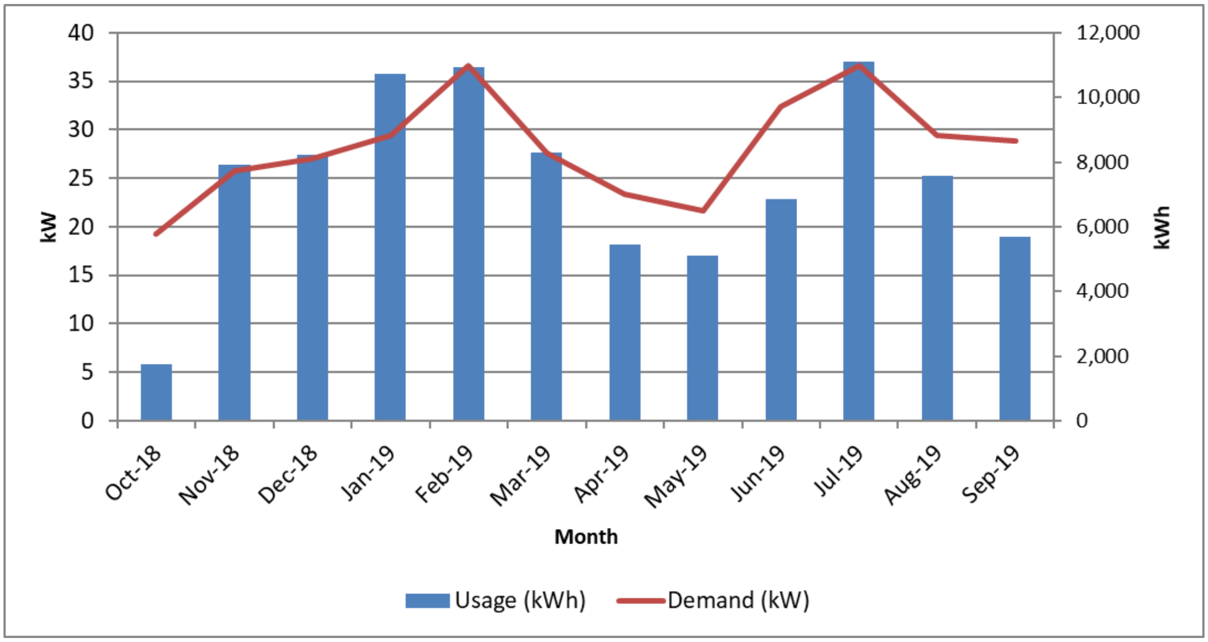
2.5.1 Electric Energy Use Profile

The facility's electricity is supplied and delivered through NYSEG. The total amount of electrical energy consumed by the facility from October 2018 to September 2019 was 89,580kWh, and the billed on-peak demand occurrent in July 2019 at 36.6kW. The annual cost of electricity was at $9,500 for an average cost of $0.11/kWh. Table 2-2, below, presents the monthly electrical energy use at the facility, and Figure 2-1, below, presents this information in a plot.

Table 2-2. Electricity Billing History

Month	Billed Demand	Net kWh	Total Electric Cost
Oct-18	19.2	1,740	$185
Nov-18	25.8	7,920	$840
Dec-18	27.0	8,220	$872
Jan-19	29.4	10,740	$1,139
Feb-19	36.6	10,920	$1,158
Mar-19	27.6	8,280	$878
Apr-19	23.4	5,460	$579
May-19	21.6	5,100	$541
Jun-19	32.4	6,840	$725
Jul-19	36.6	11,100	$1,177
Aug-19	29.4	7,560	$802
Sep-19	28.8	5,700	$604
Total:	**N/A**	**89,580**	**$9,500**

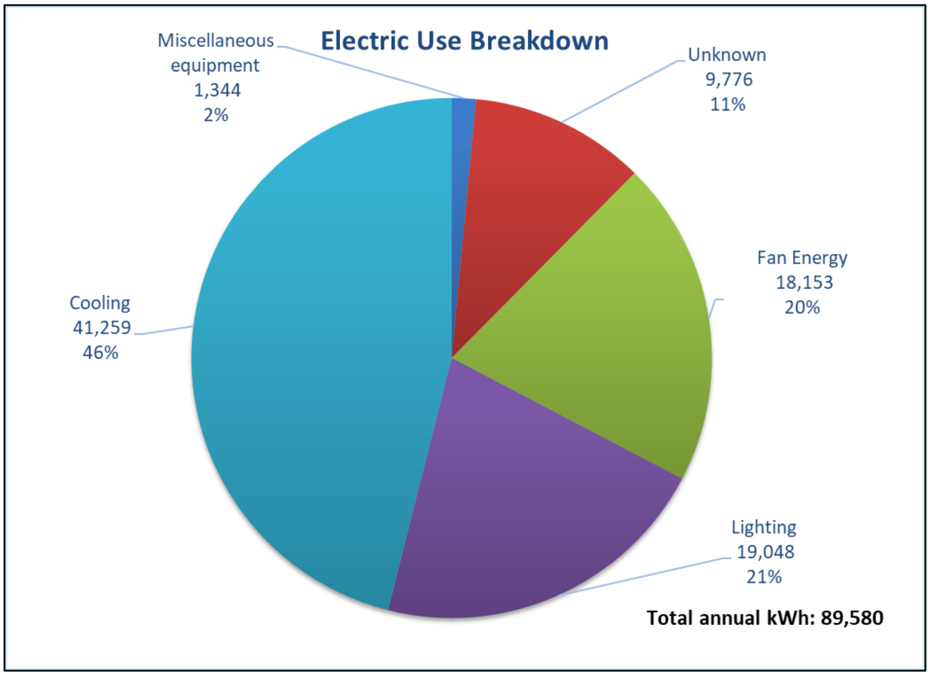
Figure 2-1. Electric Use Plot



The energy use at the facility shows two peaks throughout the year. One of the peaks occurs during the summer, which is to be expected because of the increase in the cooling load. The second occurs during the winter. Through interviews with facility staff and by conducting a walk-through, ERS verified that the only heating that takes place at the facility is provided by the gas-fired RTU. However, there is a second spike in in the chart that can only be attributed to electric heating. ERS will request further clarification from the town of Bedford Hills. If it is determined to be an anomaly, ERS can explore the cause of this spike outside the scope of this project.

A breakdown of the electric end-use at the facility is presented in Figure 2-2.

Figure 2-2. Electric Use Breakdown (kWh)



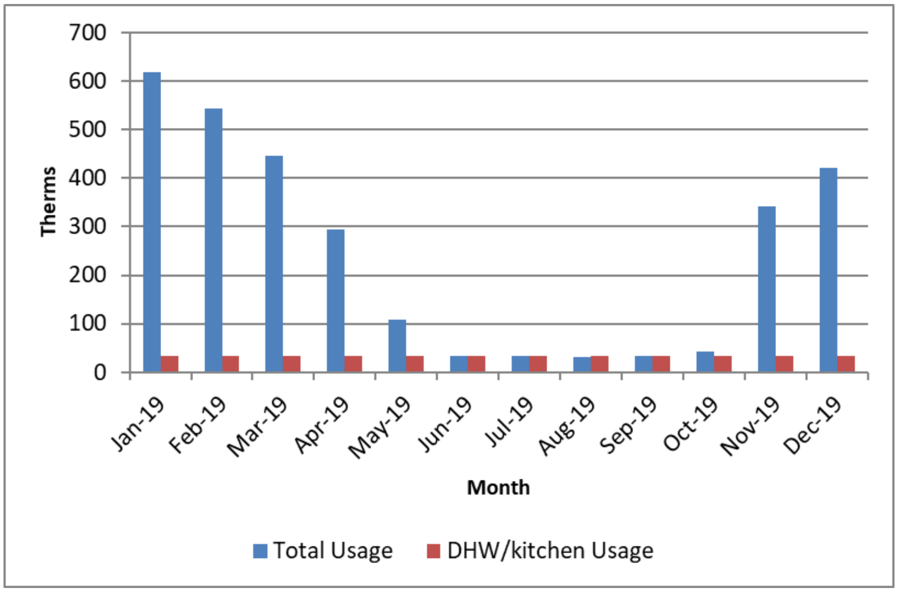
2.5.2 Natural Gas Use Profile

The facility's natural gas is supplied by and delivered through Con Edison. The total amount of gas consumed by the facility from January 2019 to December 2019 was 2,943 therms, with a maximum consumption occurring in January 2019 at 617 therms. The annual cost of natural gas was at $2,218 for an average cost of $0.75/therm. Table 2-3, below, presents the most recent monthly natural gas use available to us, and Figure 2-3, also below, presents that information in a plot.

Table 2-3. Natural Gas Billing History

Month/Year	Natural Gas Usage (Therms)	Cost
Jan-19	617	$436
Feb-19	543	$427
Mar-19	445	$350
Apr-19	294	$232
May-19	108	$85
Jun-19	34	$0
Jul-19	32	$2
Aug-19	31	$0
Sep-19	34	$0
Oct-19	42	$11
Nov-19	342	$307
Dec-19	420	$368
Total	**2,943**	**$2,218**

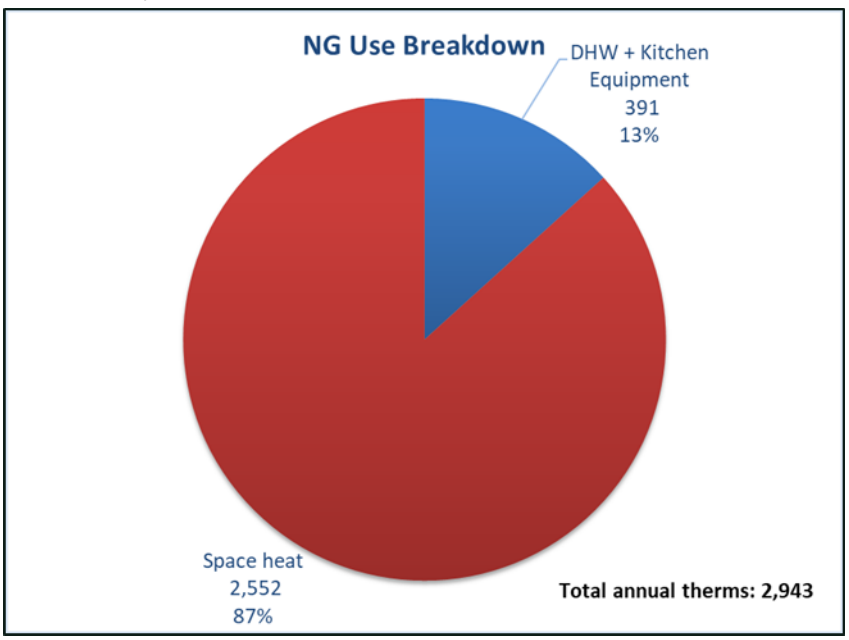
Figure 2-3. Natural Gas Use Plot



The natural gas data indicated a strong correlation with weather. Natural gas usage increases during winter months to provide space heating. The energy usage during non-heating seasons can be attributed to domestic hot water (DHW) production.

A breakdown of the natural gas end uses at the facility is presented in Figure 2-4.

Figure 2-4. Natural Gas Use Breakdown (Therms)



3 Energy Efficiency Measures

This section provides details of the recommended EEMs for the facility at 425 Cherry Street, Bedford Hills, New York. Two EEMs have been studied and are recommended for implementation, as listed below:

- EEM-1: Install energy efficient LED lighting and controls in the entire facility
- EEM-2: Replace current HVAC system with one of the following:
  - 2-a – Retrofit RTUs with VFDs
  - 2-b – A multi-zone ASHP
  - 2-c – A multi-zone VRF
  - 2-d – A multi-zone GSHP
  - 2-e – A multi-zone VRF GSHP

The following subsections indicate the estimated implementation costs and available incentives as well as the energy, demand, and cost savings for each measure.

All of the costs, incentives, and savings are estimates and may vary upon implementation.

3.1 EEM-1: Install Energy Efficient LED Lighting and Controls in the Entire Facility

Energy Impacts				
Electric Demand Savings (kW)	Electric Energy Savings (kWh/yr)	Total Annual Savings ($/yr)	Tons CO_2 Reduction	Installed Cost
6.2	12,849	$13,63	1.72	$14,854
			Simple payback w/o Incentives (years):	11.0

3.1.1 Discussion

The lights at the facility typically operate during business hours. The interior lighting technologies observed in the facility include linear and U-tube T8 fixtures with electronic ballasts, and CFL biax lamps. Light-emitting diode (LED) lamps and fixtures can offer significantly improved light quality with greater system efficiency and options for better control. We recommend replacing all of the existing lights with equivalent LED designs with lighting controls in designated areas.

3.1.2 Measure Savings and Implementation Cost

While on-site, ERS developed an inventory of the existing lights throughout the facility. ERS deployed light loggers in a sample of space types to develop a lighting operating profile. The loggers were deployed on November 26, 2019 and retrieved on December 19, 2019. ERS developed the average hourly operating profiles in the space types metered for each day of the week and then extrapolated to obtain a representative annual profile. Table 3-1, below, shows the different space types identified and their operating hours.

The facility's lighting inventory is shown in Appendix A. The recommended retrofits/replacements are as follows:

- Retrofit all 4-foot T8 fixtures with 12 W 4-foot LED tubes.
- Replace all compact fluorescent and incandescent lamps with 8 W A-lamp LEDs.
- Install occupancy sensors in all offices, conference rooms, board rooms, restrooms, and storage spaces. Table 3-1 also shows the proposed operating hours, should the occupancy sensors be installed.

Table 3-1. Facility Space Types and Operating Hours

Usage Groups	Baseline Lighting Annual Hours	Proposed Lighting Annual Hours
Open office*	1,416	1,416
Enclosed office	2,464	1,725
Staff room	1,354	948
Hallway*	2,213	2,213
Storage	1,825	1,277
Kitchen	1,776	1,243
Conference room	1,296	907

*No occupancy sensors recommended for this space-type.

ERS's list of recommended fixtures can be found in Appendix A. Using the operating hours and fixture information collected on-site, ERS determined the savings to expect from implementing the measure. The measure cost is based on an internal cost database developed using information obtained from several projects over the years. ERS estimates a material and installation cost of $14,854. The provided price includes the replacement lamp cost and the labor cost only. If further rewiring or electrical upgrades are required, an additional cost would incur. Table 3-2 shows the energy savings and economics of replacing the lights and installing controls.

Table 3-2. Energy Savings

Demand savings (kW-month)	6.2
Energy savings (kWh/yr)	12,849
Natural gas savings (Therms/yr)	0
Annual cost savings ($/yr)	$1,363
Implementation cost	$14,854
Simple payback (years)	11
NYSEG incentive*	**$1,440**
Implementation cost after incentive	**$13,414**
Simple payback (years) after incentive	**9.8**

* At current incentive availbility and level

3.2 EEM-2: Replace Current HVAC System – Five Options

Energy Impacts							
Option	Electric Peak Demand Reduction (kW)	Electric Energy Savings (kWh/yr)	Natural Gas Savings (Therms)	Total Annual Savings ($/yr)	Tons CO2 Reduction	Installed Cost ($)	Simple Payback w/o Incentive (Years)
a: Retrofit RTUs	0.0	26,069	119	$2,855	4.1	$30,000	11
b: ASHP	16.6	18,201	2,954	$4,157	18.1	$87,500	21
c: VRF	29.9	28,167	2,954	$5,214	19.5	$122,500	23
d: GSHP	29.0	29,643	2,954	$5,371	19.7	$280,000	52
e: VRF GSHP	34.7	36,742	2,954	$6,124	20.6	$350,000	57

3.2.1 Discussion

As previously stated, the building is heated and cooled with six gas-fired RTUs that are original to the building's construction. The metered data, discussed below in this section, shows that the units are not properly controlled. RTU 1, for instance, runs constantly, while the rest of the RTUs cycle on and off throughout the duration of the logging period. What follows describes methodologies to remedy the controls or to replace the existing system with clean heating and cooling.

3.2.2 Measure Savings and Implementation Cost

While on-site, ERS developed an inventory of the existing HVAC equipment at the facility. ERS also deployed current transformers on all RTUs to measure the amperage of the units as they operate. Two units serve each of the three floors; ERS deployed temperature loggers in the supply and return air ducts of one unit per floor. The logging equipment installed provides insight on the equipment's energy usage profile and its behavior with respect to outside air temperature. Our data suggests that RTU 3 did not operate throughout the logging period. This could also be a result of a faulty meter. Subsequently, we used an average of RTUs 1, 2, and 4 to evaluate RTU 3's energy usage. RTU 1's data indicates that the unit ran constantly for the entire metering period. There is no apparent relationship between the unit's operation and the time of day or outdoor air temperature. Figures 3-1 and 3-2, below, show RTU 1's fan profile with respect to hour of day and outdoor air temperature respectively.

Figure 3-1. RTU 1 Measured Amps vs Hour of Day

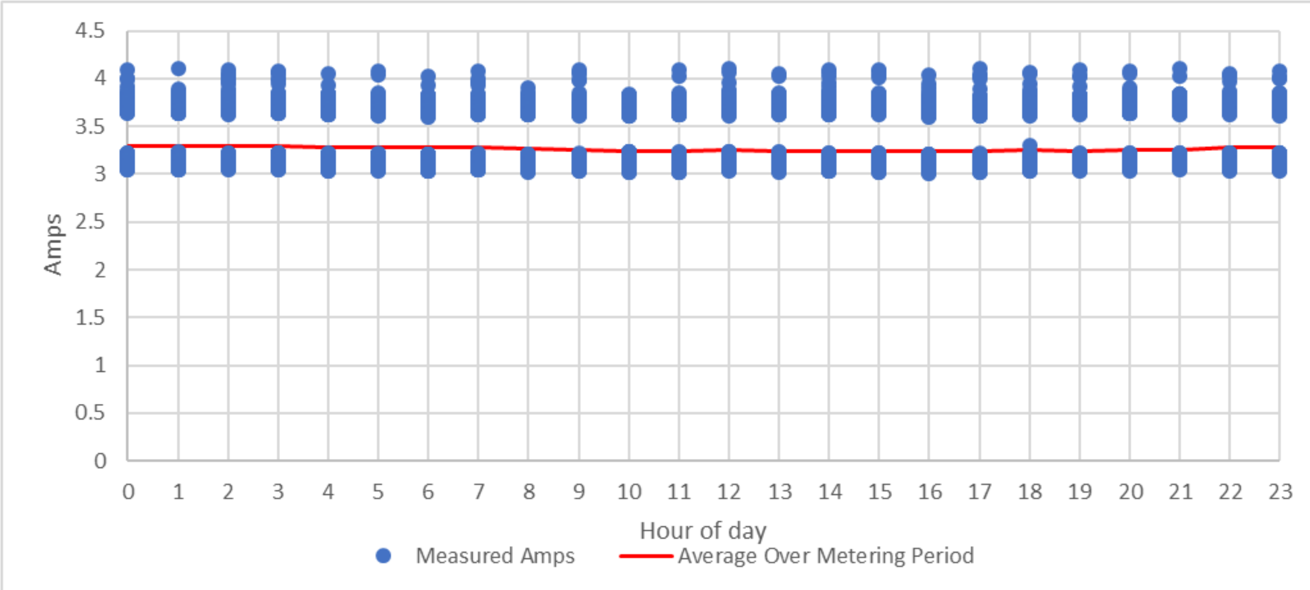
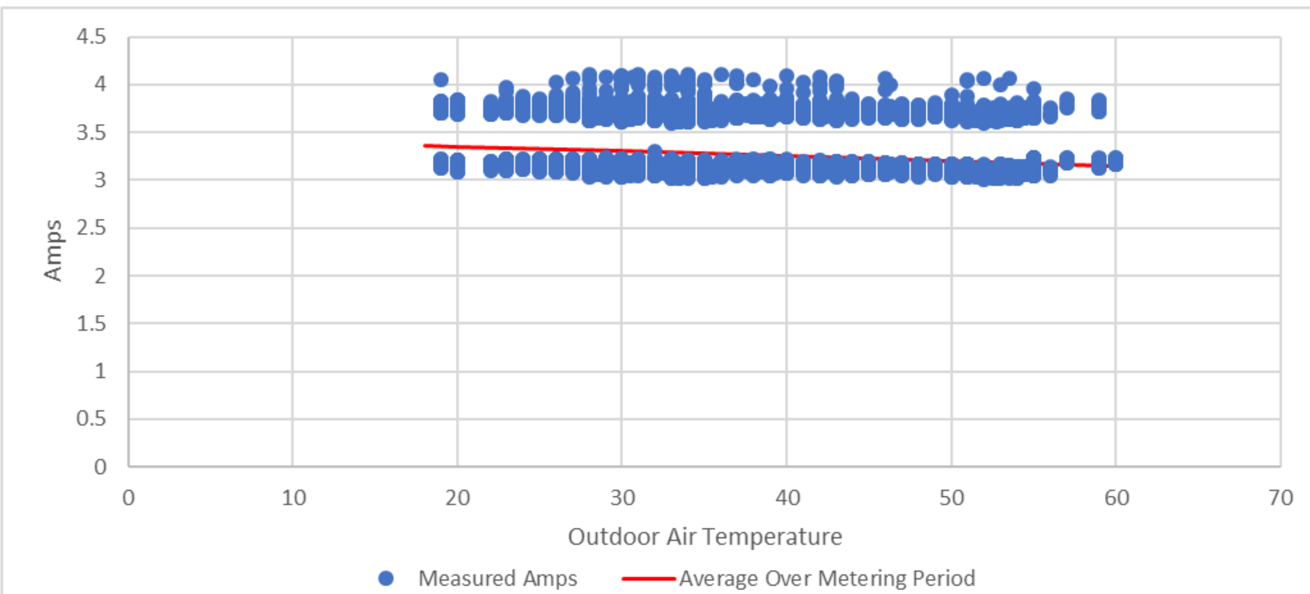


Figure 3-2. RTU 1 Measured Amps vs Outdoor Air Temperature



The two distinct divides between the data points (above and below 3.5 amps) in both graphs is attributed to the two speeds that RTU 1's supply fan can run at.

RTUs 2, 4, 5, and 6 also ran continuously with no correlation to time of day or outdoor air temperature. Those units, however, cycle on and off throughout the day, cutting back on fan energy that would have otherwise been wasted. Figures 3-3 and 3-4, below, show the operating profiles of RTUs 2, 4, 5, and 6.

Figure 3-3. RTUs 2, 4, 5, and 6 Measured Amps vs Hour of Day

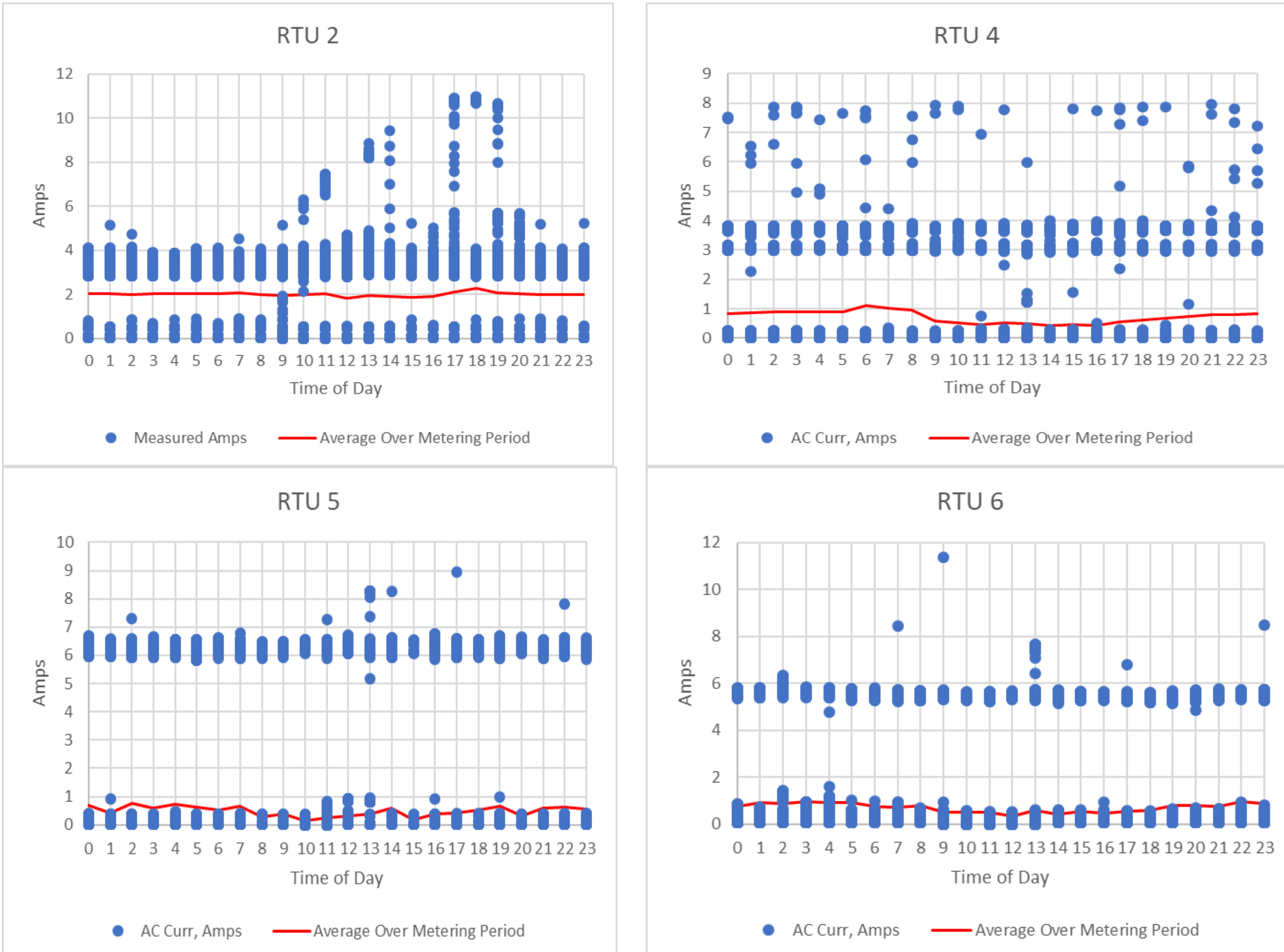
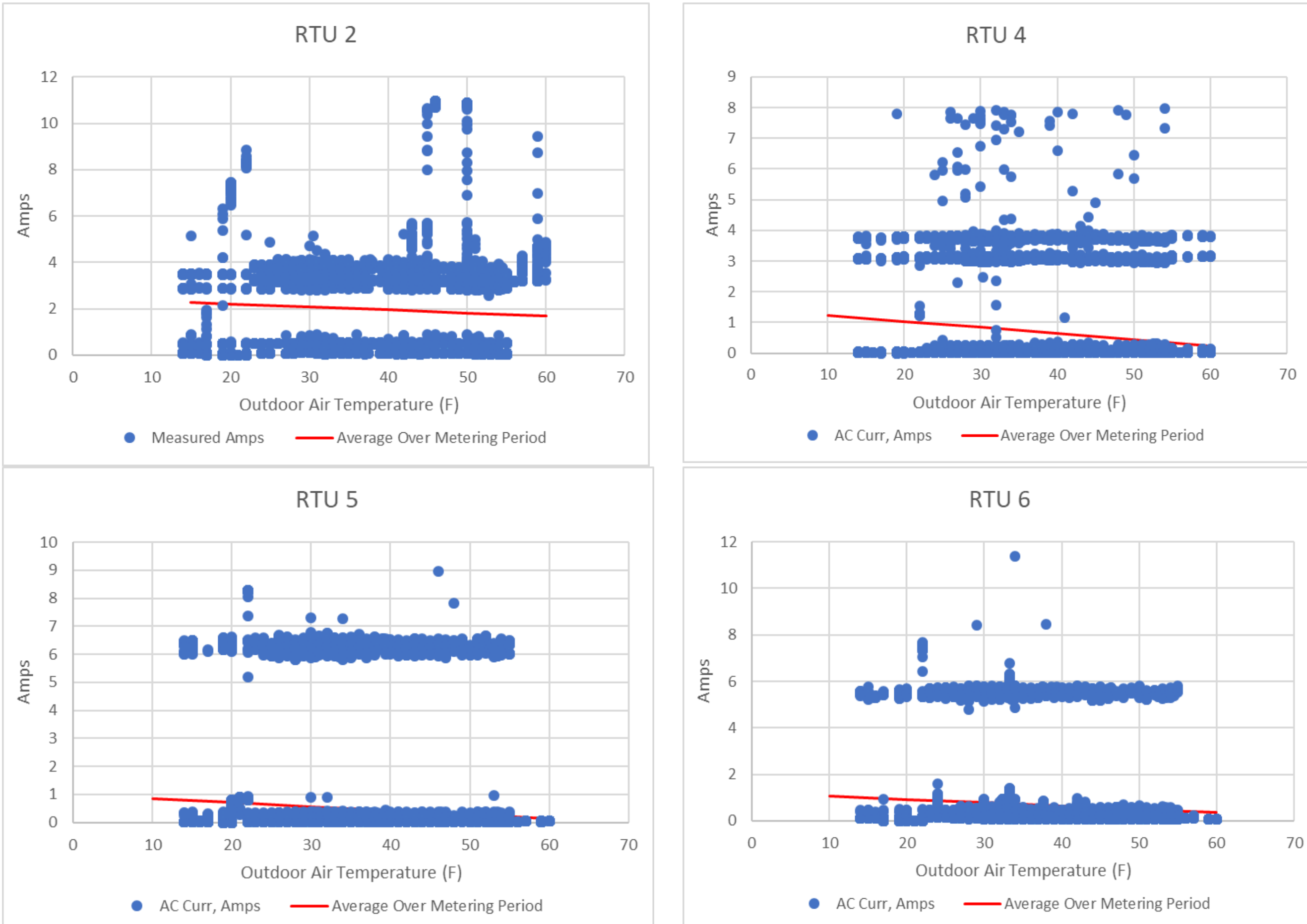


Figure 3-4. RTUs 2, 4, 5, and 6 Measured Amps vs Outdoor Air Temperature



Since the data collection occurred during the heating season, the data can only confirm that the fans run continuously regardless of the time of day or outdoor air temperature. There is no indication that the facility was also heating. We can infer from the data that the facility is in ventilation mode around the clock. The latter can result in excessive fan energy and heating energy required to condition the fresh air being supplied.

Energy monitoring, specifically for cooling equipment, typically takes place during the summer over a minimum of 2 weeks to collect ample data to appropriately establish a cooling profile. Since the project moved forward in early October, the outdoor air temperature was mild and would not have been representative of typical summer operation. As a result, ERS estimated that the baseline cooling energy usage by developing a bin analysis. The compressor and fan speed were estimated to be at 100% during the cooling season (OAT greater than 60 F); however, ERS calculated a load factor that was applied to off-peak cooling bins (OAT is between 60 and 80). The load factor was calculated to be the fan average load factor during the metering period. Appendix B includes the bin analysis and load factor calculation to each specific RTU. Table 3-3 summarizes the annual energy usage by RTU and the set-point temperatures of the zones they serve.

Table 3-3. Summary of Baseline Electric Energy Usage

RTU	Fan kWh	Compressor kWh	Total kWh	Set Point
1	3,582	13,620	17,202	72
2	2,483	8,970	11,453	70
3	2,423	8,717	11,141	NV
4	1,205	3,562	4,767	73
5	3,944	2,823	6,767	73
6	4,515	3,567	8,083	73
Total	**18,153**	**41,259**	**59,412**	**N/A**

The natural gas baseline was established by developing a regression of therms usage with outdoor air temperature. This relationship was then used to develop a bin analysis that attributes thermal usage to each temperature bin. ERS attributed thermal usage to each RTU based on the input capacity of each individual one. Table 3-4 summarizes the natural gas consumption of all six units. Appendix B includes more detailed natural gas baseline calculations.

Table 3-4. Summary of Baseline Natural Gas Usage

RTU	Therms
1	403
2	403
3	403
4	403
5	671
6	671
Total	**2,954**

EEM-2-a: Retrofit Rooftop Units with Variable Frequency Drives (VFDs)

The existing RTUs have constant-volume supply fans and compressors, meaning that they only run at a fixed speed. The fans run during both the heating and cooling seasons and constantly recirculate air throughout the building, resulting in significant energy consumption from fan operation. The compressors run at full capacity when there’s a need for cooling, even if it is minimal, resulting in higher energy usage than required. The facility does not, however, always require the full heating, cooling, or ventilation capacity that the RTUs are capable of providing. Variable frequency drive retrofit packages specifically for RTUs, are a smart control add-on that regulate the speed of both the fan and the compressor to meet the appropriate or pre-set load.

Installed on the RTUs with proper controls, those packages allow the units to adjust their speed according to a reset schedule controlled by a thermostat in the space. This measure, however, is not applicable to all RTUs and should be considered on a case-by-case basis.

ERS developed a bin analysis to determine the adequate usage and RTU loads for each bin temperature inside the operating hours (Monday through Friday from 8:00 AM – 5:00 PM). This included the percent of the loads during both occupied and unoccupied periods and overnight set-back temperature. Table 3-5 and 3-6, below, show the developed bin analysis that encompasses all RTUs with the proposed electric and natural gas operating loads respectively. A breakdown of each individual unit's operation can be found in Appendix C.

Table 3-5. Summary of Cooling Operation

	Occupied					Unoccupied				
Temp Bin	Hours (8-5)	Fan % load	Compressor % load	Total kW	Total kWh	Off Hours	Fan % load	Compressor % load	Total kW	Total kWh
95	14	100%	100%	49.8	698	0	30%	30%	2.5	-
90	21	100%	100%	49.8	1,047	2	30%	30%	2.5	5
85	64	100%	100%	49.8	3,190	12	30%	30%	2.5	29
80	156	90%	90%	38.3	5,975	54	30%	30%	2.5	133
75	211	80%	80%	28.5	6,020	135	30%	30%	2.5	332
70	287	70%	70%	20.4	5,864	277	20%	20%	0.9	247
65	301	60%	0%	2.1	639	574	20%	20%	0.9	512
60	281	50%	0%	1.3	378	756	0%	0%	0.0	-
55	257	50%	0%	1.3	346	557	0%	0%	0.0	-
50	295	60%	0%	2.1	626	559	20%	0%	0.1	76
45	163	70%	0%	3.1	509	433	20%	0%	0.1	59
40	164	80%	0%	4.4	715	580	30%	0%	0.4	218
35	204	90%	0%	5.8	1,193	504	30%	0%	0.4	189
30	213	100%	0%	7.6	1,621	411	30%	0%	0.4	154
25	136	100%	0%	7.6	1,035	302	30%	0%	0.4	113
20	84	100%	0%	7.6	639	390	30%	0%	0.4	146
15	51	100%	0%	7.6	388	162	30%	0%	0.4	61
10	16	100%	0%	7.6	122	74	30%	0%	0.4	28
5	2	100%	0%	7.6	15	47	30%	0%	0.4	18
0	0	100%	0%	7.6	-	11	30%	0%	0.4	4
Total					**31,020**		**N/A**	**N/A**	**N/A**	**2,323**

Table 3-6. Summary of Heating Operation

Temp Bin	All hours	Therms	Btu/hr	% Load - Baseline	Proposed Load Adjustment	Proposed Therms
95	14	-	-	0%	0%	-
90	23	-	-	0%	0%	-
85	76	-	-	0%	0%	-
80	210	-	-	0%	0%	-
75	346	-	-	0%	0%	-
70	564	-	-	0%	0%	-
65	875	-	-	0%	0%	-
60	1037	-	-	0%	50%	-
55	814	-	-	0%	50%	-
50	854	50	5,817	1%	60%	30
45	596	119	20,017	2%	70%	84
40	744	189	25,393	3%	80%	151
35	708	259	36,519	4%	90%	233
30	624	328	52,593	6%	100%	328
25	438	398	90,823	10%	100%	398
20	474	467	98,614	11%	100%	467
15	213	537	252,140	29%	100%	537
10	90	607	674,094	77%	100%	607
Total		**2,954**				**2,834**

Table 3-7 outlines option 2-a's summary.

Table 3-7. Option 2-a Summary

Peak Demand savings (kW-month)	0.0
Energy savings (kWh/yr)	26,069
Natural gas savings (Therms/yr)	119
Annual cost savings ($/yr)	$2,855
Implementation cost	$30,000
Simple payback (years)	10.5

The section below discusses the four heat pump options available.

ERS sized the proposed heat pumps based on the current load supplied by the HVAC system. Subsequently, we collected performance information on all four options studied and evaluated their energy usage under the baseline operating conditions with controls (EEM2-a).

The following section outlines electric and natural gas savings, cost savings, implementation costs, and available incentives for all four options proposed above. Appendix D presents a more detailed analysis for each of these options

EEM-2-b: Air Source Heat Pump (ASHP)

An ASHP uses a refrigerant system involving a compressor and a condenser to absorb heat at one place and release it at another. Unlike water source heat pumps, the refrigerant of air source heat pumps exchanges heat with the ambient air. Air source heat pumps are at most a two-speed system; therefore, the unit's compressor can only operate at one of two different levels depending on the load it has to provide. They are a low-cost electric space heater or cooler. A high-efficiency heat pump can provide up to four times as much heat as an electric resistance heater using the same amount of electricity.

For the purpose of this study, we selected a 5-ton heat pump that has a SEER of 15 and a COP of 3.5.

ERS contacted several vendors to get implementation cost estimates. On average, an ASHP installation will cost around $1,000/ton. This amount includes material and labor costs but excludes ducting costs. We recommend soliciting design and installation quotes from qualified NYSERDA vendors for more accurate costs.

Table 3-8 outlines option 2-b's summary.

Table 3-8. Option 2-b Summary

Peak Demand savings (kW-month)	16.6
Energy savings (kWh/yr)	18,201
Natural gas savings (Therms/yr)	2,954
Annual cost savings ($/yr)	$4,157
Implementation cost	$87,500
Simple payback (years)	21.0

EEM-2-c: Variable Refrigerant Flow Air Source Heat Pump (VRF)

A VRF is a more efficient air source heat pump with variable speed compressors and a modulating refrigerant fluid valve. Depending on the load that a unit has to provide, its built-in logic controls the compressor's speed (0% to 100%) and modulates the refrigerant valve (0% to 100%) to optimize the energy usage. VRFs are a great solution for multi-zone facilities since the units adapt and optimize for the required overall load in all zones and are not restricted to one or two levels of operation.

For the purpose of this study, we selected a 10-ton heat pump that has an IEER of 25 and a COP of 3.71.

On average, a VRF installation will cost approximately $2,500/ton. This amount includes material and labor costs but excludes ducting costs. We recommend soliciting design and installation quotes from qualified NYSERDA vendors for more accurate costs.

Table 3-9 outlines option 2-c's summary.

Table 3-9. Option 2-c Summary

Peak Demand savings (kW-month)	29.9
Energy savings (kWh/yr)	28,167
Natural gas savings (Therms/yr)	2,954
Annual cost savings ($/yr)	$5,214
Implementation cost	$122,500
Simple payback (years)	23.0

EEM-2-d: Ground Source Heat Pump (GSHP)

GSHPs are similar in concept to ASHPs; however, with ground source, the refrigerant exchanges heat with the underground soil instead of air, hence the name ground source. The advantage of having an underground system is that in most cases, the geological properties of the ground allows for optimal temperatures that favor efficient heat transfer.

For the purpose of this study, we selected a 6-ton water source heat pump that has a SEER of 23.9 and a COP of 4.2.

On average, a GSHP installation will cost approximately $8,000/ton. This amount includes material and labor costs as well as all piping, ducting, and drilling necessary. We recommend soliciting design and installation quotes from qualified NYSERDA vendors for more accurate costs.

The project also qualifies for a NYSERDA incentive, which offers $1,500/ton.

Geothermal heat pumps are recognized by the federal government as a qualified technology for the Investment Tax Credit (ITC). The ITC for geothermal systems is a credit equal to 10% of the cost of the system, net of any incentives. While the town of Bedford Hills does not pay federal taxes, this credit can still bring down system costs through an ownership agreement with a vendor. Under this model, the vendor who supplies the system would actually own and service the equipment and the town of Bedford Hills would pay the vendor a monthly amount agreed on between the two parties. Under this model, the vendor would be able to use the ITC, which would lower the overall cost to the town of Bedford Hills. We would encourage Bedford Hills to engage vendors to learn more about this model.

Table 3-10 outlines option 2-d's summary.

Table 3-10. Option 2-d Summary

Peak Demand savings (kW-month)	29.0
Energy savings (kWh/yr)	29,643
Natural gas savings (Therms/yr)	2,954
Annual cost savings ($/yr)	$5,371
Implementation cost	$280,000
Simple payback (years)	52.0
NYSERDA incentive*	**$52,500**
Simple payback (years) after incentive	**42.4**

*At current incentive availbility and level

EEM-2-e: Variable Refrigerant Flow Ground Source Heat Pump (VRF GSHP)

VRF GSHP is a GSHP that operates under a similar manner to a VRF, and as a result operates more efficiently than a standard GSHP.

For the purpose of this study, we selected a 5-ton water source heat pump that has a SEER of 32.9 and a COP of 5.3.

On average, a GSHP installation will cost around $10,000/ton. This amount includes material and labor costs as well as all piping, ducting, and drilling necessary. We recommend soliciting design and installation quotes from qualified NYSERDA vendors for more accurate costs.

The project also qualifies for a NYSERDA incentive which offers $1,500/ton.

Geothermal heat pumps are recognized by the federal government as a qualified technology for the ITC. The ITC for geothermal systems is a credit equal to 10% of the cost of the system, net of any incentives, and functions in the same manner as outlined above regarding the GSHP.

Table 3-11, below, outlines option 2-e's summary.

Table 3-11. Option 2-e Summary

Peak Demand savings (kW-month)	34.7
Energy savings (kWh/yr)	36,742
Natural gas savings (Therms/yr)	2,954
Annual cost savings ($/yr)	$6,124
Implementation cost	$350,000
Simple payback (years)	57.0
NYSERDA incentive*	**$52,500**
Simple payback (years) after incentive	**48.6**

*At current incentive availbility and level

4 Informational Measures

This section presents additional information for a measure that requires more detailed investigation and is beyond the scope of this assessment:

- IM-1: Replace the existing gas-fired domestic hot water heater with a heat pump hot water heater

4.1 Discussion

The facility currently has a 40-gallon, gas-fired domestic hot water heater with a 66% efficiency. Heat pump hot water heaters are an electric alternative to providing domestic hot water in a facility at a comparable price to gas (varies based on electric and natural gas costs). ERS is listing this upgrade as an informational measure since it has no cost savings associated with it. However, this measure is being reported since the town of Bedford Hills has shown interest in electrifying their facility in response to the Westchester gas moratorium.

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Implementation cost	$350,000
Simple payback (years)	57.0
NYSERDA incentive*	**$52,500**
Simple payback (years) after incentive	**48.6**

*At current incentive availbility and level

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Lighting Inventory & Proposed Fixtures

for

425 Cherry Street

Town of Bedford Hills

Description			Baseline						Proposed						Savings	
FL	Location	Operating Group	Fixture Type	Wattage	Quantity	Hours	Total Connected kW	kWh	Fixture Type	Wattage	Quantity	Hours	Total Connected kW	kWh	kW	kWh
1	Maintenance Office	Enclosed Office	(2) U-T8	59	1	2,464	0.059	145.4	(2) U-LED	24	1	1,725	0.024	41.4	0.035	104.0
1	Maintenance Office	Enclosed Office	(3) 4' T8	89	3	2,464	0.267	657.9	(3) 4' T8 LED	36	3	1,725	0.108	186.3	0.159	471.6
1	Maintenance Office	Enclosed Office	60W Incandescent	60	1	2,464	0.06	147.8	8W LED A-lamp	8	1	1,725	0.008	13.8	0.052	134.0
1	Hallway	Hallway	(2) U-T8	59	9	2,213	0.531	1,175.1	(2) U-LED	24	9	2,213	0.216	478.0	0.315	697.1
1	Main Office	Open Office	(3) 4' T8	89	7	1,416	0.623	882.2	(3) 4' T8 LED	36	7	1,416	0.252	356.9	0.371	525.4
1	Program Coordinator	Enclosed Office	(3) 4' T8	89	2	2,464	0.178	438.6	(3) 4' T8 LED	36	2	1,725	0.072	124.2	0.106	314.4
1	Copy Room	Storage	(3) 4' T8	89	1	1,825	0.089	162.4	(3) 4' T8 LED	36	1	1,277	0.036	46.0	0.053	116.4
1	Kitchen	Kitchen	(3) 4' T8	89	1	1,776	0.089	158.0	(3) 4' T8 LED	36	1	1,243	0.036	44.7	0.053	113.3
1	Storage	Storage	(3) 4' T8	89	1	1,825	0.089	162.4	(3) 4' T8 LED	36	1	1,277	0.036	46.0	0.053	116.4
1	Hallway	Hallway	(3) 4' T8	89	1	2,213	0.089	197.0	(3) 4' T8 LED	36	1	2,213	0.036	79.7	0.053	117.3
1	Conference Room	Conference Room	(3) 4' T8	89	6	1,296	0.534	692.0	(3) 4' T8 LED	36	6	907	0.216	195.9	0.318	496.1
1	Super Office	Enclosed Office	(3) 4' T8	89	4	2,464	0.356	877.1	(3) 4' T8 LED	36	4	1,725	0.144	248.4	0.212	628.8
1	Assistant Super Office	Enclosed Office	(3) 4' T8	89	2	2,464	0.178	438.6	(3) 4' T8 LED	36	2	1,725	0.072	124.2	0.106	314.4
1	Stairs	Hallway	(2) CFL biax	26	2	2,213	0.052	115.1	LED Flood Lamps	10	2	2,213	0.02	44.3	0.032	70.8
2	Staff Room	Staff Room	(3) 4' T8	89	4	1,354	0.356	482.1	(3) 4' T8 LED	36	4	948	0.144	136.5	0.212	345.6
2	Hallway	Hallway	(2) U-T8	59	1	2,213	0.059	130.6	(2) U-LED	24	1	2,213	0.024	53.1	0.035	77.5
2	Hallway	Hallway	(3) 4' T8	89	5	2,213	0.445	984.8	(3) 4' T8 LED	36	5	2,213	0.18	398.4	0.265	586.5
2	Restroom	Storage	(2) U-T8	59	1	1,825	0.059	107.7	(2) U-LED	24	1	1,277	0.024	30.7	0.035	77.0
2	Meeting Room	Conference Room	(3) 4' T8	89	10	1,296	0.89	1,153.3	(3) 4' T8 LED	36	10	907	0.36	326.6	0.53	826.8
2	Water Department	Open Office	(3) 4' T8	89	4	1,416	0.356	504.1	(3) 4' T8 LED	36	4	1,416	0.144	203.9	0.212	300.2
2	Office	Enclosed Office	(3) 4' T8	89	2	2,464	0.178	438.6	(3) 4' T8 LED	36	2	1,725	0.072	124.2	0.106	314.4
2	Finance	Open Office	(3) 4' T8	89	7	1,416	0.623	882.2	(3) 4' T8 LED	36	7	1,416	0.252	356.9	0.371	525.4
2	Office 1	Enclosed Office	(3) 4' T8	89	2	2,464	0.178	438.6	(3) 4' T8 LED	36	2	1,725	0.072	124.2	0.106	314.4
2	Office 2	Enclosed Office	(3) 4' T8	89	2	2,464	0.178	438.6	(3) 4' T8 LED	36	2	1,725	0.072	124.2	0.106	314.4
2	Storage	Storage	(3) 4' T8	89	1	1,825	0.089	162.4	(3) 4' T8 LED	36	1	1,277	0.036	46.0	0.053	116.4
3	Stairs	Hallway	(2) CFL biax	26	2	2,213	0.052	115.1	LED Flood Lamps	10	2	2,213	0.02	44.3	0.032	70.8
3	Office 1	Enclosed Office	(3) 4' T8	89	2	2,464	0.178	438.6	(3) 4' T8 LED	36	2	1,725	0.072	124.2	0.106	314.4
3	Office 2	Enclosed Office	(3) 4' T8	89	4	2,464	0.356	877.1	(3) 4' T8 LED	36	4	1,725	0.144	248.4	0.212	628.8
3	Office 3	Enclosed Office	(3) 4' T8	89	2	2,464	0.178	438.6	(3) 4' T8 LED	36	2	1,725	0.072	124.2	0.106	314.4
3	Office 4	Enclosed Office	(3) 4' T8	89	3	2,464	0.267	657.9	(3) 4' T8 LED	36	3	1,725	0.108	186.3	0.159	471.6
3	Open Office	Open Office	(3) 4' T8	89	15	1,416	1.335	1,890.5	(3) 4' T8 LED	36	15	1,416	0.54	764.7	0.795	1,125.8
3	Copy Room	Storage	(3) 4' T8	89	4	1,825	0.356	649.7	(3) 4' T8 LED	36	4	1,277	0.144	184.0	0.212	465.7
3	Office 5	Enclosed Office	(3) 4' T8	89	2	2,464	0.178	438.6	(3) 4' T8 LED	36	2	1,725	0.072	124.2	0.106	314.4
3	Office 6	Enclosed Office	(3) 4' T8	89	4	2,464	0.356	877.1	(3) 4' T8 LED	36	4	1,725	0.144	248.4	0.212	628.8
3	Conference Room	Conference Room	(3) 4' T8	89	6	1,296	0.534	692.0	(3) 4' T8 LED	36	6	907	0.216	195.9	0.318	496.1
Total							**10.395**	**19,047.65**					**4.188**	**6,198.50**	**6.207**	**12,849.15**

Appendix B

Electric & Natural Gas RTU Profiles

for

425 Cherry Street

Town of Bedford Hills

Electric Baseline

RTU 1									
Temp Bin	Hours (total)	Fan Speed	Compressor Speed	Fan kW	Fan kWh	Compressor kW	Compressor kWh	Total kW	Total kWh
95	14	100%	100%	0.6	8	6.0	84	6.6	92
90	23	100%	100%	0.6	13	6.0	138	6.6	151
85	76	100%	100%	0.6	42	6.0	457	6.6	499
80	210	100%	100%	0.4	82	4.3	896	4.7	978
75	346	100%	100%	0.4	135	4.3	1,477	4.7	1,612
70	564	100%	100%	0.4	221	4.3	2,407	4.7	2,628
65	875	100%	100%	0.4	343	4.3	3,734	4.7	4,077
60	1037	100%	100%	0.4	406	4.3	4,426	4.7	4,832
55	814	100%	0%	0.4	319	0.0	-	0.4	319
50	854	100%	0%	0.4	334	0.0	-	0.4	334
45	596	100%	0%	0.4	233	0.0	-	0.4	233
40	744	100%	0%	0.4	291	0.0	-	0.4	291
35	708	100%	0%	0.4	277	0.0	-	0.4	277
30	624	100%	0%	0.4	244	0.0	-	0.4	244
25	438	100%	0%	0.4	171	0.0	-	0.4	171
20	474	100%	0%	0.6	262	0.0	-	0.6	262
15	213	100%	0%	0.6	118	0.0	-	0.6	118
10	90	100%	0%	0.6	50	0.0	-	0.6	50
5	49	100%	0%	0.6	27	0.0	-	0.6	27
0	11	100%	0%	0.6	6	0.0	-	0.6	6
					3,582		13,620		17,202

RTU 2									
Temp Bin	Hours (total)	Fan Speed	Compressor Speed	Fan kW	Fan kWh	Compressor kW	Compressor kWh	Total kW	Total kWh
95	14	100%	100%	0.6	8	6.0	84	6.6	92
90	23	100%	100%	0.6	13	6.0	138	6.6	151
85	76	100%	100%	0.6	42	6.0	457	6.6	499
80	210	100%	100%	0.3	53	2.7	574	3.0	627
75	346	100%	100%	0.3	87	2.7	946	3.0	1,033
70	564	100%	100%	0.3	141	2.7	1,542	3.0	1,683
65	875	100%	100%	0.3	219	2.7	2,392	3.0	2,612
60	1037	100%	100%	0.3	260	2.7	2,835	3.0	3,095
55	814	100%	0%	0.3	204	0.0	-	0.3	204
50	854	100%	0%	0.3	214	0.0	-	0.3	214
45	596	100%	0%	0.3	149	0.0	-	0.3	149
40	744	100%	0%	0.3	187	0.0	-	0.3	187
35	708	100%	0%	0.3	178	0.0	-	0.3	178
30	624	100%	0%	0.3	156	0.0	-	0.3	156
25	438	100%	0%	0.3	110	0.0	-	0.3	110
20	474	100%	0%	0.6	262	0.0	-	0.6	262
15	213	100%	0%	0.6	118	0.0	-	0.6	118
10	90	100%	0%	0.6	50	0.0	-	0.6	50
5	49	100%	0%	0.6	27	0.0	-	0.6	27
0	11	100%	0%	0.6	6	0.0	-	0.6	6
					2,483		8,970		11,453

RTU 3									
Temp Bin	Hours (total)	Fan Speed	Compressor Speed	Fan kW	Fan kWh	Compressor kW	Compressor kWh	Total kW	Total kWh
95	14	100%	100%	0.6	8	6.0	84	6.6	92
90	23	100%	100%	0.6	13	6.0	138	6.6	151
85	76	100%	100%	0.6	42	6.0	457	6.6	499
80	210	100%	100%	0.2	51	2.7	557	2.9	608
75	346	100%	100%	0.2	84	2.7	917	2.9	1,001
70	564	100%	100%	0.2	137	2.7	1,495	2.9	1,632
65	875	100%	100%	0.2	213	2.7	2,319	2.9	2,532
60	1037	100%	100%	0.2	252	2.7	2,749	2.9	3,001
55	814	100%	0%	0.2	198	0.0	-	0.2	198
50	854	100%	0%	0.2	208	0.0	-	0.2	208
45	596	100%	0%	0.2	145	0.0	-	0.2	145
40	744	100%	0%	0.2	181	0.0	-	0.2	181
35	708	100%	0%	0.2	172	0.0	-	0.2	172
30	624	100%	0%	0.2	152	0.0	-	0.2	152
25	438	100%	0%	0.2	106	0.0	-	0.2	106
20	474	100%	0%	0.6	262	0.0	-	0.6	262
15	213	100%	0%	0.6	118	0.0	-	0.6	118
10	90	100%	0%	0.6	50	0.0	-	0.6	50
5	49	100%	0%	0.6	27	0.0	-	0.6	27
0	11	100%	0%	0.6	6	0.0	-	0.6	6
					2,423		8,717		11,141

RTU 4									
Temp Bin	Hours (total)	Fan Speed	Compressor Speed	Fan kW	Fan kWh	Compressor kW	Compressor kWh	Total kW	Total kWh
95	14	100%	100%	0.6	8	6.0	84	6.6	92
90	23	100%	100%	0.6	13	6.0	138	6.6	151
85	76	100%	100%	0.6	42	6.0	457	6.6	499
80	210	100%	100%	0.1	18	1.0	200	1.0	218
75	346	100%	100%	0.1	30	1.0	329	1.0	359
70	564	100%	100%	0.1	49	1.0	536	1.0	585
65	875	100%	100%	0.1	76	1.0	832	1.0	908
60	1037	100%	100%	0.1	90	1.0	986	1.0	1,076
55	814	100%	0%	0.1	71	0.0	-	0.1	71
50	854	100%	0%	0.1	74	0.0	-	0.1	74
45	596	100%	0%	0.1	52	0.0	-	0.1	52
40	744	100%	0%	0.1	65	0.0	-	0.1	65
35	708	100%	0%	0.1	62	0.0	-	0.1	62
30	624	100%	0%	0.1	54	0.0	-	0.1	54
25	438	100%	0%	0.1	38	0.0	-	0.1	38
20	474	100%	0%	0.6	262	0.0	-	0.6	262
15	213	100%	0%	0.6	118	0.0	-	0.6	118
10	90	100%	0%	0.6	50	0.0	-	0.6	50
5	49	100%	0%	0.6	27	0.0	-	0.6	27
0	11	100%	0%	0.6	6	0.0	-	0.6	6
					1,205		**3,562**		**4,767**

RTU 5									
Temp Bin	Hours (total)	Fan Speed	Compressor Speed	Fan kW	Fan kWh	Compressor kW	Compressor kWh	Total kW	Total kWh
95	14	100%	100%	2.7	38	9.1	127	11.8	165
90	23	100%	100%	2.7	62	9.1	209	11.8	271
85	76	100%	100%	2.7	205	9.1	690	11.8	895
80	210	100%	100%	0.2	37	0.6	124	0.8	161
75	346	100%	100%	0.2	61	0.6	205	0.8	266
70	564	100%	100%	0.2	99	0.6	334	0.8	434
65	875	100%	100%	0.2	154	0.6	519	0.8	673
60	1037	100%	100%	0.2	183	0.6	615	0.8	797
55	814	100%	0%	0.2	144	0.0	-	0.2	144
50	854	100%	0%	0.2	151	0.0	-	0.2	151
45	596	100%	0%	0.2	105	0.0	-	0.2	105
40	744	100%	0%	0.2	131	0.0	-	0.2	131
35	708	100%	0%	0.2	125	0.0	-	0.2	125
30	624	100%	0%	0.2	110	0.0	-	0.2	110
25	438	100%	0%	0.2	77	0.0	-	0.2	77
20	474	100%	0%	2.7	1,281	0.0	-	2.7	1,281
15	213	100%	0%	2.7	576	0.0	-	2.7	576
10	90	100%	0%	2.7	243	0.0	-	2.7	243
5	49	100%	0%	2.7	132	0.0	-	2.7	132
0	11	100%	0%	2.7	30	0.0	-	2.7	30
					3,944		2,823		6,767

RTU 6									
Temp Bin	Hours (total)	Fan Speed	Compressor Speed	Fan kW	Fan kWh	Compressor kW	Compressor kWh	Total kW	Total kWh
95	14	100%	100%	2.7	38	9.1	127	11.8	165
90	23	100%	100%	2.7	62	9.1	209	11.8	271
85	76	100%	100%	2.7	205	9.1	690	11.8	895
80	210	100%	100%	0.2	52	0.8	176	1.1	228
75	346	100%	100%	0.2	86	0.8	290	1.1	376
70	564	100%	100%	0.2	141	0.8	473	1.1	613
65	875	100%	100%	0.2	218	0.8	733	1.1	952
60	1037	100%	100%	0.2	259	0.8	869	1.1	1,128
55	814	100%	0%	0.2	203	0.0	-	0.2	203
50	854	100%	0%	0.2	213	0.0	-	0.2	213
45	596	100%	0%	0.2	149	0.0	-	0.2	149
40	744	100%	0%	0.2	186	0.0	-	0.2	186
35	708	100%	0%	0.2	177	0.0	-	0.2	177
30	624	100%	0%	0.2	156	0.0	-	0.2	156
25	438	100%	0%	0.2	109	0.0	-	0.2	109
20	474	100%	0%	2.7	1,281	0.0	-	2.7	1,281
15	213	100%	0%	2.7	576	0.0	-	2.7	576
10	90	100%	0%	2.7	243	0.0	-	2.7	243
5	49	100%	0%	2.7	132	0.0	-	2.7	132
0	11	100%	0%	2.7	30	0.0	-	2.7	30
					4,515		3,567		8,083

All RTUs									
Temp Bin	Hours (total)	Fan Speed	Compressor Speed	Fan kW	Fan kWh	Compressor kW	Compressor kWh	Total kW	Total kWh
95	14	100%	100%	7.6	107	42.2	591	49.8	698
90	23	100%	100%	7.6	175	42.2	971	49.8	1,146
85	76	100%	100%	7.6	579	42.2	3,209	49.8	3,788
80	210	100%	100%	1.4	294	12.0	2,527	13.4	2,821
75	346	100%	100%	1.4	484	12.0	4,164	13.4	4,648
70	564	100%	100%	1.4	789	12.0	6,787	13.4	7,576
65	875	100%	100%	1.4	1,224	12.0	10,530	13.4	11,753
60	1037	100%	100%	1.4	1,450	12.0	12,479	13.4	13,929
55	814	100%	0%	1.4	1,138	0.0	-	1.4	1,138
50	854	100%	0%	1.4	1,194	0.0	-	1.4	1,194
45	596	100%	0%	1.4	833	0.0	-	1.4	833
40	744	100%	0%	1.4	1,040	0.0	-	1.4	1,040
35	708	100%	0%	1.4	990	0.0	-	1.4	990
30	624	100%	0%	1.4	873	0.0	-	1.4	873
25	438	100%	0%	1.4	613	0.0	-	1.4	613
20	474	100%	0%	7.6	3,608	0.0	-	7.6	3,608
15	213	100%	0%	7.6	1,621	0.0	-	7.6	1,621
10	90	100%	0%	7.6	685	0.0	-	7.6	685
5	49	100%	0%	7.6	373	0.0	-	7.6	373
0	11	100%	0%	7.6	84	0.0	-	7.6	84
					18,153		**41,259**		**59,412**

Load Factor Calculations

Weekday	RTU 1 Hourly Average Amp Profile - From Metered Data																							
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
0	3.31	3.31	3.28	3.30	3.26	3.26	3.27	3.26	3.22	3.22	3.23	3.22	3.19	3.22	3.19	3.22	3.18	3.20	3.21	3.17	3.17	3.21	3.20	3.22
1	3.24	3.23	3.20	3.23	3.21	3.22	3.20	3.22	3.19	3.19	3.19	3.21	3.22	3.19	3.21	3.19	3.20	3.22	3.22	3.20	3.22	3.22	3.26	3.29
2	3.27	3.30	3.30	3.29	3.27	3.30	3.25	3.27	3.25	3.23	3.21	3.22	3.23	3.22	3.22	3.19	3.22	3.21	3.24	3.20	3.17	3.21	3.26	3.25
3	3.29	3.30	3.29	3.30	3.31	3.30	3.29	3.31	3.29	3.29	3.27	3.28	3.30	3.27	3.27	3.31	3.27	3.29	3.31	3.30	3.31	3.30	3.35	3.33
4	3.35	3.35	3.34	3.35	3.32	3.31	3.33	3.33	3.26	3.29	3.27	3.26	3.27	3.26	3.25	3.23	3.23	3.25	3.26	3.25	3.25	3.27	3.26	3.25
5	3.29	3.29	3.29	3.29	3.29	3.27	3.29	3.28	3.28	3.24	3.25	3.25	3.26	3.27	3.26	3.25	3.24	3.25	3.27	3.27	3.31	3.28	3.29	3.29
6	3.33	3.29	3.33	3.31	3.33	3.33	3.29	3.31	3.32	3.28	3.29	3.28	3.29	3.27	3.29	3.28	3.29	3.27	3.28	3.28	3.30	3.30	3.28	3.32

Average Amps	3.26
Full Load Amps	4.6
Load Factor	71%

Weekday	RTU 2 Hourly Average Amp Profile - From Metered Data																							
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
0	1.91	1.90	1.90	1.92	1.91	1.90	1.90	2.24	1.97	1.94	1.79	1.91	1.79	1.65	1.79	1.67	1.68	1.67	1.79	1.82	1.80	1.87	1.83	1.85
1	1.80	1.80	1.69	1.81	1.81	1.69	1.79	1.69	1.79	2.08	3.23	3.29	3.48	3.68	3.34	3.22	3.27	4.60	5.80	3.89	3.71	3.28	3.31	3.30
2	3.32	3.32	3.33	3.33	3.33	3.34	3.31	3.35	3.33	3.32	3.30	3.28	3.29	3.26	3.26	3.28	3.28	3.30	3.29	3.30	3.31	3.31	3.31	3.32
3	3.35	3.38	3.36	3.45	3.60	3.63	3.61	3.62	3.60	3.59	3.59	3.00	1.93	1.95	1.94	1.95	1.94	1.94	1.94	1.96	1.95	1.95	1.95	1.96
4	1.96	1.97	1.97	1.95	1.96	1.96	1.95	1.95	1.96	1.80	0.29	0.30	0.30	0.38	0.30	0.30	0.30	0.41	0.52	0.53	0.41	0.55	0.52	0.47
5	1.42	1.46	1.39	1.49	1.38	1.48	1.41	1.47	1.40	1.47	1.40	1.42	1.45	1.31	1.29	1.38	1.30	1.37	1.30	1.38	1.36	1.32	1.39	1.40
6	1.39	1.46	1.41	1.40	1.40	1.41	1.48	1.41	1.42	1.41	1.40	1.47	1.38	1.30	1.45	1.39	1.38	1.45	1.36	1.46	1.39	1.46	1.38	1.86

Average Amps	2.09
Full Load Amps	4.6
Load Factor	45%

Weekday	RTU 4 Hourly Average Amp Profile - From Metered Data																							
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
0	1.16	1.10	1.12	1.07	1.07	1.31	1.88	1.82	1.56	0.47	0.23	0.35	0.20	0.35	0.43	0.19	0.12	0.35	0.40	0.55	0.59	0.59	0.65	0.53
1	0.58	0.71	0.61	0.64	0.68	0.55	0.58	0.62	0.73	0.51	0.46	0.48	0.48	0.43	0.34	0.30	0.33	0.40	0.33	0.41	0.54	0.64	0.63	0.72
2	0.63	0.76	0.86	0.74	0.85	0.83	1.27	1.17	1.24	0.60	0.52	0.30	0.41	0.31	0.15	0.20	0.26	0.22	0.43	0.68	0.60	0.71	0.70	0.79
3	0.93	0.86	0.88	1.01	0.86	0.99	1.43	1.24	0.93	0.20	0.12	0.02	0.03	0.01	0.07	0.31	0.55	0.89	0.68	0.82	0.82	0.91	0.86	0.95
4	0.90	0.92	0.94	0.92	0.88	0.93	1.30	1.30	0.94	0.50	0.45	0.45	0.34	0.08	0.02	0.13	0.01	0.48	0.71	0.70	0.62	0.77	0.61	0.70
5	0.80	0.80	0.75	0.81	0.79	0.82	0.88	0.90	0.85	0.91	0.81	0.78	0.80	0.78	0.73	0.82	0.86	0.83	0.89	0.82	0.92	0.91	0.89	0.93
6	0.99	1.02	1.08	1.14	1.09	1.05	1.22	1.17	1.11	1.05	1.14	1.03	1.09	1.09	1.07	0.94	0.76	0.81	0.69	0.78	0.74	0.86	0.89	1.15

Average Amps	0.73
Full Load Amps	4.6
Load Factor	16%

RTU 3's data showed no operation. However, while on site, ERS saw the unit operating. Therefore, we can determine that the logging equipment on RTU 3 malfunctioned. As a result, RTU 3's profile was assumed to be the average of the 3 other 5-ton units.

RTU	1	2	4	3
Average Amps	3.26	2.1	0.7	2.0
Full Load Amps	4.6	4.6	4.6	4.6
Load Factor	71%	45%	16%	44%

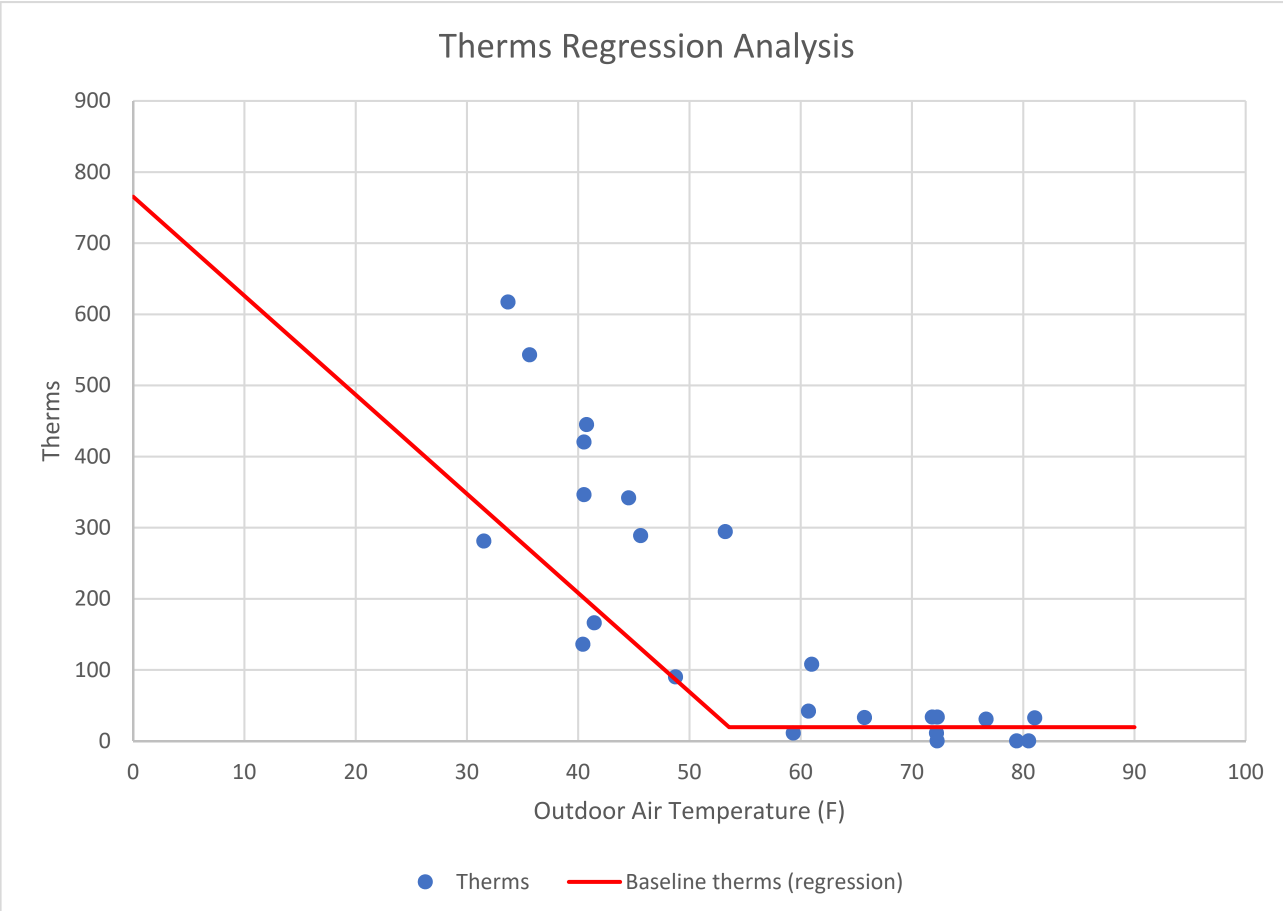
Weekday	RTU 5 Hourly Average Amp Profile - From Metered Data																							
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
0	0.62	0.57	1.08	0.60	0.57	1.14	0.05	0.98	0.25	0.46	0.78	0.05	0.54	0.04	0.52	0.04	0.20	0.98	0.62	1.14	0.36	0.30	1.14	0.61
1	0.67	0.67	0.40	0.61	1.13	0.64	0.04	1.08	0.04	0.62	0.04	0.04	0.43	0.04	0.42	0.28	0.03	0.03	0.38	0.34	0.03	0.39	0.74	0.42
2	0.04	0.81	0.31	0.74	0.39	0.39	0.74	0.39	0.40	0.84	0.05	0.37	0.05	0.05	0.74	0.04	0.50	0.66	0.04	1.11	0.04	0.77	0.04	0.75
3	0.56	0.56	1.08	0.04	1.14	0.46	0.67	0.50	0.15	0.04	0.04	0.04	0.05	0.78	0.62	0.03	0.44	0.03	1.15	0.58	0.56	0.56	0.56	0.62
4	1.10	0.04	1.10	0.56	0.61	0.56	1.11	0.05	1.21	0.05	0.21	0.52	0.04	0.04	1.09	0.05	0.58	0.34	0.84	0.59	0.58	0.57	0.59	0.57
5	0.39	0.78	0.38	0.58	0.96	0.22	0.92	0.34	0.46	0.05	0.05	0.37	0.41	0.04	0.61	0.21	0.37	0.42	0.39	0.28	0.49	0.77	0.42	0.38
6	0.81	0.04	1.12	0.40	0.81	0.73	0.46	0.78	0.06	0.79	0.15	0.68	1.01	0.14	0.78	0.35	0.78	0.47	0.49	0.98	0.40	0.39	1.13	0.57

Average Amps	0.49
Full Load Amps	7.5
Load Factor	7%

Weekday	RTU 6 Hourly Average Amp Profile - From Metered Data																							
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
0	0.86	1.06	1.10	1.05	0.87	0.85	0.62	0.58	0.61	0.18	0.94	0.20	0.22	0.18	0.17	0.17	0.17	0.60	0.18	1.02	1.01	0.18	0.99	0.96
1	0.19	0.98	0.60	0.57	0.64	1.00	0.60	0.58	0.18	0.18	0.17	0.18	0.16	0.17	0.18	0.17	0.17	0.31	0.28	0.74	0.47	0.69	0.45	0.68
2	0.59	0.78	0.96	0.64	0.62	0.77	0.76	0.74	0.50	0.25	0.25	0.58	0.23	0.22	0.22	0.26	0.25	0.50	0.51	0.75	0.74	0.68	1.01	0.62
3	1.08	0.82	0.99	1.16	1.22	1.11	1.01	0.43	1.04	0.25	0.43	0.34	0.65	0.64	0.54	0.36	0.28	1.01	0.38	0.57	1.01	1.02	0.99	0.95
4	0.62	1.01	1.06	1.01	1.05	1.01	0.15	1.14	0.84	0.28	0.61	0.19	0.19	0.65	0.54	0.21	0.22	0.61	1.02	1.04	1.04	1.00	0.66	0.60
5	1.04	0.86	0.63	1.09	1.09	1.09	0.53	0.75	0.58	1.05	0.48	0.73	0.18	0.92	0.71	1.05	0.74	0.66	1.00	1.02	0.77	0.89	1.14	1.10
6	0.93	0.89	1.06	1.15	1.09	1.10	0.76	0.93	1.39	1.03	1.05	1.05	0.74	0.71	0.74	1.16	0.89	0.75	0.81	0.66	0.88	1.11	0.95	0.85

Average Amps	0.69
Full Load Amps	7.5
Load Factor	9%

Natural Gas Baseline



Outputs

Regression parameters	
Ycp	19.4447
Xcp	53.5671
LS	-13.9253
RS	0

Temp Bin	All hours	Therms	Btu/hr	% Load - Baseline
95	14	-	-	0%
90	23	-	-	0%
85	76	-	-	0%
80	210	-	-	0%
75	346	-	-	0%
70	564	-	-	0%
65	875	-	-	0%
60	1037	-	-	0%
55	814	-	-	0%
50	854	50	5,817	1%
45	596	119	20,017	2%
40	744	189	25,393	3%
35	708	259	36,519	4%
30	624	328	52,593	6%
25	438	398	90,823	10%
20	474	467	98,614	11%
15	213	537	252,140	29%
10	90	607	674,094	77%
Total		**2,954**		

Appendix C

RTU Packaged Controls Calculations

for

425 Cherry Street

Town of Bedford Hills

Occupied Operating Profile

RTU 1							
Temp Bin	**Hours (8-5)**	**Fan Speed**	**Compressor Speed**	**Fan kW**	**Comp kW**	**Total kW**	**Total kWh**
95	14	100%	100%	0.6	6.0	6.6	91.98
90	21	100%	100%	0.6	6.0	6.6	137.97
85	64	100%	100%	0.6	6.0	6.6	420.48
80	156	90%	90%	0.4	4.6	5.0	787.58
75	211	80%	80%	0.3	3.4	3.8	793.55
70	287	70%	70%	0.2	2.5	2.7	773.02
65	301	60%	0%	0.2	0.0	0.2	46.33
60	281	50%	0%	0.1	0.0	0.1	27.42
55	257	50%	0%	0.1	0.0	0.1	25.08
50	295	60%	0%	0.2	0.0	0.2	45.41
45	163	70%	0%	0.2	0.0	0.2	36.89
40	164	80%	0%	0.3	0.0	0.3	51.82
35	204	90%	0%	0.4	0.0	0.4	86.53
30	213	100%	0%	0.6	0.0	0.6	117.58
25	136	100%	0%	0.6	0.0	0.6	75.07
20	84	100%	0%	0.6	0.0	0.6	46.37
15	51	100%	0%	0.6	0.0	0.6	28.15
10	16	100%	0%	0.6	0.0	0.6	8.83
5	2	100%	0%	0.6	0.0	0.6	1.10
0	0	100%	0%	0.6	0.0	0.6	-
Total							**3,601**

RTU 2							
Temp Bin	**Hours (8-5)**	**Fan Speed**	**Compressor Speed**	**Fan kW**	**Comp kW**	**Total kW**	**Total kWh**
95	14	100%	100%	0.6	6.0	6.6	91.98
90	21	100%	100%	0.6	6.0	6.6	137.97
85	64	100%	100%	0.6	6.0	6.6	420.48
80	156	90%	90%	0.4	4.6	5.0	787.58
75	211	80%	80%	0.3	3.4	3.8	793.55
70	287	70%	70%	0.2	2.5	2.7	773.02
65	301	60%	0%	0.2	0.0	0.2	46.33
60	281	50%	0%	0.1	0.0	0.1	27.42
55	257	50%	0%	0.1	0.0	0.1	25.08
50	295	60%	0%	0.2	0.0	0.2	45.41
45	163	70%	0%	0.2	0.0	0.2	36.89
40	164	80%	0%	0.3	0.0	0.3	51.82
35	204	90%	0%	0.4	0.0	0.4	86.53
30	213	100%	0%	0.6	0.0	0.6	117.58
25	136	100%	0%	0.6	0.0	0.6	75.07
20	84	100%	0%	0.6	0.0	0.6	46.37
15	51	100%	0%	0.6	0.0	0.6	28.15
10	16	100%	0%	0.6	0.0	0.6	8.83
5	2	100%	0%	0.6	0.0	0.6	1.10
0	0	100%	0%	0.6	0.0	0.6	-
Total							**3,601**

RTU 3							
Temp Bin	Hours (8-5)	Fan Speed	Compressor Speed	Fan kW	Comp kW	Total kW	Total kWh
95	14	100%	100%	0.6	6.0	6.6	91.98
90	21	100%	100%	0.6	6.0	6.6	137.97
85	64	100%	100%	0.6	6.0	6.6	420.48
80	156	90%	90%	0.4	4.6	5.0	787.58
75	211	80%	80%	0.3	3.4	3.8	793.55
70	287	70%	70%	0.2	2.5	2.7	773.02
65	301	60%	0%	0.2	0.0	0.2	46.33
60	281	50%	0%	0.1	0.0	0.1	27.42
55	257	50%	0%	0.1	0.0	0.1	25.08
50	295	60%	0%	0.2	0.0	0.2	45.41
45	163	70%	0%	0.2	0.0	0.2	36.89
40	164	80%	0%	0.3	0.0	0.3	51.82
35	204	90%	0%	0.4	0.0	0.4	86.53
30	213	100%	0%	0.6	0.0	0.6	117.58
25	136	100%	0%	0.6	0.0	0.6	75.07
20	84	100%	0%	0.6	0.0	0.6	46.37
15	51	100%	0%	0.6	0.0	0.6	28.15
10	16	100%	0%	0.6	0.0	0.6	8.83
5	2	100%	0%	0.6	0.0	0.6	1.10
0	0	100%	0%	0.6	0.0	0.6	-
Total							**3,601**

RTU 4							
Temp Bin	Hours (8-5)	Fan Speed	Compressor Speed	Fan kW	Comp kW	Total kW	Total kWh
95	14	100%	100%	0.6	6.0	6.6	91.98
90	21	100%	100%	0.6	6.0	6.6	137.97
85	64	100%	100%	0.6	6.0	6.6	420.48
80	156	90%	90%	0.4	4.6	5.0	787.58
75	211	80%	80%	0.3	3.4	3.8	793.55
70	287	70%	70%	0.2	2.5	2.7	773.02
65	301	60%	0%	0.2	0.0	0.2	46.33
60	281	50%	0%	0.1	0.0	0.1	27.42
55	257	50%	0%	0.1	0.0	0.1	25.08
50	295	60%	0%	0.2	0.0	0.2	45.41
45	163	70%	0%	0.2	0.0	0.2	36.89
40	164	80%	0%	0.3	0.0	0.3	51.82
35	204	90%	0%	0.4	0.0	0.4	86.53
30	213	100%	0%	0.6	0.0	0.6	117.58
25	136	100%	0%	0.6	0.0	0.6	75.07
20	84	100%	0%	0.6	0.0	0.6	46.37
15	51	100%	0%	0.6	0.0	0.6	28.15
10	16	100%	0%	0.6	0.0	0.6	8.83
5	2	100%	0%	0.6	0.0	0.6	1.10
0	0	100%	0%	0.6	0.0	0.6	-
Total							**3,601**

RTU 5							
Temp Bin	Hours (8-5)	Fan Speed	Compressor Speed	Fan kW	Comp kW	Total kW	Total kWh
95	14	100%	100%	2.7	9.1	11.8	164.92
90	21	100%	100%	2.7	9.1	11.8	247.38
85	64	100%	100%	2.7	9.1	11.8	753.92
80	156	90%	90%	2.1	7.0	9.1	1,412.13
75	211	80%	80%	1.5	5.2	6.7	1,422.83
70	287	70%	70%	1.1	3.7	4.8	1,386.03
65	301	60%	0%	0.8	0.0	0.8	226.79
60	281	50%	0%	0.5	0.0	0.5	134.22
55	257	50%	0%	0.5	0.0	0.5	122.76
50	295	60%	0%	0.8	0.0	0.8	222.27
45	163	70%	0%	1.1	0.0	1.1	180.56
40	164	80%	0%	1.5	0.0	1.5	253.66
35	204	90%	0%	2.1	0.0	2.1	423.57
30	213	100%	0%	2.7	0.0	2.7	575.53
25	136	100%	0%	2.7	0.0	2.7	367.47
20	84	100%	0%	2.7	0.0	2.7	226.97
15	51	100%	0%	2.7	0.0	2.7	137.80
10	16	100%	0%	2.7	0.0	2.7	43.23
5	2	100%	0%	2.7	0.0	2.7	5.40
0	0	100%	0%	2.7	0.0	2.7	-
Total							8,307

RTU 6							
Temp Bin	Hours (8-5)	Fan Speed	Compressor Speed	Fan kW	Comp kW	Total kW	Total kWh
95	14	100%	100%	2.7	9.1	11.8	164.92
90	21	100%	100%	2.7	9.1	11.8	247.38
85	64	100%	100%	2.7	9.1	11.8	753.92
80	156	90%	90%	2.1	7.0	9.1	1,412.13
75	211	80%	80%	1.5	5.2	6.7	1,422.83
70	287	70%	70%	1.1	3.7	4.8	1,386.03
65	301	60%	0%	0.8	0.0	0.8	226.79
60	281	50%	0%	0.5	0.0	0.5	134.22
55	257	50%	0%	0.5	0.0	0.5	122.76
50	295	60%	0%	0.8	0.0	0.8	222.27
45	163	70%	0%	1.1	0.0	1.1	180.56
40	164	80%	0%	1.5	0.0	1.5	253.66
35	204	90%	0%	2.1	0.0	2.1	423.57
30	213	100%	0%	2.7	0.0	2.7	575.53
25	136	100%	0%	2.7	0.0	2.7	367.47
20	84	100%	0%	2.7	0.0	2.7	226.97
15	51	100%	0%	2.7	0.0	2.7	137.80
10	16	100%	0%	2.7	0.0	2.7	43.23
5	2	100%	0%	2.7	0.0	2.7	5.40
0	0	100%	0%	2.7	0.0	2.7	-
Total							8,307

Unoccupied Operating Profile

RTU 1							
Temp Bin	Off Hours	Fan Speed	Compressor Speed	Fan kW	Comp kW	Total kW	Total kWh
95	0	30%	30%	0.0	0.3	0.3	-
90	2	30%	30%	0.0	0.3	0.3	0.65
85	12	30%	30%	0.0	0.3	0.3	3.89
80	54	30%	30%	0.0	0.3	0.3	17.49
75	135	30%	30%	0.0	0.3	0.3	43.72
70	277	20%	20%	0.0	0.1	0.1	32.56
65	574	20%	20%	0.0	0.1	0.1	67.46
60	756	0%	0%	0.0	0.0	0.0	-
55	557	0%	0%	0.0	0.0	0.0	-
50	559	20%	0%	0.0	0.0	0.0	5.52
45	433	20%	0%	0.0	0.0	0.0	4.28
40	580	30%	0%	0.0	0.0	0.0	15.78
35	504	30%	0%	0.0	0.0	0.0	13.71
30	411	30%	0%	0.0	0.0	0.0	11.18
25	302	30%	0%	0.0	0.0	0.0	8.22
20	390	30%	0%	0.0	0.0	0.0	10.61
15	162	30%	0%	0.0	0.0	0.0	4.41
10	74	30%	0%	0.0	0.0	0.0	2.01
5	47	30%	0%	0.0	0.0	0.0	1.28
0	11	30%	0%	0.0	0.0	0.0	0.30
Total							**243**

RTU 2							
Temp Bin	Hours (8-5)	Fan Speed	Compressor Speed	Fan kW	Comp kW	Total kW	Total kWh
95	0	30%	30%	0.0	0.3	0.3	-
90	2	30%	30%	0.0	0.3	0.3	0.65
85	12	30%	30%	0.0	0.3	0.3	3.89
80	54	30%	30%	0.0	0.3	0.3	17.49
75	135	30%	30%	0.0	0.3	0.3	43.72
70	277	20%	20%	0.0	0.1	0.1	32.56
65	574	20%	20%	0.0	0.1	0.1	67.46
60	756	0%	0%	0.0	0.0	0.0	-
55	557	0%	0%	0.0	0.0	0.0	-
50	559	20%	0%	0.0	0.0	0.0	5.52
45	433	20%	0%	0.0	0.0	0.0	4.28
40	580	30%	0%	0.0	0.0	0.0	15.78
35	504	30%	0%	0.0	0.0	0.0	13.71
30	411	30%	0%	0.0	0.0	0.0	11.18
25	302	30%	0%	0.0	0.0	0.0	8.22
20	390	30%	0%	0.0	0.0	0.0	10.61
15	162	30%	0%	0.0	0.0	0.0	4.41
10	74	30%	0%	0.0	0.0	0.0	2.01
5	47	30%	0%	0.0	0.0	0.0	1.28
0	11	30%	0%	0.0	0.0	0.0	0.30
Total							**243**

RTU 3							
Temp Bin	Hours (8-5)	Fan Speed	Compressor Speed	Fan kW	Comp kW	Total kW	Total kWh
95	0	30%	30%	0.0	0.3	0.3	-
90	2	30%	30%	0.0	0.3	0.3	0.65
85	12	30%	30%	0.0	0.3	0.3	3.89
80	54	30%	30%	0.0	0.3	0.3	17.49
75	135	30%	30%	0.0	0.3	0.3	43.72
70	277	20%	20%	0.0	0.1	0.1	32.56
65	574	20%	20%	0.0	0.1	0.1	67.46
60	756	0%	0%	0.0	0.0	0.0	-
55	557	0%	0%	0.0	0.0	0.0	-
50	559	20%	0%	0.0	0.0	0.0	5.52
45	433	20%	0%	0.0	0.0	0.0	4.28
40	580	30%	0%	0.0	0.0	0.0	15.78
35	504	30%	0%	0.0	0.0	0.0	13.71
30	411	30%	0%	0.0	0.0	0.0	11.18
25	302	30%	0%	0.0	0.0	0.0	8.22
20	390	30%	0%	0.0	0.0	0.0	10.61
15	162	30%	0%	0.0	0.0	0.0	4.41
10	74	30%	0%	0.0	0.0	0.0	2.01
5	47	30%	0%	0.0	0.0	0.0	1.28
0	11	30%	0%	0.0	0.0	0.0	0.30
Total							243

RTU 4							
Temp Bin	Hours (8-5)	Fan Speed	Compressor Speed	Fan kW	Comp kW	Total kW	Total kWh
95	0	30%	30%	0.0	0.3	0.3	-
90	2	30%	30%	0.0	0.3	0.3	0.65
85	12	30%	30%	0.0	0.3	0.3	3.89
80	54	30%	30%	0.0	0.3	0.3	17.49
75	135	30%	30%	0.0	0.3	0.3	43.72
70	277	20%	20%	0.0	0.1	0.1	32.56
65	574	20%	20%	0.0	0.1	0.1	67.46
60	756	0%	0%	0.0	0.0	0.0	-
55	557	0%	0%	0.0	0.0	0.0	-
50	559	20%	0%	0.0	0.0	0.0	5.52
45	433	20%	0%	0.0	0.0	0.0	4.28
40	580	30%	0%	0.0	0.0	0.0	15.78
35	504	30%	0%	0.0	0.0	0.0	13.71
30	411	30%	0%	0.0	0.0	0.0	11.18
25	302	30%	0%	0.0	0.0	0.0	8.22
20	390	30%	0%	0.0	0.0	0.0	10.61
15	162	30%	0%	0.0	0.0	0.0	4.41
10	74	30%	0%	0.0	0.0	0.0	2.01
5	47	30%	0%	0.0	0.0	0.0	1.28
0	11	30%	0%	0.0	0.0	0.0	0.30
Total							243

RTU 5							
Temp Bin	Hours (8-5)	Fan Speed	Compressor Speed	Fan kW	Comp kW	Total kW	Total kWh
95	0	30%	30%	0.1	0.4	0.6	-
90	2	30%	30%	0.1	0.4	0.6	1.16
85	12	30%	30%	0.1	0.4	0.6	6.97
80	54	30%	30%	0.1	0.4	0.6	31.36
75	135	30%	30%	0.1	0.4	0.6	78.39
70	277	20%	20%	0.0	0.2	0.2	58.37
65	574	20%	20%	0.0	0.2	0.2	120.96
60	756	0%	0%	0.0	0.0	0.0	-
55	557	0%	0%	0.0	0.0	0.0	-
50	559	20%	0%	0.0	0.0	0.0	27.02
45	433	20%	0%	0.0	0.0	0.0	20.93
40	580	30%	0%	0.1	0.0	0.1	77.25
35	504	30%	0%	0.1	0.0	0.1	67.13
30	411	30%	0%	0.1	0.0	0.1	54.74
25	302	30%	0%	0.1	0.0	0.1	40.22
20	390	30%	0%	0.1	0.0	0.1	51.95
15	162	30%	0%	0.1	0.0	0.1	21.58
10	74	30%	0%	0.1	0.0	0.1	9.86
5	47	30%	0%	0.1	0.0	0.1	6.26
0	11	30%	0%	0.1	0.0	0.1	1.47
Total							676

RTU 6							
Temp Bin	Hours (8-5)	Fan Speed	Compressor Speed	Fan kW	Comp kW	Total kW	Total kWh
95	0	30%	30%	0.1	0.4	0.6	-
90	2	30%	30%	0.1	0.4	0.6	1.16
85	12	30%	30%	0.1	0.4	0.6	6.97
80	54	30%	30%	0.1	0.4	0.6	31.36
75	135	30%	30%	0.1	0.4	0.6	78.39
70	277	20%	20%	0.0	0.2	0.2	58.37
65	574	20%	20%	0.0	0.2	0.2	120.96
60	756	0%	0%	0.0	0.0	0.0	-
55	557	0%	0%	0.0	0.0	0.0	-
50	559	20%	0%	0.0	0.0	0.0	27.02
45	433	20%	0%	0.0	0.0	0.0	20.93
40	580	30%	0%	0.1	0.0	0.1	77.25
35	504	30%	0%	0.1	0.0	0.1	67.13
30	411	30%	0%	0.1	0.0	0.1	54.74
25	302	30%	0%	0.1	0.0	0.1	40.22
20	390	30%	0%	0.1	0.0	0.1	51.95
15	162	30%	0%	0.1	0.0	0.1	21.58
10	74	30%	0%	0.1	0.0	0.1	9.86
5	47	30%	0%	0.1	0.0	0.1	6.26
0	11	30%	0%	0.1	0.0	0.1	1.47
Total							676

Temp Bin	Occupied					Unoccupied				
	Hours (8-5)	Fan % load	Compressor % load	Total kW	Total kWh	Off Hours	Fan % load	Compressor % load	Total kW	Total kWh
95	14	100%	100%	49.8	698	0	30%	30%	2.5	-
90	21	100%	100%	49.8	1,047	2	30%	30%	2.5	5
85	64	100%	100%	49.8	3,190	12	30%	30%	2.5	29
80	156	90%	90%	38.3	5,975	54	30%	30%	2.5	133
75	211	80%	80%	28.5	6,020	135	30%	30%	2.5	332
70	287	70%	70%	20.4	5,864	277	20%	20%	0.9	247
65	301	60%	0%	2.1	639	574	20%	20%	0.9	512
60	281	50%	0%	1.3	378	756	0%	0%	-	-
55	257	50%	0%	1.3	346	557	0%	0%	-	-
50	295	60%	0%	2.1	626	559	20%	0%	0.1	76
45	163	70%	0%	3.1	509	433	20%	0%	0.1	59
40	164	80%	0%	4.4	715	580	30%	0%	0.4	218
35	204	90%	0%	5.8	1,193	504	30%	0%	0.4	189
30	213	100%	0%	7.6	1,621	411	30%	0%	0.4	154
25	136	100%	0%	7.6	1,035	302	30%	0%	0.4	113
20	84	100%	0%	7.6	639	390	30%	0%	0.4	146
15	51	100%	0%	7.6	388	162	30%	0%	0.4	61
10	16	100%	0%	7.6	122	74	30%	0%	0.4	28
5	2	100%	0%	7.6	15	47	30%	0%	0.4	18
0	0	100%	0%	7.6	-	11	30%	0%	0.4	4
Total					**31,020**		**N/A**	**N/A**	**N/A**	**2,323**

Natural Gas Calculations

General Info				Heating (Btu/hr)	
RTU	Floor	Make	Model	Input Max	Output
1	2nd	Lennox	GCS16 - 060 - 120 - 1Y	120,000.00	96,000.00
2	2nd	Lennox	GCS16 - 060 - 120 - 1Y	120,000.00	96,000.00
3	1st	Lennox	GCS16 - 060 - 120 - 1Y	120,000.00	96,000.00
4	1st	Lennox	GCS16 - 060 - 120 - 1Y	120,000.00	96,000.00
5	3rd	Lennox	GCS24 - 953 - 200 - 1Y	200,000.00	160,000.00
6	3rd	Lennox	GCS24 - 953 - 200 - 1Y	200,000.00	160,000.00
Total				880,000.00	704,000.00

Temp Bin	All hours	Therms	Btu/hr	% Load - Baseline	Proposed Load Adjustment	Proposed Therms
95	14	-	-	0%	0%	-
90	23	-	-	0%	0%	-
85	76	-	-	0%	0%	-
80	210	-	-	0%	0%	-
75	346	-	-	0%	0%	-
70	564	-	-	0%	0%	-
65	875	-	-	0%	0%	-
60	1037	-	-	0%	50%	-
55	814	-	-	0%	50%	-
50	854	50	5,817	1%	60%	30
45	596	119	20,017	2%	70%	84
40	744	189	25,393	3%	80%	151
35	708	259	36,519	4%	90%	233
30	624	328	52,593	6%	100%	328
25	438	398	90,823	10%	100%	398
20	474	467	98,614	11%	100%	467
15	213	537	252,140	29%	100%	537
10	90	607	674,094	77%	100%	607
Total		2,954				2,834

Appendix D

Heat Pump Calculations

for

425 Cherry Street

Town of Bedford Hills

Electric Energy Savings

Performance During Operating Hours

				Total Load - RTU Controls Package			ASHP		VRF		GSHP		GSHP VRF	
Temp Bin	**Hours (8-5)**	**Fan Speed**	**Compressor Speed**	**kW**	**kWh**	**BTU/hr**	**kW**	**kWh**	**kW**	**kWh**	**kW**	**kWh**	**kW**	**kWh**
95	14	100%	100%	49.8	698	498,400	33.2	465	19.9	279	20.9	292	15.1	212
90	21	100%	100%	49.8	1,047	498,400	33.2	698	19.9	419	20.9	438	15.1	318
85	64	100%	100%	49.8	3,190	498,400	33.2	2,127	19.9	1,276	20.9	1,335	15.1	970
80	156	90%	90%	38.3	5,975	382,987	25.5	3,983	15.3	2,390	16.0	2,500	11.6	1,816
75	211	80%	80%	28.5	6,020	285,301	19.0	4,013	11.4	2,408	11.9	2,519	8.7	1,830
70	287	70%	70%	20.4	5,864	204,326	13.6	3,909	8.2	2,346	8.5	2,454	6.2	1,782
65	301	60%	0%	2.1	639	21,226	1.4	426	0.8	256	0.9	267	0.6	194
60	281	50%	0%	1.3	378	13,456	0.9	252	0.5	151	0.6	158	0.4	115
55	257	50%	0%	1.3	346	13,456	0.9	231	0.5	138	0.6	145	0.4	105
50	295	60%	0%	2.1	626	21,226	1.4	417	0.8	250	0.9	262	0.6	190
45	163	70%	0%	3.1	509	31,206	2.1	339	1.2	203	1.3	213	0.9	155
40	164	80%	0%	4.4	715	43,574	2.9	476	1.7	286	1.8	299	1.3	217
35	204	90%	0%	5.8	1,193	58,493	3.9	796	2.3	477	2.4	499	1.8	363
30	213	100%	0%	7.6	1,621	76,120	5.1	1,081	3.0	649	3.2	678	2.3	493
25	136	100%	0%	7.6	1,035	76,120	5.1	690	3.0	414	3.2	433	2.3	315
20	84	100%	0%	7.6	639	76,120	5.1	426	3.0	256	3.2	268	2.3	194
15	51	100%	0%	7.6	388	76,120	5.1	259	3.0	155	3.2	162	2.3	118
10	16	100%	0%	7.6	122	76,120	5.1	81	3.0	49	3.2	51	2.3	37
5	2	100%	0%	7.6	15	76,120	5.1	10	3.0	6	3.2	6	2.3	5
0	0	100%	0%	7.6	-	76,120	5.1	-	3.0	-	3.2	-	2.3	-
Total					**31,020**			**20,680**		**12,408**		**12,979**		**9,428**

Performance During Off Hours

				Total Load - RTU Controls Package			ASHP		VRF		GSHP		GSHP VRF	
Temp Bin	**Off Hours**	**Fan Speed**	**Compressor Speed**	**kW**	**kWh**	**BTU/hr**	**kW**	**kWh**	**kW**	**kWh**	**kW**	**kWh**	**kW**	**kWh**
95	0	30%	30%	2.5	-	24,569	1.6	-	1.0	-	1.0	-	0.7	-
90	2	30%	30%	2.5	5	24,569	1.6	3	1.0	2	1.0	2	0.7	1
85	12	30%	30%	2.5	29	24,569	1.6	20	1.0	12	1.0	12	0.7	9
80	54	30%	30%	2.5	133	24,569	1.6	88	1.0	53	1.0	56	0.7	40
75	135	30%	30%	2.5	332	24,569	1.6	221	1.0	133	1.0	139	0.7	101
70	277	20%	20%	0.9	247	8,916	0.6	165	0.4	99	0.4	103	0.3	75
65	574	20%	20%	0.9	512	8,916	0.6	341	0.4	205	0.4	214	0.3	156
60	756	0%	0%	-	-	-	-	-	-	-	-	-	-	-
55	557	0%	0%	-	-	-	-	-	-	-	-	-	-	-
50	559	20%	0%	0.1	76	1,362	0.1	51	0.1	30	0.1	32	0.0	23
45	433	20%	0%	0.1	59	1,362	0.1	39	0.1	24	0.1	25	0.0	18
40	580	30%	0%	0.4	218	3,752	0.3	145	0.2	87	0.2	91	0.1	66
35	504	30%	0%	0.4	189	3,752	0.3	126	0.2	76	0.2	79	0.1	57
30	411	30%	0%	0.4	154	3,752	0.3	103	0.2	62	0.2	65	0.1	47
25	302	30%	0%	0.4	113	3,752	0.3	76	0.2	45	0.2	47	0.1	34
20	390	30%	0%	0.4	146	3,752	0.3	98	0.2	59	0.2	61	0.1	44
15	162	30%	0%	0.4	61	3,752	0.3	41	0.2	24	0.2	25	0.1	18
10	74	30%	0%	0.4	28	3,752	0.3	19	0.2	11	0.2	12	0.1	8
5	47	30%	0%	0.4	18	3,752	0.3	12	0.2	7	0.2	7	0.1	5
0	11	30%	0%	0.4	4	3,752	0.3	3	0.2	2	0.2	2	0.1	1
								1,549		**929**		**972**		**706**

Natural Gas Energy Savings

			Total Load - RTU Controls Package			ASHP		VRF		GSHP		GSHP VRF	
Temp Bin	All hours	%load	Therms	BTU/hr	Output btu/hr	kW	kWh	kW	kWh	kW	kWh	kW	kWh
95	14	0%	-	-	-	-	-	-	-	-	-	-	-
90	23	0%	-	-	-	-	-	-	-	-	-	-	-
85	76	0%	-	-	-	-	-	-	-	-	-	-	-
80	210	0%	-	-	-	-	-	-	-	-	-	-	-
75	346	0%	-	-	-	-	-	-	-	-	-	-	-
70	564	0%	-	-	-	-	-	-	-	-	-	-	-
65	875	0%	-	-	-	-	-	-	-	-	-	-	-
60	1037	0%	-	-	-	-	-	-	-	-	-	-	-
55	814	0%	-	-	-	-	-	-	-	-	-	-	-
50	854	0%	30	3,490	2,792	0.2	200	0.2	188	0.2	166	0.2	132
45	596	2%	84	14,012	11,209	0.9	559	0.9	528	0.8	466	0.6	369
40	744	2%	151	20,315	16,252	1.4	1,012	1.3	955	1.1	844	0.9	668
35	708	4%	233	32,867	26,293	2.2	1,558	2.1	1,470	1.8	1,299	1.5	1,029
30	624	6%	328	52,593	42,074	3.5	2,198	3.3	2,073	2.9	1,832	2.3	1,451
25	438	10%	398	90,823	72,659	6.1	2,664	5.7	2,513	5.1	2,220	4.0	1,759
20	474	11%	467	98,614	78,891	6.6	3,130	6.2	2,953	5.5	2,609	4.4	2,067
15	213	29%	537	252,140	201,712	16.9	3,597	15.9	3,393	14.1	2,997	11.2	2,375
10	90	77%	607	674,094	539,276	45.1	4,063	42.6	3,833	37.6	3,386	29.8	2,683
Total			**2,834**				**18,982**		**17,907**		**15,818**		**12,535**

Summary

	Cooling + Fan Energy			Heating						
Technology	kWh Usage	kWh Savings	Cost Savings	Therms Usage	Therms Savings	Cost Savings - NG	Added electric load	Added Electric Cost	Cost Savings	Total cost savings
Baseline	59,412	N/A	N/A	2,954	N/A	N/A	N/A	N/A	N/A	N/A
RTU Controls Package	33,343	26,069	$ 2,765	2,834	119	$ 89.95	N/A	N/A	N/A	$ 2,765
ASHP	22,229	37,183	$ 3,943	-	2,954	$ 2,227.09	18,982	$ 2,012.99	$ 214.10	$ 4,157
VRF	13,337	46,075	$ 4,886	-	2,954	$ 2,227.09	17,907	$ 1,899.05	$ 328.04	$ 5,214
GSHP	13,951	45,461	$ 4,821	-	2,954	$ 2,227.09	15,818	$ 1,677.49	$ 549.60	$ 5,371
GSHP VRF	10,135	49,277	$ 5,226	-	2,954	$ 2,227.09	12,535	$ 1,329.33	$ 897.76	$ 6,124