

ENERGY EFFICIENT MEASURES TO REDUCE ELECTRICAL ENERGY USE IN
COMMERCIAL BUILDINGS IN NEW YORK CITY

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To my son, since you came to my life all I do is for you, you are my motive to keep going and be a better person everyday, thanks for illuminating my life and for all the love you give me with each and everything you do, I love you more than words can describe.

To my family thank you for your love, patience, support and unwavering belief in me, without you I would be the person I am today.

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To my friends, classmates and professors who were with me over the years, thanks for all the happy moments and for leave footprints that marked my life.

GLOSSARY

EEM: Energy Efficiency Measure.

LEED: Leadership in Energy and Environmental Design.

LEED NC V3: Leadership in Energy and Environmental Design for New Construction and Major Renovations, Version 3.

GSF: Gross Square Footage

ASHRAE: American Society of Heating, Refrigerating, and Air-Conditioning Engineers

USGBC: United States Green Building Council

HVAC: Heating, Ventilating, and Air Conditioning

LPD: Lighting Power Density

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1. INTRODUCTION

Buildings in United States represents 40% of energy use in the country, this corresponds to about 10% of global energy use and contributes as much as 30% of a building operating cost (Stroupe, 2010). The importance of a green construction has become one of the greatest challenges for engineers who have to deal with energy efficiency measures, which means using less energy to achieve same results or use the same amount of energy to produce a better result. Here is where sustainability and environmental quality start a relationship that can be address as “Environmental Sustainability”, the balance between satisfy human needs while preserving the natural processes of the environment.

2. OBJECTIVES

2.1 General Objective

The purpose of this thesis is to show an actual energy analysis of a residential building locate in New York City, implementing a simulation-based control approach to analyzed the primary energy use and annual cost in a new residential building in order to achieve The Leadership in Energy & Environmental Design (LEED) certification.

2.2 Specific Objectives

- 2.2.1 Create a model that is able to act almost as the real building and track its physical behavior using DOE2-eQuest¹
- 2.2.2 Demonstrate a percentage improvement in the proposed building performance compared with the baseline building.
- 2.2.3 Utilize energy efficient measures to reduce electrical energy use and aims to achieve LEED certification

¹ DOE-2 is a widely used and accepted freeware building energy analysis program that can predict the energy use and cost for all types of buildings. DOE-2 uses a description of the building layout, constructions, operating schedules, conditioning systems (lighting, HVAC, etc.) and utility rates provided by the user, along with weather data, to perform an hourly simulation of the building and to estimate utility bills. (Hirsch, 2012)

3. ENERGY SIMULATION SUMMARY

GEA Consulting Engineers, acting as the design engineers, was hired by the owner, East Village 207 Residential LLC² for energy modeling for compliance with LEED NC V3. This report details the results of the energy simulation done with the 100% construction documents. This report only refers to entities within the LEED³ project boundary.

The project consists of a new eight-story high-end residential condominium building with 81 units, as shown in illustration 1, and approximately 117,905 GSF, equivalent to 10,953.73 m², is located at 211 E 13th Street in New York, NY.

The residential portion of the building will function 24-7. The design goal is to utilize energy efficient measures to reduce electrical energy use and aims to achieve LEED certification.

² A Limited Liability Company (LLC) is a hybrid type of legal structure that provides the limited liability features of a corporation and the tax efficiencies and operational flexibility of a partnership. (Brady, 2014)

³ LEED, or Leadership in Energy & Environmental Design, is a green building certification program that recognizes best-in-class building strategies and practices. To receive LEED certification, building projects satisfy prerequisites and earn points to achieve different levels of certification. (USGBC, 2012)

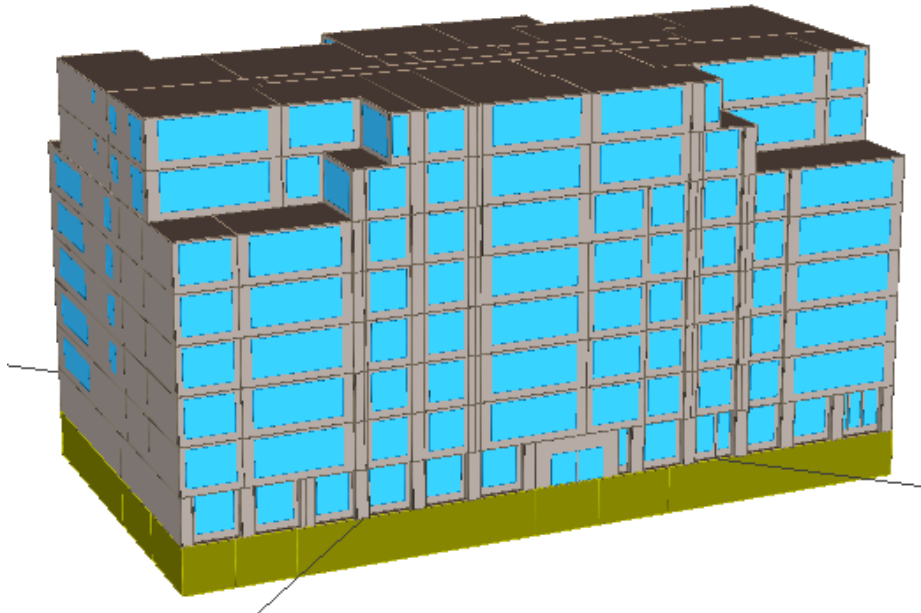


Illustration 1 – eQuest Building Model

LEED EA Credit 1⁴ requires a building to demonstrate a percentage improvement in the proposed building performance compared with the baseline building. The Credit rewards 1 point for achieving 12% reduction in energy costs. Additionally, the Credit rewards another point for each subsequent reduction of 2% in the building’s energy cost. The residential building at 211 E. 13th Street achieved a projected 30.6% energy cost savings percentage as shown in Table 1.

Building	Annual Energy Cost (\$)	Annual Savings (\$)	Annual Savings (% vs Base)	LEED EA Credit 1 Points
LEED Baseline	\$241,739	NA	NA	NA
Proposed Design	\$168,372	\$73,367	30.3%	10

Table 1 - Design vs Proposed Building Summary

⁴ Credit Category: Energy Atmosphere, Optimize Energy Performance

4. METODOLOGY

The model uses a utility structure created to reflect ConEdison's residential rate. It has an effective rate of \$0.23/kWh. This reflects monthly charges, peak demand rates. The natural gas rate follows a typical NYC firm gas rate. It is modeled on \$1.57/therm.

The building was modeled using DOE eQuest 3.64. The simulation was done in accordance with ASHRAE 90.1-2007 Appendix G: Performance Rating Method. All assumptions are based on modeling standards accepted by the USGBC for LEED applications.

4.1 References and Standards Used

- A. New York City Mechanical Code (2008)
- B. New York City Building Code (2008)
- C. New York City Energy Code (2011)
- D. ASHRAE Standard 90.1-2007
- E. ASHRAE Standard 62.1-2007
- F. ASHRAE Standard 55-2007
- G. Summer design conditions
 - i. Outside: 89 °F (32 °C) db, 73°F (23 °C) wb
 - ii. Inside: 78 °F (26 °C) db, 50% RH
- H. Winter design conditions
 - i. Outside: 12 °F (-11 °C)
 - ii. Inside: 70 °F (21 °C)
- I. Occupancy
 - i. Occupancy load based on number of bedrooms for all apartments

5. BASELINE BUILDING DESCRIPTION

The envelope has been designed to maximize views and daylight penetration while employing high performance materials and design to minimize energy consumption. These materials and design include:

- Orientation/exposure based construction selection
- Continuous insulation to prevent thermal bridging
- Continuous air barrier to reduce air infiltration
- Highly reflective pavers

The apartments will be constantly ventilated by Rooftop Units (RTUs). The RTUs will supply the common areas and the apartments with 100% outside air to serve as make-up air for the toilet exhaust. All bathroom exhaust will be returned to the RTU Energy Recovery Wheel and then exhausted to the outdoors. The apartment kitchen hood will be directly exhausted to the outdoors when the hood is operating.

The apartments will be individually conditioned by Variable Refrigerant Flow (VRF) system with heat recovery. The VRF systems are composed of indoor fan coil units and a rooftop mounted outdoor air-cooled condensing unit. The indoor units can operate in cooling and heating mode independently of operating mode (heating/cooling) of other indoor units connected to the same condensing units.

The system shall directly control HVAC equipment as specified in the Sequence of Operations for HVAC Controls. Each zone controller shall provide occupied and unoccupied modes of operation by individual zone. Energy conservation features such as night setback and demand level adjustment of setpoints as specified in the

control sequence of operations. Control wiring is installed in a daisy chain configuration from indoor unit to remote controllers.

The VRF Controls Network consists of remote controllers, schedule timers, system controllers, centralized controllers, and integrated web based interface communicating over a high-speed communication bus. VRF Controls Network supports operation monitoring, scheduling, error email distribution, personal browsers, tenant billing, online maintenance support, and could be integrated with Building Management Systems (BMS) using either LonWorks⁵ or BACnet⁶ interfaces. The control system shall consist of a high-speed, peer-to-peer network of DDC controllers and a web-based operator interface. A depiction of each mechanical system and building floor plan by a point-and-click graphic. A web server with a network interface card shall gather data from this system and generate web pages accessible through a conventional web browser on each PC connected to the network. The Owner shall provide an IP address to allow this system to be accessed, configured, and programmed via the Internet. The below figure illustrates a sample of the Controls Network Configuration

⁵ Local Operating Network is a networking platform specifically created to address the needs of control applications. The platform is built on a protocol created by Echelon Corporation for networking devices over media such as twisted pair, powerlines, fiber optics, and RF. It is used for the automation of various functions within buildings such as lighting and HVAC (<http://en.wikipedia.org/wiki/LonWorks>)

⁶ BACnet is a communications protocol for building automation and control networks. It is an ASHRAE, ANSI, and ISO 16484-5 standard protocol (<http://en.wikipedia.org/wiki/BACnet>)

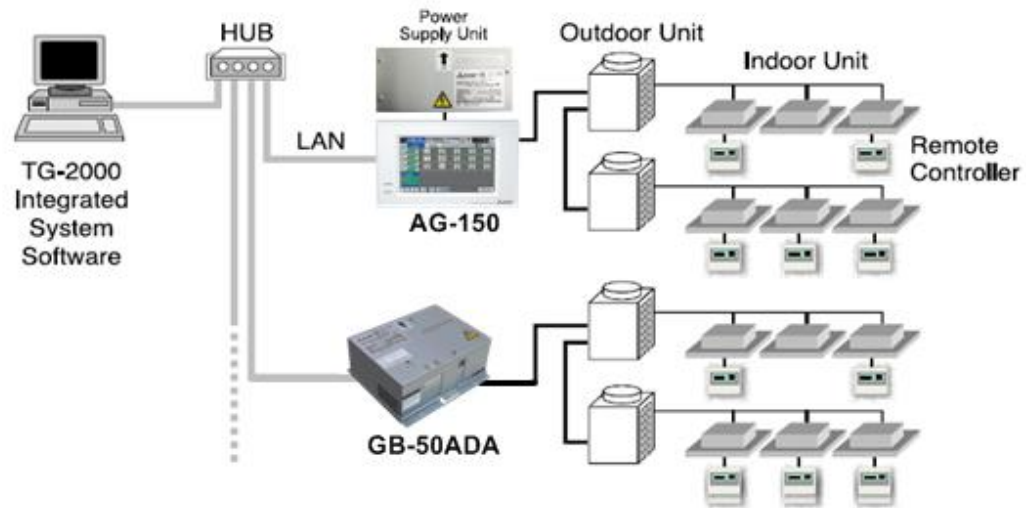


Illustration 2 - VRF Controls System Network

The building was designed with living spaces on the perimeter for interior lighting systems to allow natural light to have a deeper penetration into occupied spaces. This design allows values lower than code lighting densities to be installed and maintain equivalent quality of life. Energy Star rated appliances are installed throughout the building.

Gas fired condensing domestic water heaters with hot water storage tanks are installed. These water heaters are 98% efficient and feature high modulation capability for better load matching.

6. ENERGY EFFICIENCY MEASURES

The following is a summary of the Energy Efficiency Measures (EEMS). The savings shown in each table reflect the interactive savings of each EEM within the final design. It is important to note, that the order in which a parametric run of an EEM in the energy simulation is completed has a direct influence on its interactive savings. The savings shown in the 3rd and 4th columns of the summary tables are in reference to an EEM's savings when compared to the trial before. For example; EEM3 is run on a simulation that has already incorporated EEM1 and EEM2. The "stacking order" of EEM's means that EEM1 will always have the greatest potential savings because it is saving against the baseline model, which always has the highest annual energy cost. Therefore, it is important to analyze the entire design and not only focus on each parametric run.

6.1 EEM 1 – Variable Refrigerant Flow (VRF) HVAC System

A VRF with heat recovery system is used in the design building. The 100% OA Roof Top Units (RTU's) supply the space with all of its requisite fresh air. The VRF systems handle the cooling and heating of the apartment spaces. The VRF HVAC system is simulated against an ASHRAE building, which has Packaged Terminal Heat Pumps. Table 2 shows how this improved HVAC system saves 12.7% of the building's total annual energy cost. Illustrations 3 and 4 show the schematic diagram for the VRF and RTU's systems.

#	EEM	Annual Energy Cost (\$)	Annual Savings (\$)	Annual Savings (% vs Base)
-	Baseline Design	\$241,739	NA	NA
1	VRF HVAC System	\$210,946	\$30,793	12.7%

Table 2 - EEM 1 Summary

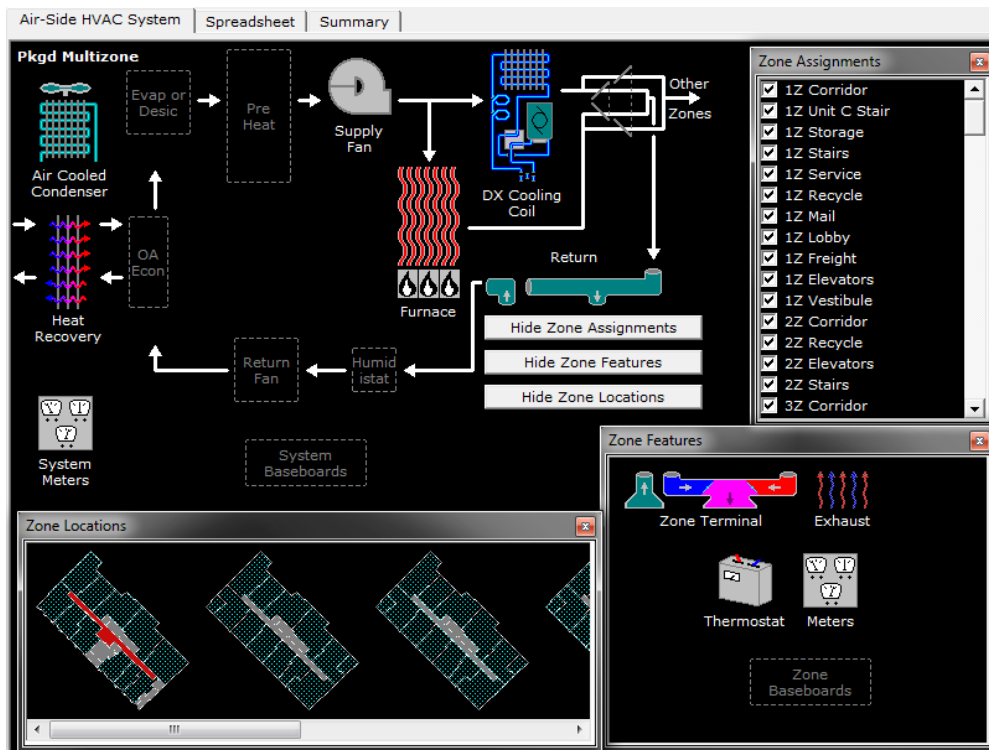


Illustration 3 - RTU-1 and RTU-2 Schematic

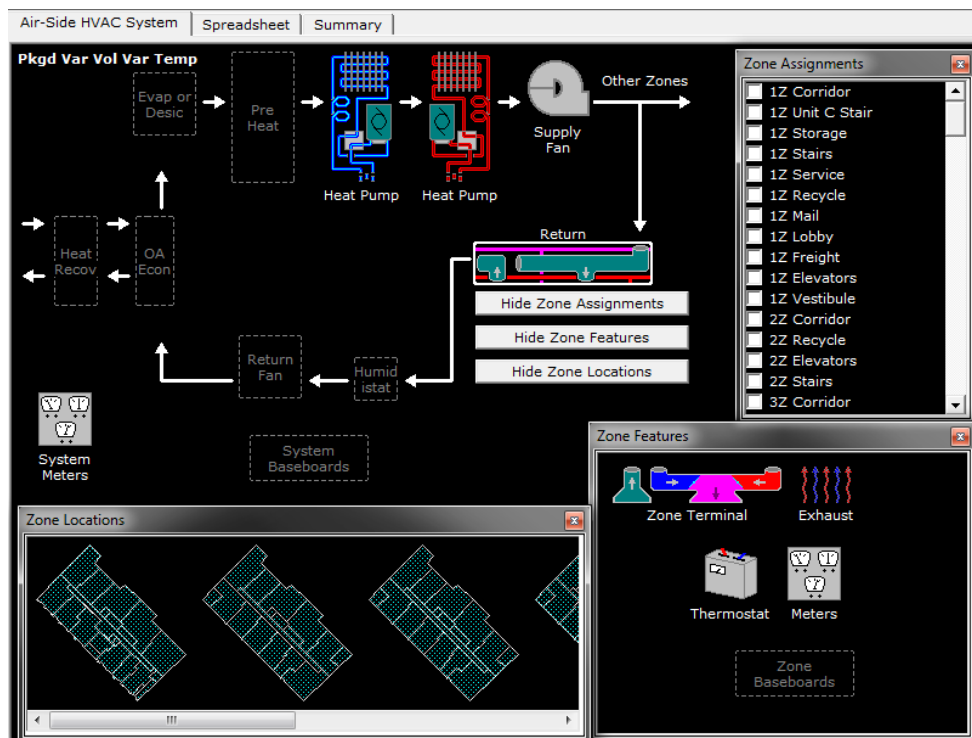


Illustration 4 - VRF Schematic

6.2 EEM 2 – Energy Recovery Ventilator (ERV)

An Energy Recovery Ventilator is installed on RTU-1 and RTU-2. The ERV uses a total energy wheel to pre-condition the entering outdoor air (OA) by exchanging sensible heat and water vapor the exhaust air (EA) stream. During the cooling season the energy wheel pre-cools and pre-dehumidifies the OA. The annual savings is shown in Table 3.

#	EEM	Annual Energy Cost (\$)	Annual Savings (\$)	Annual Savings (% vs Base)
-	Baseline Design	\$241,739	NA	NA
2	ERV	\$203,688	\$7,258	3.4%

Table 3 – EEM 2 Summary

6.3 EEM 3 – Design Window

The design windows are based on PPG Solarban 70 – 6mm modeled with Superspacer. The design conditions are shown in Table 4:

EEM	Building	Assembly U-Value	SHGC	Visible Transmittance
-	LEED Baseline	0.55	0.40	0.60
3	Proposed Design	0.38	0.23	0.60

Table 4 - EEM 3 Details

The design windows do not factor in any savings from interior shading devices such as curtains. The window improvement savings are shown in Table 5 below:

#	EEM	Annual Energy Cost (\$)	Annual Savings (\$)	Annual Savings (% vs Base)
-	Baseline Design	\$241,739	NA	NA
3	Design Window	\$196,022	\$7,666	3.6%

Table 5 - EEM 3 Summary

6.4 EEM 4 – Design Wall

This improved envelope includes better walls (both cellar and above grade) and roofing. The improved envelope does not include window improvements. The windows were already included in EEM 3. The design conditions for EEM 4 are show in Table 6 and the envelope improvement savings are shown in Table 7 below.

6.4.1 North and South Walls

- 4" Face Brick
- 1" Air Space
- 2 1/4" XPS rigid insulation, min R-12
- 6" Korfil insulated cmu, min R-6
- 1" Air Space
- 3 5/8" mtl stud
- 5/8" gwb

6.4.2 East and West Walls

- 4" Face Brick
- 1" Air Space
- 2 1/4" XPS rigid insulation, min R-12
- 8" High-R Korfil insulated cmu, min R-12
- 1" Air Space
- 3 5/8" mtl stud
- 5/8" gwb

6.4.3 Roof

- 2" Concrete Paver on Shim
- Filter Fabric
- 4" Rigid Insulation
- Drainage Mat
- Protection Board
- 8" Cast in Place Concrete Slab

These design conditions were modeled as:

Building	Assembly U-Value
LEED Baseline	0.065
Proposed North/South	0.045
Proposed East/West	0.035
Party Walls	Adiabatic

Table 6 - EEM 4 Details

#	EEM	Annual Energy Cost (\$)	Annual Savings (\$)	Annual Savings (% vs Base)
-	Baseline Design	\$241,739	NA	NA
4	Design Wall	\$191,575	\$4,447	2.1%

Table 7 - EEM 4 Summary

6.5 EEM 5 – Design DHW

The baseline domestic water heaters are gas storage water heaters. Their efficiency is based on ASHRAE 90.1 2007 Table 7.8.

The design domestic water heaters are condensing gas storage water heaters. They have 260-gallon storage tanks and are 98% efficient. The design DHW Heater offers a four-stage burner, which allows the unit to better match the demand curve. Energy savings for water heater savings can be attributed to their modulation capabilities as much as their thermal efficiency. See Table 8 for annual savings.

#	EEM	Annual Energy Cost (\$)	Annual Savings (\$)	Annual Savings (% vs Base)
0	Baseline Design	\$241,739	NA	NA
5	Design DHW	\$183,782	\$7,793	3.7%

Table 8 - EEM 5 Summary

6.6 EEM 6 - Lighting Improvements

The baseline lighting densities are based on ASHRAE 90.1 maximum densities; see lighting details in Table 9.

Lighting Components	Baseline Design	Proposed Design
Apartment LPD (W/SF)	0.7 W/SF	0.6 W/SF
Common Area LPD (W/SF)	ASHRAE 90.1 Table 9.6.1 Baseline LPD's Lobby: 1.3 W/SF Corridor: 0.5 W/SF Stairs: 0.6 W/SF Storage, Active: 0.8 W/SF Storage, Inactive: 0.3 W/SF Restroom: 0.9 W/SF Office: 1.1 W/SF Multipurpose: 1.3 W/SF Elec/Mech: 1.5 W/SF	Baseline LPD's Lobby: 1.04 W/SF Corridor: 0.4 W/SF Stairs: 0.48 W/SF Storage, Active: 0.64 W/SF Storage, Inactive: 0.24 W/SF Restroom: 0.72 W/SF Office: 0.88 W/SF Multipurpose: 1.04 W/SF Elec/Mech: 1.2 W/SF
Lighting Controls (Spaces)	Time-of Day control or Occupancy Sensor Unless 24 Hour space	Time-of Day control or Occupancy Sensor Unless 24 Hour space
Exit Signs (kW)	5W/face	5 W/face
Garage Lighting (W/SF)	NA	NA
Exterior Lighting Power (kW)	Uncovered Parking: 0.15 W/SF Walkways less than 10 ft wide: 1.0 W/LF Building Entrances and Exits: 30 W/LF of door width of Main entries and 20 W/LF for other doors Canopies: 1.25 W/SF Outdoor Sales: 0.5 W/SF Facades: 0.2 W/SF for each illuminate wall 5.0 W/LF for each illumunited wall Parking near 24-hour retail entrances: 800 W per main entry	20% reduction in exterior lighting

Table 9 - EEM 6 Details

The lower lighting densities reduce both, the electrical consumption and demand from the lights. Also, there are auxiliary effects on the sizing of the HVAC system do to the lower internal gains produced by the appliances. Lighting annual savings shown in Table 10

#	EEM	Annual Energy Cost (\$)	Annual Savings (\$)	Annual Savings (% vs Base)
0	Baseline Design	\$241,739	NA	NA
6	Lighting Improvement	\$172,429	\$11,353	5.4%

Table 10 - EEM 6 Summary

6.7 EEM 7 - Energy Star Appliances

In residential multifamily buildings, appliances comprise a large portion of electricity and hot water consumption. Over the last decade, significant improvements in appliance efficiency have been made, and the EnergyStar label allows for recognition of these benefits. While the differences between a non-rated and an EnergyStar appliance may seem small, taken together these appliances dramatically reduce the overall energy consumption of the building. Refer to Table 11 for EnergyStar appliances details and Table 12 for annual water usage.

	Proposed	Baseline	Sensible	Latent
Refrigerator, kWh/yr-unit	423	529	Heat Ratio	Heat Ratio
Refrigerator, kWh/yr-bldg	34263	42849		
Refrigerator, W/SqFt	0.182	0.228	1.0	0.0
Electric Stove, kWh/yr-unit	Internal Energy Source	Internal Energy Source		
Electric Stove, kWh/yr-bldg	2126 BTUH per Apt	2126 BTUH per Apt		
Dishwasher, kWh/yr-unit	164	206		
Dishwasher, kWh/yr-bldg	13284	16686		
Dishwasher, W/SqFt	0.071	0.089	0.60	0.15
In-Unit Clothes Washer, kWh/yr	57	81		
In-Unit Clothes Washer, kWh/yr-bldg	4617	6561		
In-Unit Washer, W/SqFt	0.025	0.035	0.8	0.0
In-Unit Dryer, kWh/yr-bldg	4615	4615		
In-Unit Dryer, W/SqFt	0.025	0.025	1.00	0.00
Common Washer, kWh/yr-machine	138	196		
Common Washer, kWh/yr-bldg	11178	15876		

Table 11 - EEM 7 Details

Appliance Water Usage	Baseline Design	Proposed Design
Dishwasher (gal/yr)	1290 gal/yr	860 gal/yr
Clothes Washer (gal/yr)	2436 gal/yr	1127 gal/yr

Table 12 - EEM 7 Water Usage Details

The savings from a reduced hot water demand was factored into EEM 4 – Design DHW. EEM – 6 is only concerned with the lower electricity demand and consumption directly attributed to the more efficient equipment. There are auxiliary

effects on the sizing of the HVAC system do to the lower internal gains produced by the appliances. Table 13 shows the annual savings for EEM 7.

#	EEM	Annual Energy Cost (\$)	Annual Savings (\$)	Annual Savings (% vs Base)
0	Baseline Design	\$241,739	NA	NA
7	Energy Star Appliances	\$168,372	\$4,057	1.9%

Table 13 - EEM 7 Summary

7. RESULTS

The design building has all seven-energy efficiency measures incorporated into it. When these measures are all modeled together to create the Proposed Design they save **30.3%** of the annual energy cost of the building with an annual savings of **\$73,367**. These savings are illustrated in Table 14 below.

#	EEM	Annual Energy Cost (\$)	Annual Savings (\$)	Annual Savings (% vs Base)
0	Baseline Design	\$241,739	NA	NA
1	VRF HVAC System	\$210,946	\$30,793	12.7%
2	ERV	\$203,688	\$7,258	3.4%
3	Design Window	\$196,022	\$7,666	3.6%
4	Design Wall	\$191,575	\$4,447	2.1%
5	Design DHW	\$183,782	\$7,793	3.7%
6	Lighting Improvement	\$172,429	\$11,353	5.4%
7	Energy Star Appliances	\$168,372	\$4,057	1.9%
8	Proposed Design	\$168,372	\$73,367	30.3%

Table 14 - Baseline vs Proposed Design Summary

The design building saves 30.3% of the annual energy cost when compared to the ASHRAE 90.1 baseline building. This savings results in **10 LEED points**. The LEED NC EA Credit 1 rewards each 2% of savings above 12% with an additional LEED point.

8. CONCLUSIONS

After analyzing the data compiled on eQuest software using different EEM's that would help achieve significant energy savings, 30.3% of annual energy cost, was decided that the proposed building design would follow the following specifications.

The apartments will be condition by Variable Refrigerant Flow (VRF) systems; the spaces will be heated and cooled via concealed ducted horizontal Fan Coil Units (FCUs). These units are connected to air-cooled condensing units on the roof. The common area will use VRF systems too, that will condition the entrance lobby. The spaces will be heated and cooled via concealed ducted horizontal FCUs with a plenum return. These units are connected to air-cooled condensing units on the roof. An Energy Recovery Ventilator (ERV) will be installed in the occupied cellar space to capture the energy from the return air. The ERV will be provided with: Static Plate, heat transfer and humidity transfer

The air-cooled condensing units will be located on the main roof; they will serve the indoor FCUs. The two-pipe heat recovery system can operate simultaneously in cooling and heating mode. This units use R-410A refrigerant. The Roof Top Units that are located on the main roof will provide the outside air to the apartments, and common areas. The units are 100% outside air, DX/Gas Fired System. Supply air will be distributed via constant volume duct distribution system. The units will be provided with: Energy Recovery (Energy Wheel), 100% Air Side Economizer and DX/Gas Fired, Multi Stage cooling and modulating gas heating.

The domestic hot water will be available 24/7 year round (except for period of maintenance or mechanical failure). High Efficiency Modular Boilers will generate domestic hot water. A high efficiency hot water recirculation pump is also provided

to comply with plumbing code requirements and to compensate for the heat loss in supply distribution piping between the domestic hot water heater and fixtures.

A 500 kW diesel emergency generator will provide the emergency power. The generator will be roof mounted in outdoor sound/weatherproof enclosure and will service elevator, fire pump, fire alarm and telephone central equipment, egress lighting, lighting in toilet rooms and telephone equipment room, smoke purge fans.

The lighting will use a master time clock with photoelectric control for all entrance and site lighting, Bi-Level or occupancy sensors for common area lighting and master time clock control for lighting in corridors, exteriors, and other public areas.

The windows, wall and roof systems will be insulated for energy savings and acoustics. Shading and glazing with low solar heat gain coefficients to cut peak solar loads on South and West.

As a result of the energy simulation done, the design building is eligible to get the LEED certification.

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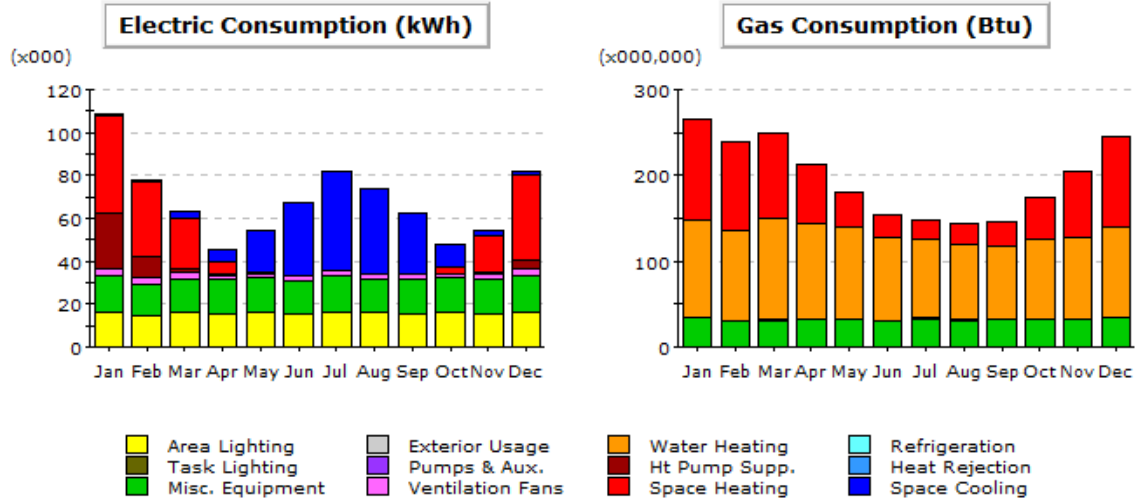
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Appendix A - Energy Simulation Results - Baseline



Electric Consumption (kWh x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	0.40	1.03	3.16	6.06	19.70	34.00	46.32	39.35	28.58	10.13	2.28	1.30	192.31
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	45.81	34.22	23.90	5.86	0.52	0.00	-	-	0.09	2.93	17.00	40.18	170.51
HP Supp.	25.88	10.14	1.82	0.14	0.00	-	-	-	-	0.06	0.91	4.12	43.07
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	3.34	2.81	2.65	1.76	1.80	2.08	2.51	2.26	1.91	1.67	2.13	2.97	27.89
Pumps & Aux.	0.05	0.04	0.04	0.02	0.01	0.02	0.04	0.03	0.01	0.01	0.03	0.04	0.33
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	17.15	15.15	16.05	16.35	16.42	15.64	17.14	16.05	16.38	16.77	16.38	17.15	196.64
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	15.92	14.38	15.91	15.41	15.92	15.40	15.92	15.91	15.41	15.92	15.41	15.92	187.42
Total	108.56	77.77	63.54	45.60	54.37	67.14	81.93	73.60	62.37	47.48	54.13	81.68	818.17

Gas Consumption (Btu x000,000)

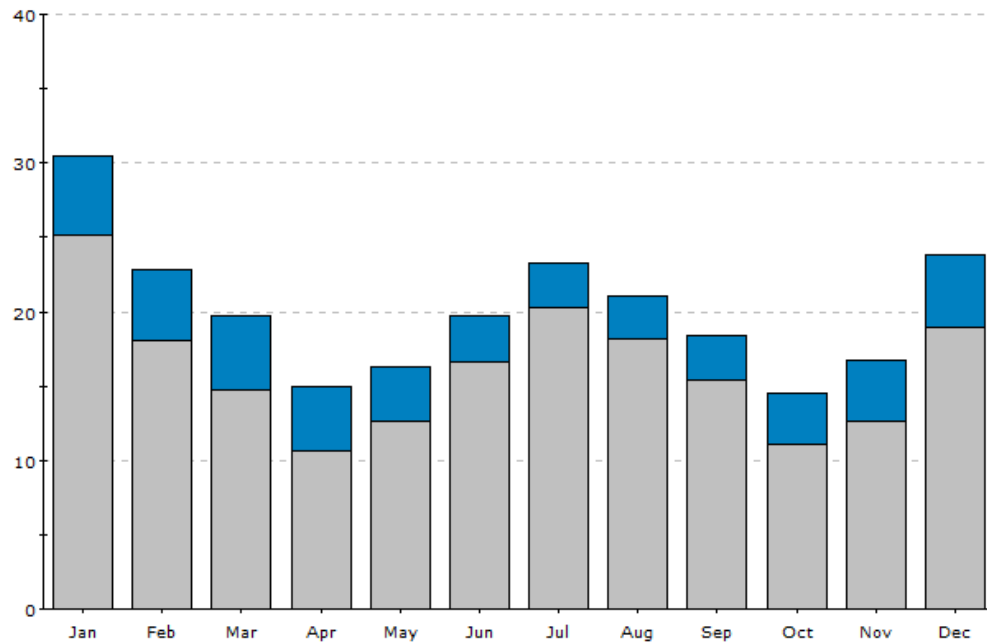
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	118.4	102.6	99.3	69.1	41.3	26.0	22.0	24.1	28.4	49.7	77.7	104.0	762.4
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	113.6	106.4	118.0	112.1	107.5	96.2	92.4	88.0	84.9	91.6	95.5	106.5	1,212.6
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	0.4	0.4	0.5	0.5	0.5	0.5	0.6	0.6	0.5	0.5	0.5	0.4	6.0
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	33.5	29.5	31.3	31.9	32.0	30.5	33.4	31.3	31.9	32.7	31.9	33.5	383.5
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	265.8	238.9	249.1	213.6	181.4	153.2	148.4	144.0	145.7	174.6	205.6	244.3	2,364.5

Annual Energy Consumption by Enduse

	Electricity kWh (x000)	Natural Gas MBtu	Steam Btu	Chilled Water Btu
Space Cool	192.31	-	-	-
Heat Reject.	-	-	-	-
Refrigeration	-	-	-	-
Space Heat	170.51	762.4	-	-
HP Supp.	43.07	-	-	-
Hot Water	-	1,212.6	-	-
Vent. Fans	27.89	-	-	-
Pumps & Aux.	0.33	6.0	-	-
Ext. Usage	-	-	-	-
Misc. Equip.	196.64	383.5	-	-
Task Lights	-	-	-	-
Area Lights	187.42	-	-	-
Total	818.17	2,364.5	-	-

Monthly Utility Bills (\$)

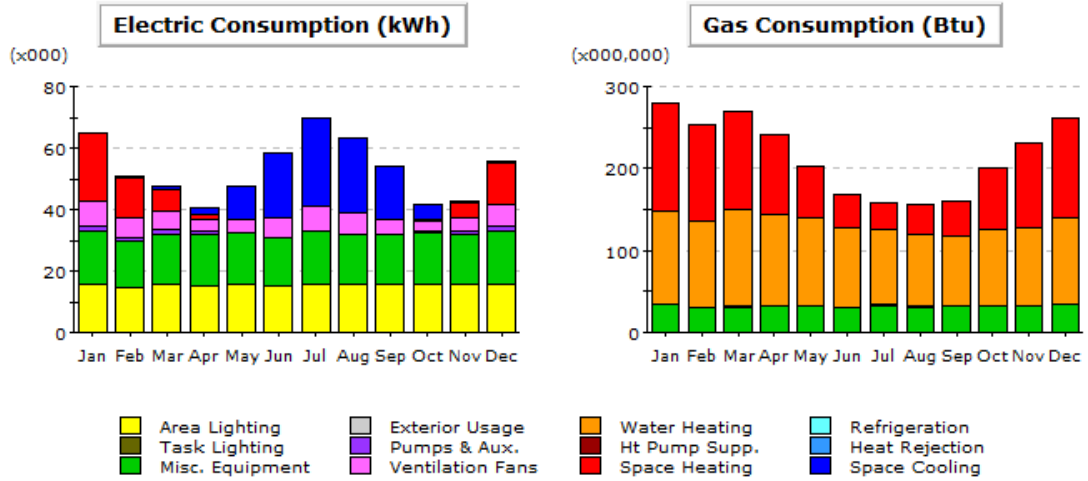
(x000)



ConEd SmGen SC-2 Non-TOU Elec (annual bill: \$ 194,101)
 ConEd Gen SC-2 Heating Gas (annual bill: \$ 47,638)

Total Annual Bill Across All Rates: \$ 241,739

Appendix B - Energy Simulation Results - EEM 1 - VRF HVA



Electric Consumption (kWh x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	0.14	0.33	1.29	2.46	11.01	21.14	28.75	24.33	17.17	5.00	0.79	0.50	112.91
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	22.03	12.88	7.03	1.26	0.06	-	-	-	0.01	0.52	4.72	13.72	62.22
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	8.43	6.51	5.64	3.66	4.17	6.14	7.82	6.67	4.97	2.96	4.26	6.95	68.17
Pumps & Aux.	1.27	1.46	1.73	1.44	0.12	0.02	0.04	0.03	0.04	0.47	1.39	1.35	9.35
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	17.15	15.15	16.05	16.35	16.42	15.64	17.14	16.05	16.38	16.77	16.38	17.15	196.64
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	15.92	14.38	15.91	15.41	15.92	15.40	15.92	15.91	15.41	15.92	15.41	15.92	187.42
Total	64.94	50.71	47.65	40.57	47.69	58.35	69.67	62.99	53.97	41.63	42.94	55.59	636.71

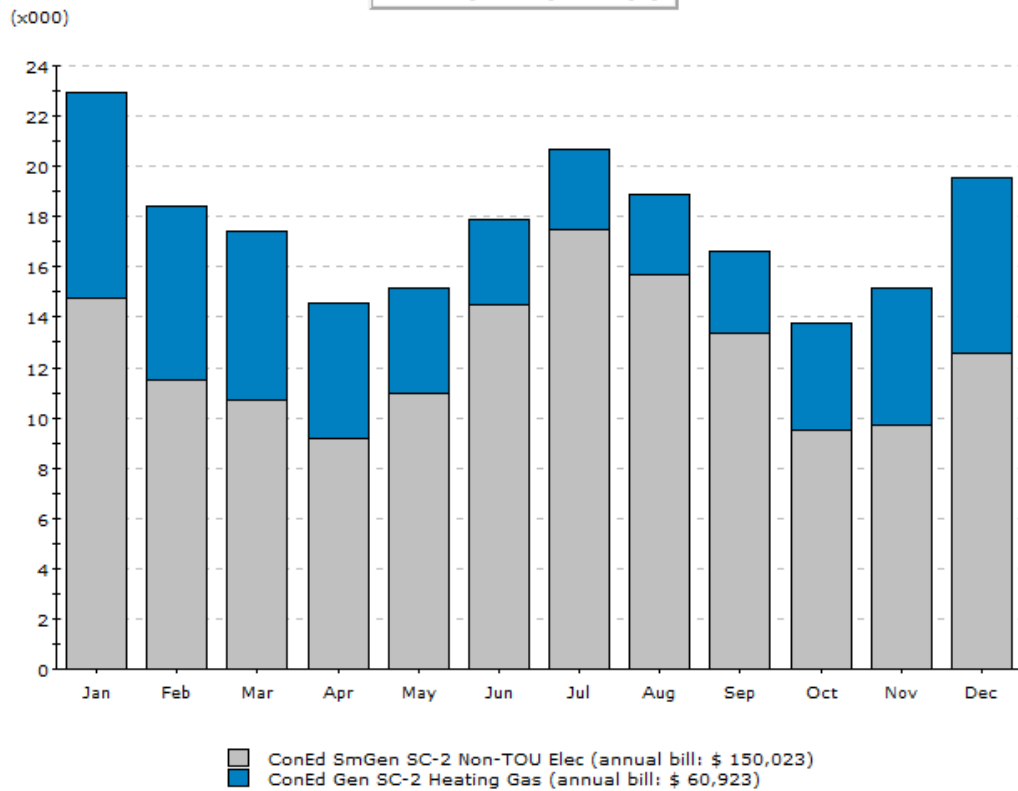
Gas Consumption (Btu x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	132.8	117.1	119.1	97.5	63.1	40.3	32.6	35.5	42.2	75.0	103.3	121.3	979.7
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	113.5	106.3	118.0	112.1	107.5	96.1	92.3	88.0	84.9	91.6	95.5	106.4	1,212.2
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	0.5	0.4	0.5	0.5	0.5	0.6	0.6	0.6	0.5	0.5	0.5	0.5	6.3
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	33.5	29.5	31.3	31.9	32.0	30.5	33.4	31.3	31.9	32.7	31.9	33.5	383.5
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	280.2	253.4	268.9	241.9	203.2	167.5	159.0	155.4	159.6	199.9	231.2	261.6	2,581.7

Annual Energy Consumption by Enduse

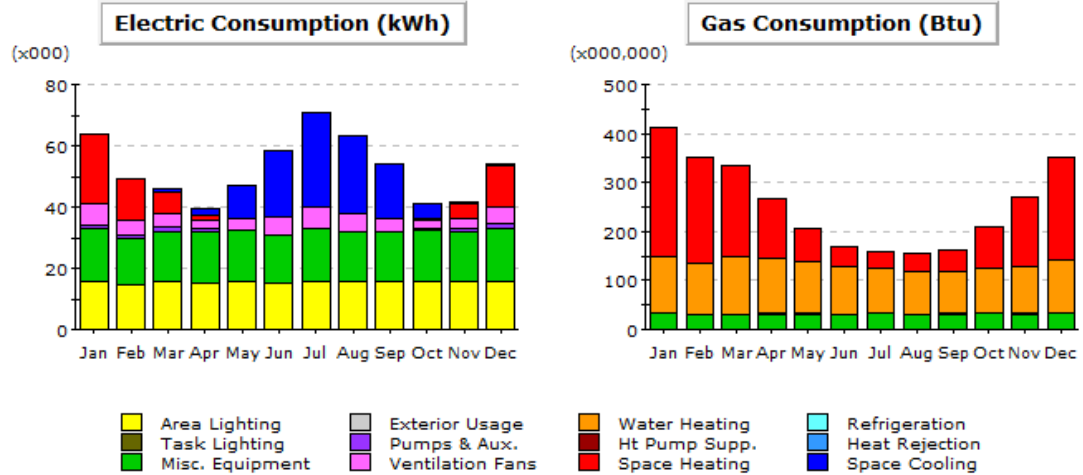
	Electricity kWh (x000)	Natural Gas MBtu	Steam Btu	Chilled Water Btu
Space Cool	112.91	-	-	-
Heat Reject.	-	-	-	-
Refrigeration	-	-	-	-
Space Heat	62.22	979.7	-	-
HP Supp.	-	-	-	-
Hot Water	-	1,212.2	-	-
Vent. Fans	68.17	-	-	-
Pumps & Aux.	9.35	6.3	-	-
Ext. Usage	-	-	-	-
Misc. Equip.	196.64	383.5	-	-
Task Lights	-	-	-	-
Area Lights	187.42	-	-	-
Total	636.71	2,581.7	-	-

Monthly Utility Bills (\$)



Total Annual Bill Across All Rates: \$ 210,946

Appendix C - Energy Simulation Results - EEM 2 - ERV



Electric Consumption (kWh x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	0.13	0.32	1.22	2.31	10.82	21.78	30.77	25.52	17.55	4.64	0.66	0.43	116.17
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	22.58	13.26	7.20	1.28	0.06	-	-	-	0.01	0.53	4.83	14.04	63.78
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	6.70	4.92	4.05	2.59	3.87	5.59	6.86	6.01	4.63	2.61	3.03	5.36	56.22
Pumps & Aux.	1.21	1.42	1.70	1.43	0.11	-	-	-	0.03	0.46	1.37	1.31	9.03
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	17.15	15.15	16.05	16.35	16.42	15.64	17.14	16.05	16.38	16.77	16.38	17.15	196.64
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	15.92	14.38	15.91	15.41	15.92	15.40	15.92	15.91	15.41	15.92	15.41	15.92	187.42
Total	63.69	49.45	46.14	39.37	47.20	58.42	70.68	63.50	54.00	40.93	41.68	54.21	629.26

Gas Consumption (Btu x000,000)

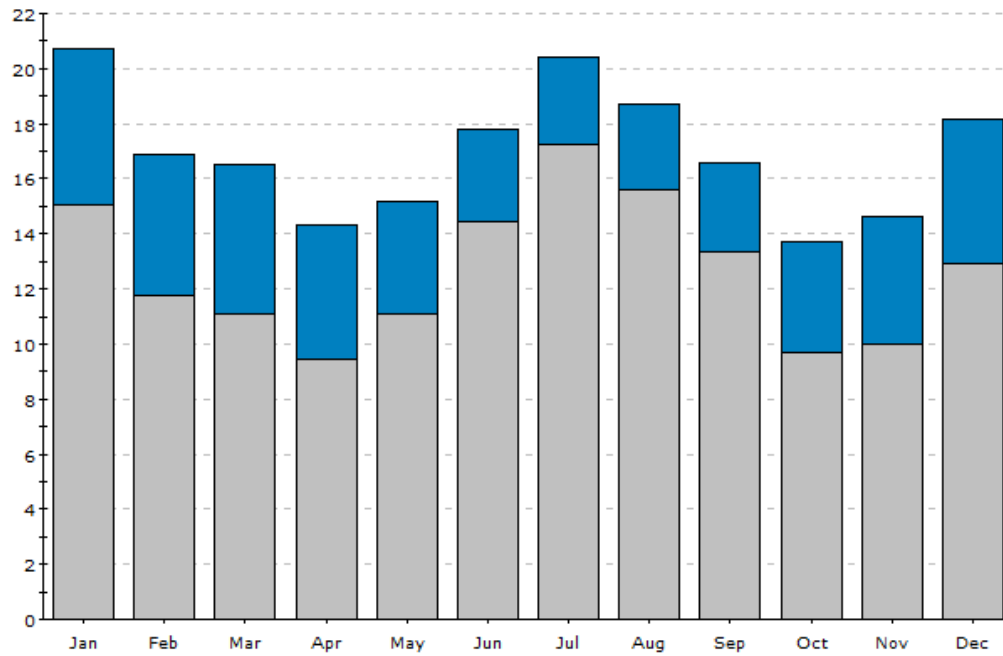
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	266.5	213.5	185.0	122.2	66.8	41.3	32.2	36.3	44.1	83.4	143.0	211.2	1,445.5
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	113.6	106.3	118.0	112.1	107.5	96.1	92.3	88.0	84.9	91.6	95.5	106.4	1,212.2
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	0.4	0.4	0.4	0.5	0.5	0.5	0.6	0.6	0.5	0.5	0.5	0.4	5.8
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	33.5	29.5	31.3	31.9	32.0	30.5	33.4	31.3	31.9	32.7	31.9	33.5	383.5
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	413.8	349.7	334.8	266.6	206.9	168.5	158.5	156.2	161.5	208.2	270.9	351.5	3,047.0

Annual Energy Consumption by Enduse

	Electricity kWh (x000)	Natural Gas MBtu	Steam Btu	Chilled Water Btu
Space Cool	116.17	-	-	-
Heat Reject.	-	-	-	-
Refrigeration	-	-	-	-
Space Heat	63.78	1,445.5	-	-
HP Supp.	-	-	-	-
Hot Water	-	1,212.2	-	-
Vent. Fans	56.22	-	-	-
Pumps & Aux.	9.03	5.8	-	-
Ext. Usage	-	-	-	-
Misc. Equip.	196.64	383.5	-	-
Task Lights	-	-	-	-
Area Lights	187.42	-	-	-
Total	629.26	3,047.0	-	-

Monthly Utility Bills (\$)

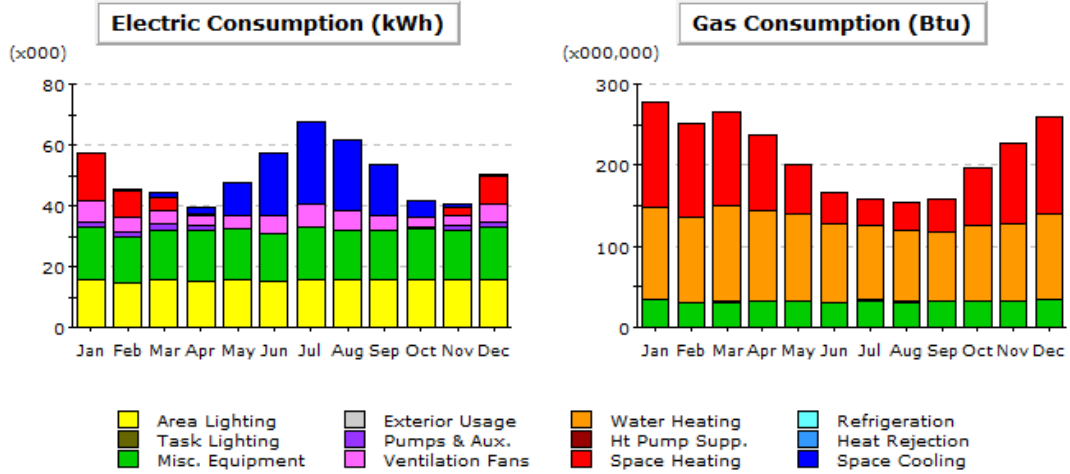
(x000)



- ConEd SmGen SC-2 Non-TOU Elec (annual bill: \$ 151,713)
- ConEd Gen SC-2 Heating Gas (annual bill: \$ 51,974)

Total Annual Bill Across All Rates: \$ 203,687

Appendix D - Energy Simulation Results - EEM 3 - Design Windows



Electric Consumption (kWh x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	0.13	0.30	1.26	2.55	10.93	20.37	27.41	23.46	16.80	5.18	0.86	0.51	109.75
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	15.70	8.56	4.33	0.54	0.02	-	-	-	0.00	0.21	2.75	9.28	41.37
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	6.80	5.21	4.62	3.31	4.05	5.75	7.21	6.21	4.72	2.83	3.49	5.61	59.80
Pumps & Aux.	1.56	1.73	1.96	1.54	0.13	0.02	0.04	0.03	0.04	0.50	1.57	1.62	10.72
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	17.15	15.15	16.05	16.35	16.42	15.64	17.14	16.05	16.38	16.77	16.38	17.15	196.64
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	15.92	14.38	15.91	15.41	15.92	15.40	15.92	15.91	15.41	15.92	15.41	15.92	187.42
Total	57.26	45.32	44.14	39.69	47.46	57.19	67.72	61.66	53.34	41.41	40.44	50.08	605.71

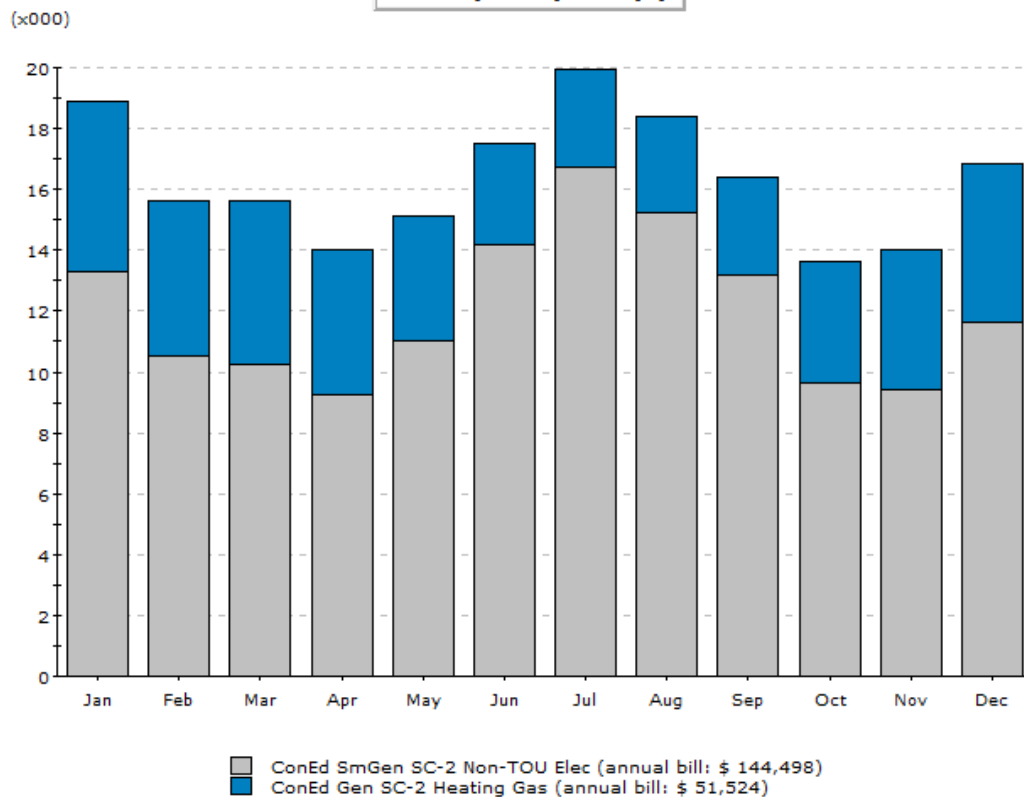
Gas Consumption (Btu x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	131.2	115.5	116.5	93.2	61.4	39.8	32.4	35.1	41.4	71.5	99.9	119.5	957.5
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	113.6	106.3	118.0	112.0	107.5	96.1	92.3	87.9	84.8	91.5	95.5	106.4	1,211.9
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	0.5	0.4	0.5	0.5	0.6	0.6	0.6	0.6	0.5	0.5	0.5	0.5	6.3
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	33.5	29.5	31.3	31.9	32.0	30.5	33.4	31.3	31.9	32.7	31.9	33.5	383.5
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	278.7	251.8	266.3	237.6	201.4	167.0	158.8	155.0	158.7	196.3	227.8	259.9	2,559.2

Annual Energy Consumption by Enduse

	Electricity kWh (x000)	Natural Gas MBtu	Steam Btu	Chilled Water Btu
Space Cool	109.75	-	-	-
Heat Reject.	-	-	-	-
Refrigeration	-	-	-	-
Space Heat	41.37	957.5	-	-
HP Supp.	-	-	-	-
Hot Water	-	1,211.9	-	-
Vent. Fans	59.80	-	-	-
Pumps & Aux.	10.72	6.3	-	-
Ext. Usage	-	-	-	-
Misc. Equip.	196.64	383.5	-	-
Task Lights	-	-	-	-
Area Lights	187.42	-	-	-
Total	605.71	2,559.2	-	-

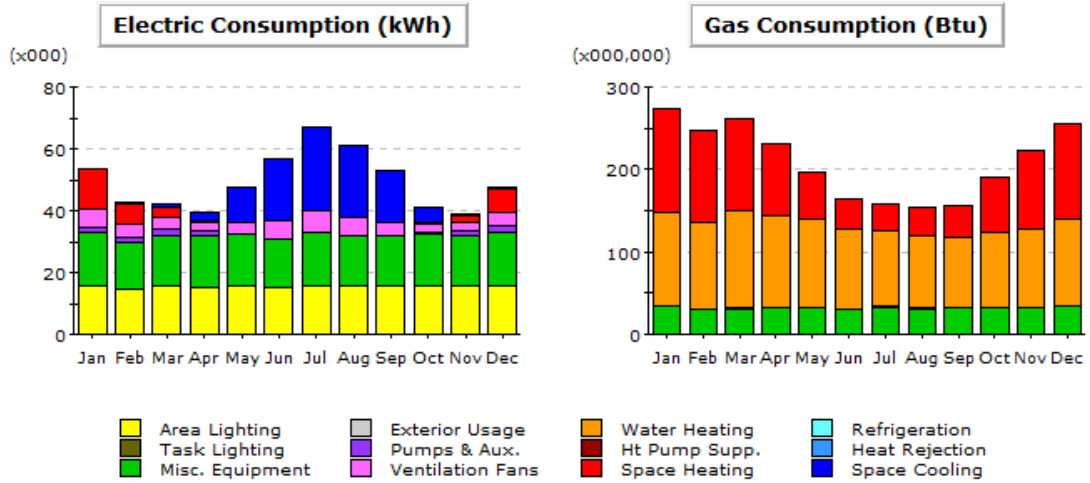
Monthly Utility Bills (\$)



Total Annual Bill Across All Rates: \$ 196,022

In heating dominated climates such as New York is it important to address the heat loss through glazing, especially in buildings with substantial glazing. This measure is modeled as improving the Windows' U-Value from 0.55 to 0.38 and the SHGC from 0.4 to 0.348. The windows are modeled to have no frames as these values represent the entire assemblies' thermal properties.

Appendix E - Energy Simulation Results - EEM 4 - Design Envelope



Electric Consumption (kWh x000)

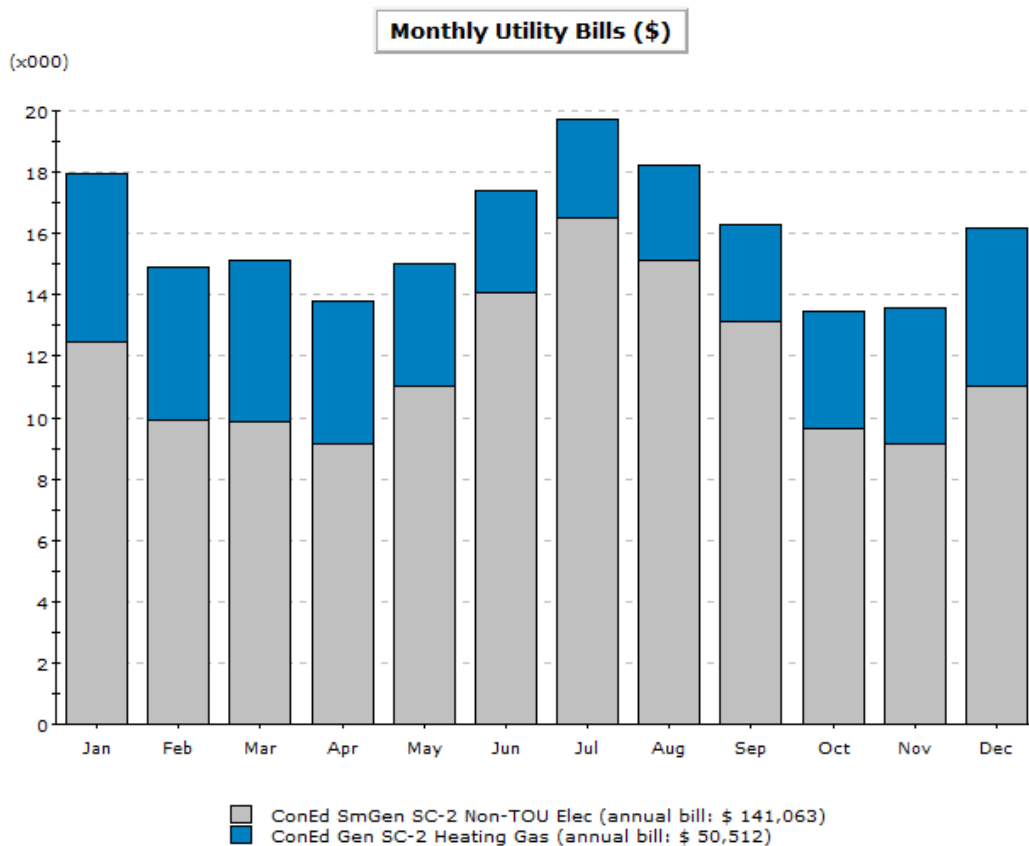
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	0.14	0.32	1.28	2.64	10.97	20.16	26.87	23.12	16.65	5.27	0.90	0.52	108.83
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	12.77	6.49	2.99	0.19	0.00	-	-	-	-	0.06	1.76	7.22	31.49
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	5.88	4.44	4.00	3.08	3.98	5.51	6.90	5.97	4.57	2.73	3.01	4.81	54.89
Pumps & Aux.	1.76	1.92	2.11	1.59	0.13	0.02	0.04	0.03	0.04	0.52	1.69	1.81	11.66
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	17.15	15.15	16.05	16.35	16.42	15.64	17.14	16.05	16.38	16.77	16.38	17.15	196.64
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	15.92	14.38	15.91	15.41	15.92	15.40	15.92	15.91	15.41	15.92	15.41	15.92	187.42
Total	53.63	42.68	42.35	39.26	47.41	56.74	66.87	61.08	53.04	41.27	39.15	47.44	590.93

Gas Consumption (Btu x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	125.5	110.6	110.7	86.5	57.4	38.1	31.4	33.7	39.0	65.5	94.0	114.3	906.8
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	113.7	106.5	118.2	112.0	107.2	96.0	92.2	87.8	84.6	91.3	95.6	106.6	1,211.8
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.5	0.5	6.4
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	33.5	29.5	31.3	31.9	32.0	30.5	33.4	31.3	31.9	32.7	31.9	33.5	383.5
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	273.2	247.1	260.7	230.9	197.2	165.1	157.7	153.4	156.1	190.1	222.1	254.9	2,508.5

Annual Energy Consumption by Enduse

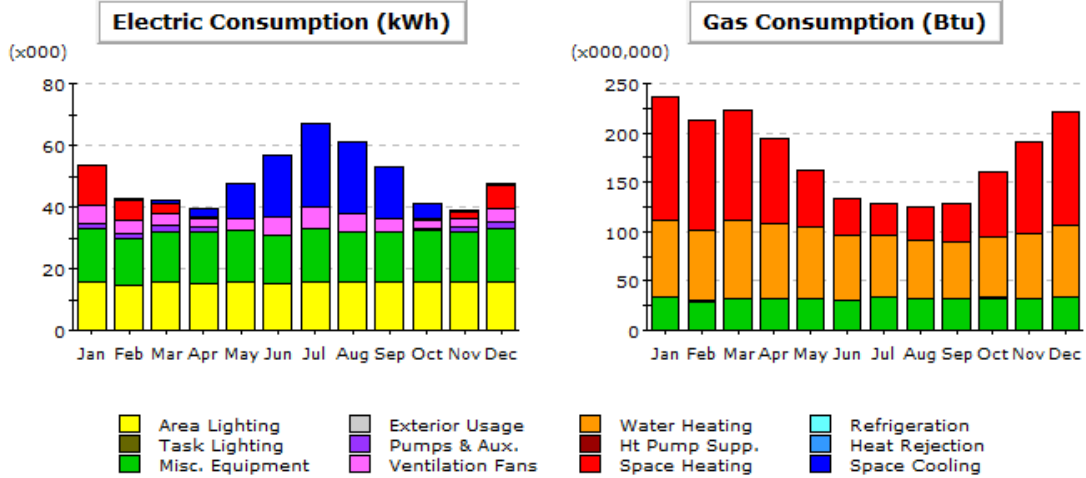
	Electricity kWh (x000)	Natural Gas MBtu	Steam Btu	Chilled Water Btu
Space Cool	108.83	-	-	-
Heat Reject.	-	-	-	-
Refrigeration	-	-	-	-
Space Heat	31.49	906.8	-	-
HP Supp.	-	-	-	-
Hot Water	-	1,211.8	-	-
Vent. Fans	54.89	-	-	-
Pumps & Aux.	11.66	6.4	-	-
Ext. Usage	-	-	-	-
Misc. Equip.	196.64	383.5	-	-
Task Lights	-	-	-	-
Area Lights	187.42	-	-	-
Total	590.93	2,508.5	-	-



Total Annual Bill Across All Rates: \$ 191,575

Improving the exterior walls involves insulating the exterior walls to exceed code requirements to reduce energy consumption during both the heating and cooling months. This is important in buildings whose window-wall ratios exceed 40%. This measure is modeled as improving the Exterior Wall's U-Value from 0.064 to 0.05.

Appendix F - Energy Simulation Results - EEM 5 - Design DHW



Electric Consumption (kWh x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	0.14	0.32	1.28	2.64	10.97	20.16	26.87	23.12	16.65	5.27	0.90	0.52	108.83
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	12.77	6.49	2.99	0.19	0.00	-	-	-	-	0.06	1.76	7.22	31.49
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	5.88	4.44	4.00	3.08	3.98	5.51	6.90	5.97	4.57	2.73	3.01	4.81	54.89
Pumps & Aux.	1.76	1.92	2.11	1.59	0.13	0.02	0.04	0.03	0.04	0.52	1.69	1.81	11.66
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	17.15	15.15	16.05	16.35	16.42	15.64	17.14	16.05	16.38	16.77	16.38	17.15	196.64
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	15.92	14.38	15.91	15.41	15.92	15.40	15.92	15.91	15.41	15.92	15.41	15.92	187.42
Total	53.63	42.68	42.35	39.26	47.41	56.74	66.87	61.08	53.04	41.27	39.15	47.44	590.93

Gas Consumption (Btu x000,000)

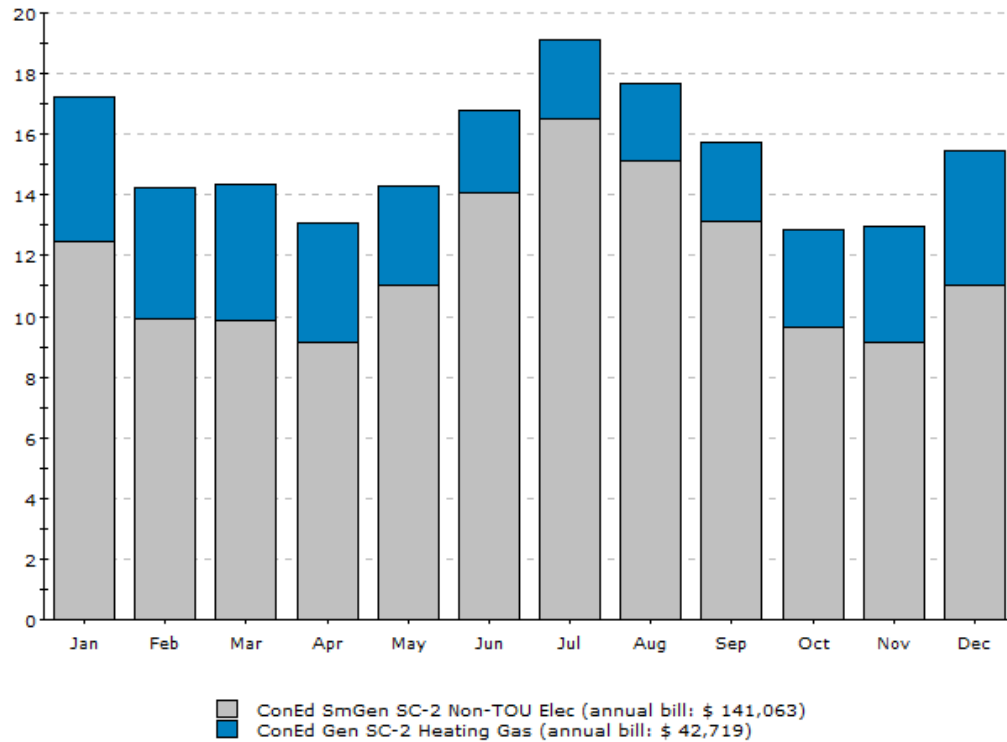
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	125.5	110.6	110.7	86.5	57.4	38.1	31.4	33.7	39.0	65.5	94.0	114.3	906.8
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	77.0	72.1	80.0	75.7	72.5	65.0	62.6	59.7	57.5	62.0	65.0	72.3	821.5
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.5	0.5	6.4
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	33.5	29.5	31.3	31.9	32.0	30.5	33.4	31.3	31.9	32.7	31.9	33.5	383.5
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	236.5	212.7	222.5	194.6	162.5	134.2	128.0	125.3	129.0	160.8	191.4	220.6	2,118.2

Annual Energy Consumption by Enduse

	Electricity kWh (x000)	Natural Gas MBtu	Steam Btu	Chilled Water Btu
Space Cool	108.83	-	-	-
Heat Reject.	-	-	-	-
Refrigeration	-	-	-	-
Space Heat	31.49	906.8	-	-
HP Supp.	-	-	-	-
Hot Water	-	821.5	-	-
Vent. Fans	54.89	-	-	-
Pumps & Aux.	11.66	6.4	-	-
Ext. Usage	-	-	-	-
Misc. Equip.	196.64	383.5	-	-
Task Lights	-	-	-	-
Area Lights	187.42	-	-	-
Total	590.93	2,118.2	-	-

Monthly Utility Bills (\$)

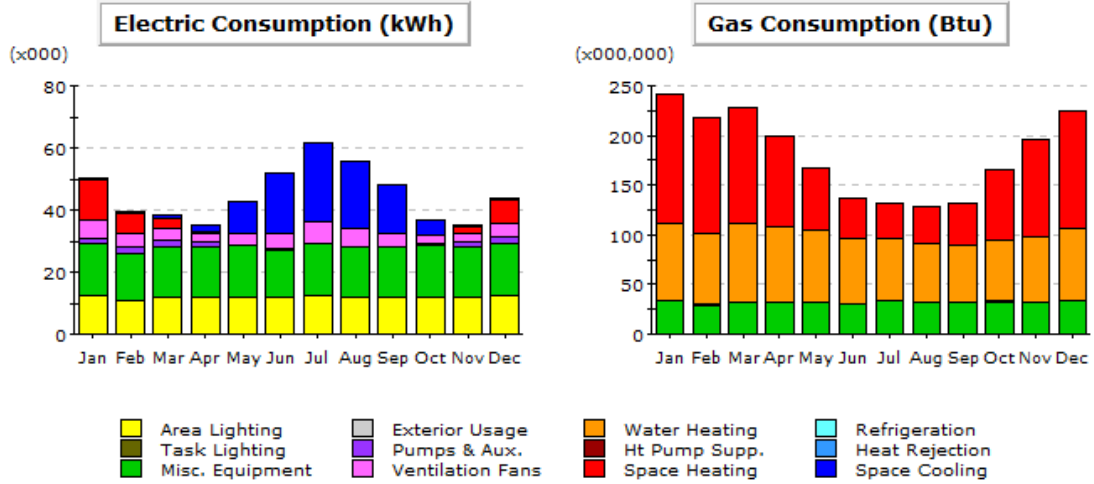
(x000)



Total Annual Bill Across All Rates: \$ 183,782

A condensing DHW Heater with a storage tank will allow for DHW to be produced at 97% efficiency. DHW can be produced at extremely high efficiencies due to the cold feed water delivered to the unit. The storage tank helps to offset the peak demands for DHW. This measure was modeled as a 97% efficient DHW Heater with a condensing efficiency curve and a 5:1 turndown ratio.

Appendix G - Energy Simulation Results - EEM 6 - Design Lighting



Electric Consumption (kWh x000)

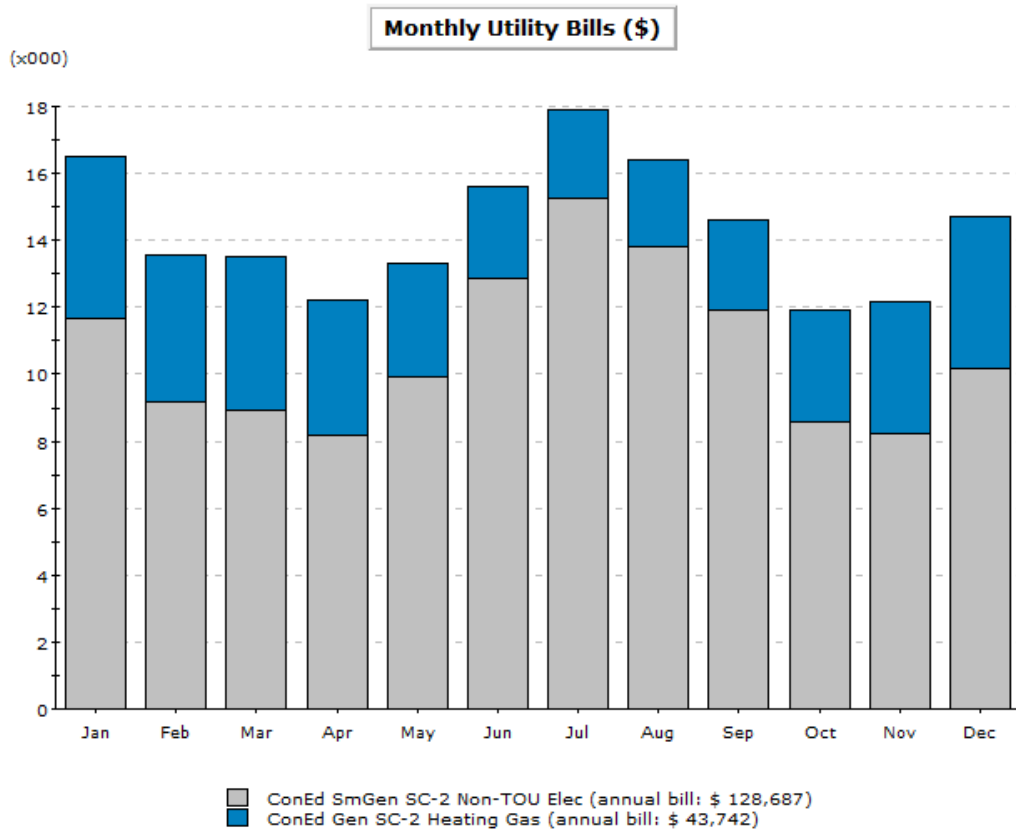
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	0.14	0.30	1.17	2.41	10.27	19.24	25.62	21.92	15.66	4.79	0.73	0.44	102.67
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	13.25	6.82	3.19	0.22	0.00	-	-	-	-	0.08	1.91	7.60	33.07
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	5.68	4.24	3.76	2.82	3.74	5.27	6.61	5.70	4.34	2.53	2.80	4.61	52.10
Pumps & Aux.	1.73	1.89	2.09	1.59	0.13	0.02	0.04	0.03	0.04	0.52	1.67	1.78	11.52
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	17.15	15.15	16.05	16.35	16.42	15.64	17.14	16.05	16.38	16.77	16.38	17.15	196.64
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	12.17	10.94	12.02	11.74	12.07	11.64	12.17	12.02	11.74	12.12	11.74	12.17	142.54
Total	50.12	39.34	38.28	35.12	42.62	51.82	61.57	55.71	48.16	36.80	35.24	43.75	538.54

Gas Consumption (Btu x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	129.9	115.0	116.0	91.7	61.6	41.5	34.7	37.2	42.5	70.1	98.9	118.8	957.9
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	77.1	72.1	80.0	75.8	72.5	65.0	62.6	59.7	57.5	62.1	65.0	72.3	821.5
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.5	0.5	6.4
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	33.5	29.5	31.3	31.9	32.0	30.5	33.4	31.3	31.9	32.7	31.9	33.5	383.5
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	240.9	217.1	227.7	199.9	166.7	137.6	131.3	128.7	132.5	165.5	196.3	225.1	2,169.4

Annual Energy Consumption by Enduse

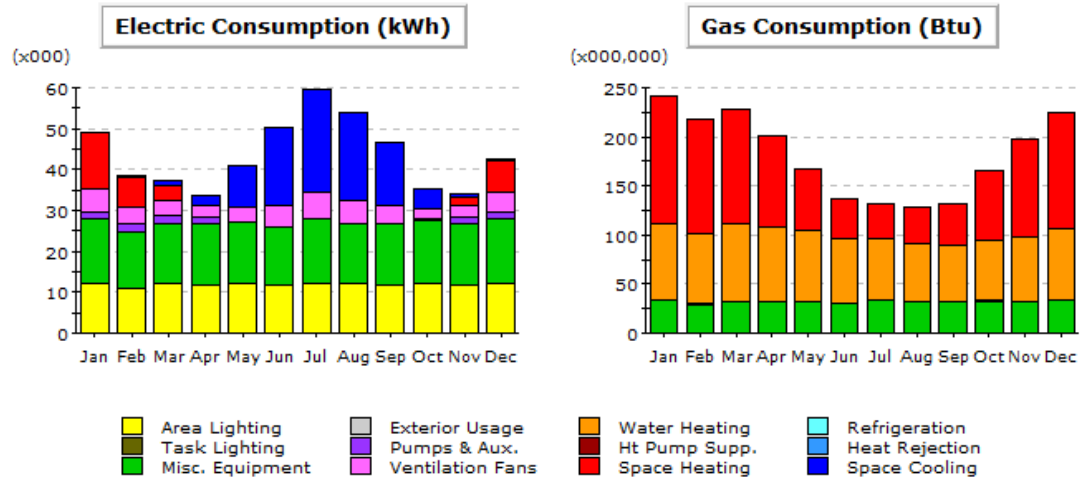
	Electricity kWh (x000)	Natural Gas MBtu	Steam Btu	Chilled Water Btu
Space Cool	102.67	-	-	-
Heat Reject.	-	-	-	-
Refrigeration	-	-	-	-
Space Heat	33.07	957.9	-	-
HP Supp.	-	-	-	-
Hot Water	-	821.5	-	-
Vent. Fans	52.10	-	-	-
Pumps & Aux.	11.52	6.4	-	-
Ext. Usage	-	-	-	-
Misc. Equip.	196.64	383.5	-	-
Task Lights	-	-	-	-
Area Lights	142.54	-	-	-
Total	538.54	2,169.4	-	-



Total Annual Bill Across All Rates: \$ 172,429

The lighting design will implement electrically ballasted, high efficiency T-5 or T-8 fluorescent fixtures for maintenance rooms, hallways, meeting rooms, stairwells, and other rooms. This measure is modeled with these fixtures and a 20% reduction in the lighting density of the apartments hard-wired lighting.

Appendix H - Energy Simulation Results - EEM 7 - Appliances



Electric Consumption (kWh x000)

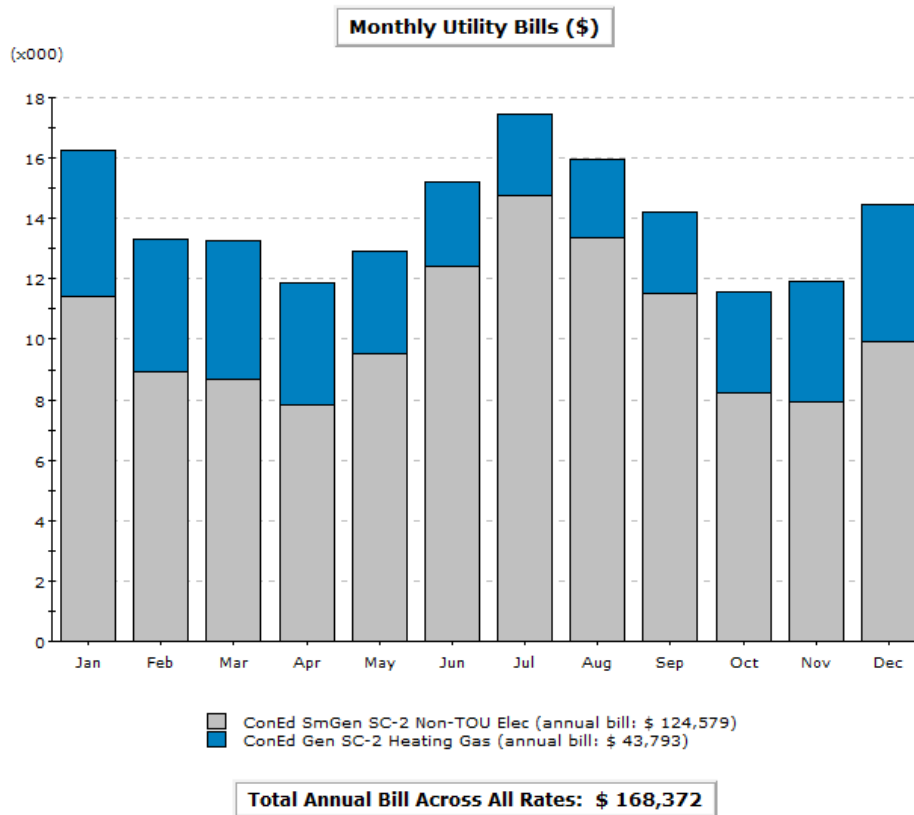
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	0.13	0.28	1.12	2.29	10.04	18.94	25.28	21.61	15.39	4.63	0.69	0.42	100.82
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	13.66	7.07	3.38	0.23	0.00	-	-	-	-	0.08	2.02	7.89	34.34
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	5.75	4.28	3.77	2.75	3.62	5.16	6.49	5.59	4.23	2.44	2.81	4.65	51.55
Pumps & Aux.	1.70	1.86	2.07	1.59	0.13	0.02	0.04	0.03	0.04	0.52	1.66	1.75	11.40
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	15.75	13.91	14.74	15.01	15.07	14.36	15.73	14.74	15.03	15.40	15.03	15.75	180.52
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	12.17	10.94	12.02	11.74	12.07	11.64	12.17	12.02	11.74	12.12	11.74	12.17	142.54
Total	49.15	38.35	37.10	33.61	40.94	50.12	59.71	53.98	46.44	35.18	33.96	42.63	521.16

Gas Consumption (Btu x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	130.1	115.2	116.3	92.2	61.7	41.5	34.7	37.2	42.5	70.4	99.6	119.1	960.4
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	77.0	72.1	80.0	75.8	72.5	65.0	62.6	59.7	57.5	62.1	65.0	72.3	821.6
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.5	0.5	6.4
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	33.5	29.5	31.3	31.9	32.0	30.5	33.4	31.3	31.9	32.7	31.9	33.5	383.5
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	241.1	217.3	228.1	200.4	166.8	137.6	131.3	128.7	132.5	165.8	197.0	225.4	2,172.0

Annual Energy Consumption by Enduse

	Electricity kWh (x000)	Natural Gas MBtu	Steam Btu	Chilled Water Btu
Space Cool	100.82	-	-	-
Heat Reject.	-	-	-	-
Refrigeration	-	-	-	-
Space Heat	34.34	960.4	-	-
HP Supp.	-	-	-	-
Hot Water	-	821.6	-	-
Vent. Fans	51.55	-	-	-
Pumps & Aux.	11.40	6.4	-	-
Ext. Usage	-	-	-	-
Misc. Equip.	180.52	383.5	-	-
Task Lights	-	-	-	-
Area Lights	142.54	-	-	-
Total	521.16	2,172.0	-	-



The appliances were specified as is standard with NYSERDA (New York State Energy Research and Development Authority) Multifamily Performance Program’s Energy Simulation Guidelines. This standard was developed specifically for New York Multifamily buildings and gives an accurate representation of typical appliance consumption and densities for residential spaces.