



## **Energy Reduction Plan Report**

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### *Stratford Towers*



*1340 Stratford Ave, NY 10472*

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## 1. Executive Summary

Assessment Date: 08/15/2013	Location: Bronx, NY
ZIP Code: 10472	No. of Recommendations: 4

Energy consumption and the corresponding electricity, #4 fuel oil, and natural gas costs from Jun 2012 to Nov 2010 at this facility consisted of the following:

<b>Electricity</b>	
kWh	Dollars
753,400	\$153,346

<b>#4 Fuel Oil</b>	
MMBtu	Dollars
11,158	250,568

<b>Natural Gas</b>	
MMBtu	Dollars
834	8,281

The total energy used is equivalent to 14,563MMBtu. Total energy costs for this period was nearly \$412,195. The energy reduction plans (ERP) contained in this report could save 603,243 kWh/yr of electricity and 11,158 MMBtu/yr of #4 fuel oil and could consume 13,609 MMBtu/yr of natural gas. The total energy cost savings would amount to approximately \$216,327/yr or approximately 52% of the annual energy costs for this facility. The total estimated implementation cost is \$330,643 which gives an average simple payback of 1.5 years.

Carbon dioxide emissions could be reduced by the following amounts if ERPs No. 1 to 4 were implemented.

Energy Source	Energy Conserved	CO <sub>2</sub> emission Rate	CO <sub>2</sub> emission Saved (lbs)
Electricity	603,243 kWh	0.952 lb/kWh	574,287
#4 Fuel Oil	11,158 MMBtu	159.66 lb/kWh	1,781,486
Natural Gas	-13,609 MMBtu	116.39 lb/MMBtu	-1,583,952

Table below lists the unit costs of resources used in estimating the energy cost savings in energy reduction plans.

**Table 1: Rate structure for resources**

<b>Resource</b>	<b>Units</b>	<b>Rate</b>
Electricity	\$/kWh	0.2035
#4 Fuel oil	\$/MMBtu	22.46
Natural Gas	\$/MMBtu	9.93

## Recommendations

The tabulated results of the assessment project conducted at this company are shown in table below.

ERP No.	Opportunity	Potential Savings (\$/yr)	Electricity Savings (kWh/yr)	#4 Fuel (MMBtu/yr)	#Natural gas (MMBtu/yr)	Implementation Cost (\$)	Payback (yrs)
1	Replace #4 Oil Fired Boilers with 65 kW Micro-turbine and Natural gas Fired Boiler	197,853	512,460	11,158	(13,609)	296,850	1.5
2	Replace the Incandescent Lamps with Compact Fluorescent Lamps	9,081	44,626	-	-	3,468	0.4
3	Replace the Existing T12 Fluorescent Bulbs and Magnetic Ballasts with LED and T8 Fluorescent Bulbs and Electronic Ballasts with Reflectors in the Building	5,091	25,018	-	-	13,435	2.6
4	Install Temperature Setback Controls on the AC units in the Apartments	4,302	21,139	-	-	16,890	3.9
	<b>Total</b>	<b>216,327</b>	<b>603,243</b>	<b>11,158</b>	<b>-13,609</b>	<b>330,643</b>	<b>1.5</b>

## 2. BACKGROUND

Stratford towers are located in Bronx, NY and built in 1966. It is a square shaped building consisting of 11 stories. The total area of the building is 95,370 sq.ft. This building has 84 one bed room and 45 studio apartments. It is a residential building and most of the energy systems are similar to that found in a common house building. Major energy consuming equipment of the building is shown in Table 2.1.

**Table2.1: Major Energy Equipment**

Equipment	Capacity	Unit	Quantity
Boilers	4.05	MMBtu/hr	2
Fuel oil supply pumps	3	hp	2
Water Pumps	5	hp	2
T12 Circular Lamps	32	Watt	243
T12-2ft Lamps	20	Watt	44
T12-4ft Lamps	34	Watt	32
T12-4ft Lamps	40	Watt	2
T12 - 8ft Lamps	75	Watt	6
T12-8ft Lamps	60	Watt	8
Incandescent Bulbs	100	Watt	252
Incandescent Bulbs	60	Watt	213
Window Ac Units	8,000	Btu/hr	213
Refrigerators	14.8	Cu.ft	129

### 3. ENERGY ACCOUNTING

An essential component of any energy management program is a continuing account of energy use and its cost. This can be developed by keeping up-to-date records of energy consumption and associated costs on a monthly basis. When utility bills are received, it is recommended that energy use and costs be recorded as soon as practical. A separate record will be required for each type of energy used, i.e., gas, electrical, oil, etc. A combination will be necessary, for example, when both gas and oil are used interchangeably in a boiler. A single energy unit should be used to express the heating values of the various fuel sources so that a meaningful comparison of fuel types and fuel combinations can be made. The primary energy unit in this report is the Btu, British thermal unit, or million BTUs (MMBtu). The conversion factors are:

ENERGY UNIT	ENERGY EQUIVALENT
1 kWh	3,413 Btu
1 Therm	100,000 Btu
1 cu ft natural gas	1,000 Btu *
1 gallon No. 2 oil (diesel)	140,000 Btu *
1 gallon No. 4 oil	145,000 Btu *
1 gallon gasoline	130,000 Btu *
1 gallon propane	92,000 Btu *
1 ton coal	20,000,000 Btu *
1 hp h (electric)	2,545 Btu
1 hp h (boiler)	33,500 Btu
1 MMBtu	293 kWh

\*Varies with supplier

The value of energy and cost records can be understood by examining the data representing your facility on the following pages. The energy usage is tabulated by month in the following tables. Total annual energy usage and costs are also shown. From these figures, trends and irregularities in energy usage and costs can be detected and the relative merits of energy conservation and load management can be assessed.

In addition to plotting monthly energy consumption and cost, it may be desirable to plot the ratio of monthly energy consumption to monthly production. An appropriate measure of production should be used that is consistent with the company's record-keeping procedures. The measure of production used can be gross sales, number of units produced or processed, pounds of raw material used, etc. It is important that the same time period be used for energy consumption and production.

### Electrical Usage Summary

Year	Month	Energy Usage (kWh)	Demand (kW)	Delivery Cost (\$)	Supply Cost (\$)	Total Cost (\$)	MMBtu *
<b>2012-2013</b>	Jun	60,200	154	5,802.26	7,370.12	13,172.38	205
	Jul	88,200	192	9,092.56	9,708.41	18,800.97	301
	Aug	98,400	200	9,422.51	10,831.15	20,253.66	336
	Sep	87,000	168	8,291.46	9,576.32	17,867.78	297
	Oct	56,600	126	5,454.91	6,164.07	11,618.98	193
	Nov	52,200	126	4,699.78	5,800.83	10,500.61	178
	Dec	52,200	102	4,699.78	5,800.83	10,500.61	178
	Jan	58,200	96	4,871.20	6,406.23	11,277.43	199
	Feb	51,800	106	4,433.00	5,701.76	10,134.76	177
	Mar	51,200	94	3,800.29	5,635.72	9,436.01	175
	Apr	51,800	96	4,267.12	5,701.76	9,968.88	177
	May	45,600	92	4,089.71	5,724.65	9,814.36	156
<b>Total</b>		<b>753,400</b>	<b>-</b>	<b>68,925</b>	<b>84,422</b>	<b>153,346</b>	<b>2,571</b>
<b>Avg</b>		<b>62,783</b>	<b>129</b>	<b>5,744</b>	<b>7,035</b>	<b>12,779</b>	<b>214</b>

\* 1 MMBtu = 293 kWh

Average kWh Cost	= \$0.2035	Average kWh Cost	= Total Cost / Energy Usage
Average MMBtu Cost	= \$59.64	Average MMBtu Cost	= Total Cost / MMBtu

#### #4 Fuel Oil Usage Summary

Year	Month	Gallons *	MMBtu **	Fuel Cost (\$)	\$/MMBtu
2012-2013	Jun	3,234	468.9	9,089.59	19.38
	Jul	2,502	362.8	7,364.77	20.30
	Aug	2,090	303.1	6,834.33	22.55
	Sep	912	132.2	3,006.08	22.73
	Oct	3,001	435.1	10,023.43	23.03
	Nov	7,075	1,025.9	22,689.22	22.12
	Dec	6,007	871.0	19,437.93	22.32
	Jan	10,499	1,522.4	34,395.13	22.59
	Feb	17,969	2,605.5	63,116.63	24.22
	Mar	12,013	1,741.9	38,789.31	22.27
	Apr	8,511	1,234.1	26,498.33	21.47
	May	3,140	455.3	9,323.49	20.48
<b>Total</b>		<b>76,953</b>	<b>11,158</b>	<b>250,568</b>	<b>22.46</b>

\* 1 Gallon of #4 Fuel oil = 145,000 Btu

\*\* 1 MMBtu = 1,000,000 Btu

Average Cost Per MMBtu = Fuel Cost (\$)/ MMBtu  
= **\$22.46/MMBtu**

### Natural Gas Usage Summary

Year	Month	Therms *	MMBtu	Gas Cost (\$)	\$/MMBtu
<b>2012-2013</b>	Jun	666	66.60	640.84	9.62
	Jul	626	62.60	558.53	8.92
	Aug	650	65.00	581.94	8.95
	Sep	668	66.80	623.32	9.33
	Oct	414	41.40	392.77	9.49
	Nov	676	67.60	665.75	9.85
	Dec	852	85.20	941.65	11.05
	Jan	800	80.00	920.60	11.51
	Feb	836	83.60	966.06	11.56
	Mar	728	72.80	868.87	11.94
	Apr	730	73.00	892.14	12.22
	May	697	69.70	869.85	12.48
<b>Total</b>		<b>8,343</b>	<b>834</b>	<b>8,281</b>	<b>9.93</b>

\* 1 Therm = 0.1 MMBtu

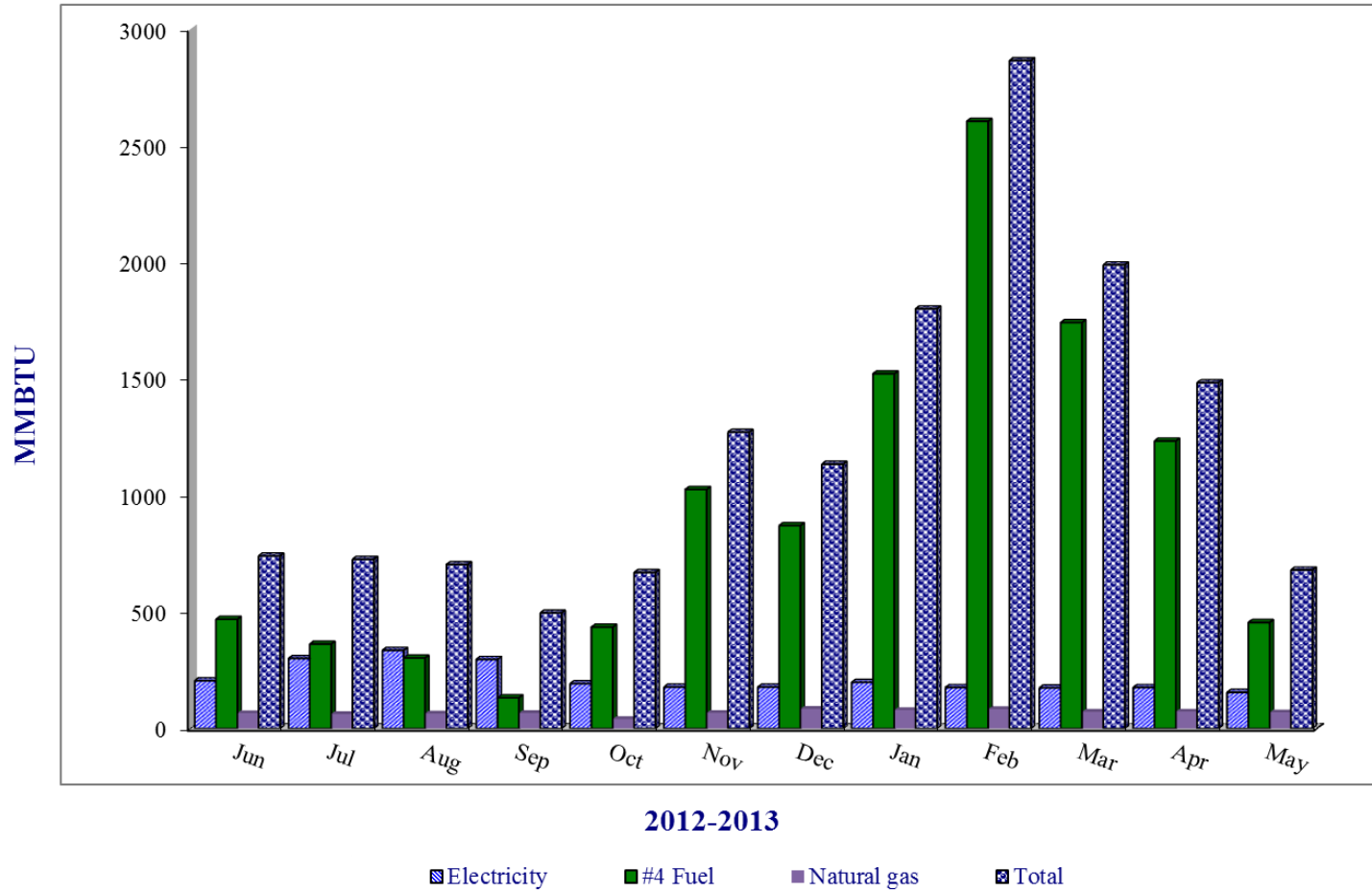
Average Cost Per MMBtu = Gas Cost (\$)/ Gas Consumption (MMBtu)  
 = **\$9.93/MMBtu**

### Facility Energy Summary

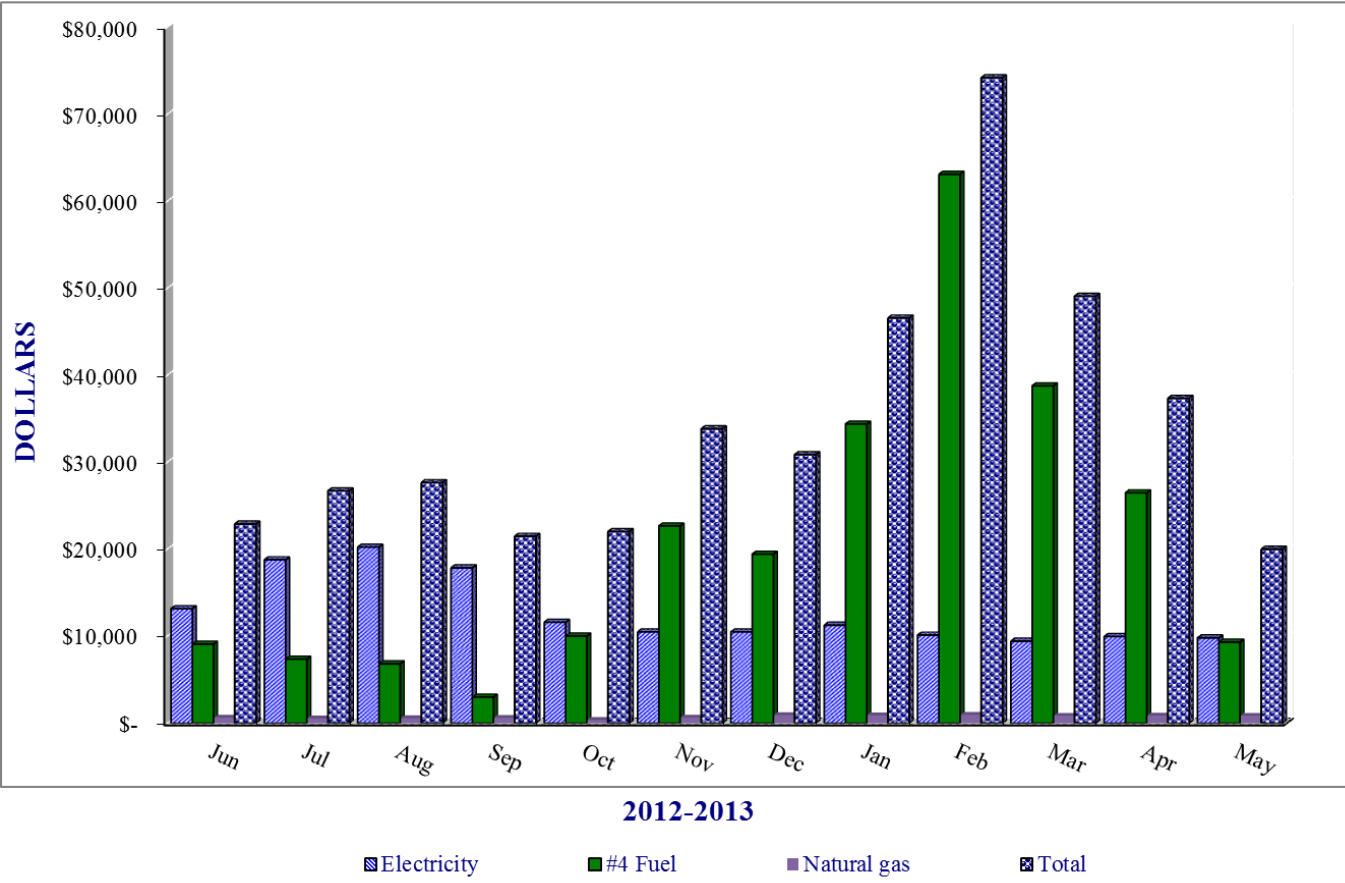
Year	Month	Electricity Cost (\$) per MMBtu	#4 Fuel Cost (\$) per MMBtu	Natural gas Cost (\$) per MMBtu	Electricity use Btu/Sq. ft	#4 Fuel use Btu/Sq. ft	Natural gas use Btu/Sq. ft	Facility Total Btu/Sq. ft	Electricity cost(\$)/Sq. Ft	#4 Fuel cost(\$)/Sq. Ft	Natural gas cost(\$)/Sq. Ft	Facility Energy cost(\$)/Sq. Ft
<b>2012-2013</b>	Jun	64.11	19.38	9.62	2,154	4,917	698	7,770	0.14	0.095	0.007	0.24
	Jul	62.46	20.30	8.92	3,156	3,804	656	6,960	0.20	0.077	0.006	0.28
	Aug	60.31	22.55	8.95	3,521	3,178	682	6,699	0.21	0.072	0.006	0.29
	Sep	60.18	22.73	9.33	3,113	1,387	700	4,500	0.19	0.032	0.007	0.23
	Oct	60.15	23.03	9.49	2,026	4,563	434	6,588	0.12	0.105	0.004	0.23
	Nov	58.94	22.12	9.85	1,868	10,757	709	12,625	0.11	0.238	0.007	0.35
	Dec	58.94	22.32	11.05	1,868	9,133	893	11,001	0.11	0.204	0.010	0.32
	Jan	56.77	22.59	11.51	2,083	15,963	839	18,045	0.12	0.361	0.010	0.49
	Feb	57.33	24.22	11.56	1,854	27,320	877	29,174	0.11	0.662	0.010	0.78
	Mar	54.00	22.27	11.94	1,832	18,264	763	20,097	0.10	0.407	0.009	0.51
	Apr	56.39	21.47	12.22	1,854	12,940	765	14,794	0.10	0.278	0.009	0.39
	May	63.06	20.48	12.48	1,632	4,774	731	6,406	0.10	0.098	0.009	0.21
<b>Average</b>		<b>59.64</b>	<b>22.46</b>	<b>9.93</b>	<b>2,247</b>	<b>9,750</b>	<b>729</b>	<b>12,055</b>	<b>0.134</b>	<b>0.219</b>	<b>0.008</b>	<b>0.361</b>

Total energy used in MMBtu = 14,564  
 Total cost of energy used in \$ = 412,196  
 Total area of the building in sq. ft. = 95,370

## ENERGY USAGE



### ENERGY COST



## 4. Energy Reduction Plans

### ERP No.1: Replace #4 Oil Fired Boilers with 65 kW Micro-turbine and Natural gas Fired Boiler

Resource	Annual Savings			Project Cost	Simple Payback
	Amount	CO <sub>2</sub> (lbs)*	Dollars		
Electricity	512,460 kWh**	487,862	\$104,286	-	-
Natural Gas	-13,609 MMBtu	-1,583,952	-\$135,137	-	-
Fuel oil#4	11,158 MMBtu	1,781,486	\$250,568		
O&M Cost	-	-	-\$21,864		
Capital	-	-	-	\$281,850	-
Eng. Cost	-	-	-	\$15,000	-
<b>Total</b>	-	685,396	\$197,853	\$296,850	1.05 years

\* 1 kWh  $\equiv$  0.952 lbs of CO<sub>2</sub>, 1MMBtu of natural gas = 116.39 lbs of CO<sub>2</sub> & 1 MMBtu of fuel oil#4 = 159.66 lbs of CO<sub>2</sub>

\*\* This is the amount of electricity generated using micro turbine CHP . Though this electricity cost is saved , the actual consumption by residents remains same

#### Recommended Action

It is recommended to replace existing old boilers with 65 kW micro-turbine and natural gas fired boiler. This measure will increase the overall heating efficiency and result in significant energy cost savings.

#### Background

Currently, the building has two 4.05 MMBtu/hr boilers which are using #4 fuel oil. These boilers are very old and consuming more energy. Hence, it is recommended to install micro-turbine and use waste heat to produce hot water. The remaining heat load requirements of the building can be fulfilled by using new natural gas fired boiler.



**Fig 4.1.1: Current Boiler in the Building**

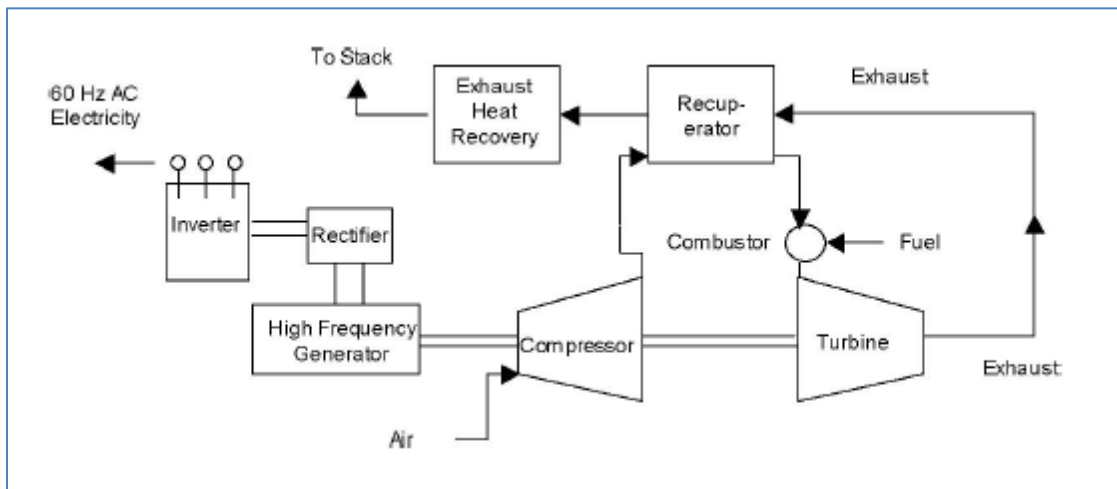
Currently, boilers are supplying hot water for domestic use and comfort heating purposes of the building. The current energy consumption of the existing boilers is shown in Table 4.1.1.

**Table 4.1.1: #4 Fuel Oil Usage Summary (2012-2013)**

Month	Gallons	MMBtu*	Fuel Oil Cost (\$)
Jun	3,234	468.9	9,089.59
Jul	2,502	362.8	7,364.77
Aug	2,090	303.1	6,834.33
Sep	912	132.2	3,006.08
Oct	3,001	435.1	10,023.43
Nov	7,075	1,025.9	22,689.22
Dec	6,007	871.0	19,437.93
Jan	10,499	1,522.4	34,395.13
Feb	17,969	2,605.5	63,116.63
Mar	12,013	1,741.9	38,789.31
Apr	8,511	1,234.1	26,498.33
May	3,140	455.3	9,323.49
<b>Total</b>	<b>76,953</b>	<b>11,158</b>	<b>250,568</b>

\*1 MMBtu = 6.90 Gallons of #4 Fuel Oil

Anticipated Savings



**Fig 4.1.2: Proposed Scenario<sup>1</sup>**

<sup>1</sup> [http://www.epa.gov/chp/documents/catalog\\_chptech\\_microturbines.pdf](http://www.epa.gov/chp/documents/catalog_chptech_microturbines.pdf)

By installing the micro-turbine and new boiler, #4 fuel oil usage can be completely offset.

$$\begin{aligned} \#4 \text{ fuel oil savings} &= 11,158 \text{ MMBtu/yr} \\ \#4 \text{ fuel oil cost savings} &= \$250,568/\text{yr} \end{aligned}$$

The performance parameters of 65kW micro turbine are shown in Table 4.1.3<sup>2</sup>

**Table 4.1.3: Performance parameters of 65kW Micro Turbine**

Performance Characteristics	
Nominal Electricity Capacity (kW)	65
Compressor Parasitic power (kW)	2
Electric Heat Rate (Btu/kWh), HHV	13,891
Fuel Input (MMBtu/hr)	0.875
CHP Characteristics	
Exhaust Flow (lbs/sec)	1.12
Heat Output (MMBtu/hr)	0.41

The amount of electricity generated by using the 65 kW micro turbine can be calculated as;

$$\begin{aligned} \text{Electricity generation} &= 65 \text{ kW} \times 8,760 \text{ hrs/yr} \times 0.90 \text{ (availability factor)} \\ &= 512,460 \text{ kWh/yr} \\ \text{Electricity cost savings} &= 512,460 \text{ kWh/yr} \times \$0.2035/\text{kWh}^* \\ &= \$104,286/\text{yr} \end{aligned}$$

\* Average kWh cost (kW cost was combined in kWh rate)

The amount of natural gas ( $NG_{req}$ ) required to supply to micro turbine can be calculated as follows:

$$\begin{aligned} NG_{req} &= \text{Electric heat rate} \times 512,460 \text{ kWh/yr} \\ &= 13,891 \text{ Btu/kWh} \times 512,460 \text{ kWh/yr} / 100 \\ &= 7,118,581,860 \text{ btu/yr} \\ &= 7,119 \text{ MMBtu/yr} \end{aligned}$$

The amount of the heat available ( $H_a$ ) from the turbine can be calculated as follows:

$$\begin{aligned} H_a &= \text{Heat rate available} \times 8,760 \text{ hrs/yr} \times \text{availability factor} \\ &= 0.41 \text{ MMbtu/hr} \times 8,760 \times 0.90 \\ &= 3,232 \text{ MMbtu/yr} \end{aligned}$$

<sup>2</sup> [http://www.epa.gov/chp/documents/catalog\\_chptech\\_microturbines.pdf](http://www.epa.gov/chp/documents/catalog_chptech_microturbines.pdf)

The total amount of #4 fuel oil consumed during the seven heating months (Oct-Apr) and five cooling months (May-Sept) is 9,436 and 1,722MMBtu respectively.

**Table 4.1.2 Summary of #4 fuel oil consumption in 2012-2013**

<b>Year (2012-2013)</b>	<b>Month</b>	<b>#4 Fuel Oil (bought) (MMBtu)</b>
Cooling Season	May	455.3
	Jun	468.9
	Jul	362.8
	Aug	303.1
	Sept	132.2
Heating Season	Oct	435.1
	Nov	1,025.90
	Dec	871
	Jan	1,522.40
	Feb	2,605.50
	Mar	1,741.90
	Apr	1,234.10
<b>Total</b>		<b>11,158</b>

Energy Requirement:

The energy delivered to the building through hot water and comfort heating is lesser than bought energy. The heat load of the building during summer and winter months can be calculated as follows:

$$\begin{aligned}
 \text{Heat Load during summer} &= 1,722 \text{ MMBtu} \times \text{eff of old boiler} \\
 &= 1,722 \text{ MMBtu} \times 0.75 \\
 &= 1,292 \text{ MMBtu}
 \end{aligned}$$

$$\begin{aligned}
 \text{Heat Load during winter} &= 9,436 \text{ MMBtu} \times \text{eff of old boiler} \\
 &= 9,436 \text{ MMBtu} \times 0.75 \\
 &= 7,077 \text{ MMBtu}
 \end{aligned}$$

The amount of heat available from turbine during winter ( $H_{aw}$ ) and summer ( $H_{as}$ ) months is 1,885 and 1,347 MMBtu respectively.

During summer months, domestic use of hot water of the building will be delivered by the heat available from the turbine. But during the winter months, due to additional comfort heating requirement, the new NG boiler needs to be operated to meet the building heat requirements.

The amount of heat required ( $H_{ew}$ ) from NG boiler during the winter can be calculates as;

$$\begin{aligned}
 H_{ew} &= 7,077 \text{ MMBtu} - 1,885 \text{ MMBtu} \\
 &= 5,192 \text{ MMBtu}
 \end{aligned}$$

The natural gas consumption of the boiler ( $NG_{Boiler}$ ) to supply 5,192 MMBtu of heat can be estimated as

$$\begin{aligned} NG_{Boiler} &= 5,192 \text{ MMBtu} / \text{Eff of boiler} \\ &= 5,192 \text{ MMBtu} / 0.80 \\ &= 6,490 \text{ MMBtu} \end{aligned}$$

The net amount natural gas required is,

$$\begin{aligned} NG &= NG_{req} + NG_{Boiler} \\ &= 7,119 \text{ MMBtu/yr} + 6,490 \text{ MMBtu/yr} \\ &= 13,609 \text{ MMBtu/yr} \end{aligned}$$

$$\begin{aligned} \text{Natural gas cost} &= 13,609 \text{ MMBtu/yr} \times \$9.93/\text{MMBtu} \\ &= \$135,137/\text{yr} \end{aligned}$$

### Size of the boiler

From the #4 fuel consumption, it can be noticed that in the month of February the peak load (2,605.50 MMBtu) has occurred. The boiler should be able to meet the peak load requirements of the building. The peak load of the building (PL) can be calculated as;

$$PL = (\text{February NG consumption} \times \text{EFF}_o / \text{EFF}_N) - \text{Heat available from turbine in Feb}$$

Where,

$$\begin{aligned} \text{Eff}_o &= \text{Efficiency of old boiler, } 0.75 \\ \text{Eff}_N &= \text{Efficiency of new boiler, } 0.80 \end{aligned}$$

$$\begin{aligned} PL &= 2,605.90 \text{ MMBtu/month} \times (0.75/0.80) - 269 \text{ MMBtu/month} \\ &= 2,174 \text{ MMBtu/month} \end{aligned}$$

The capacity of the boiler can be estimated as,

$$\begin{aligned} \text{Boiler Capacity} &= (2,174 \text{ MMBtu/month}) / (28 \text{ days} \times 24 \text{ hrs} \times \text{safety factor}) \\ &= 2,174 / (28 \times 24 \times .80) \\ &= 4.04 \text{ MMBtu/hr} \end{aligned}$$

Hence, it is recommended to install 5 MMBtu/hr boiler to meet heat load requirements of the building.

Operating and Maintenance cost:

According to micro turbine manufacturers, the typical maintenance cost of a micro turbine is about \$0.03/kW

$$\begin{aligned} \text{The maintenance cost of a turbine} &= \$0.03/\text{kW} \times 512,460 \text{ kWh/yr} \\ &= \$15,374/\text{yr} \end{aligned}$$

According to boiler manufactures, the typical maintenance cost of the boiler is about \$1/MMBtu input.

$$\begin{aligned} \text{The maintenance cost of a turbine} &= \$1/\text{MMBtu} \times 6,490 \text{ MMBtu/yr} \\ &= \$6,490/\text{yr} \end{aligned}$$

Net Cost savings (NCS)

$$\begin{aligned} \text{NCS} &= \$250,568/\text{yr} + \$104,286 - \$135,137/\text{yr} - \$15,374/\text{yr} - \$6,490/\text{yr} \\ &= \$197,853/\text{yr} \end{aligned}$$

Implementation cost

A detailed engineering analysis and feasibility study needs to be carried out before actual implementation of this recommendation. According a micro turbine manufacturer, the cost of a turbine generator set designed for this process would be about \$2,490 per kW which includes installation cost.

The boiler capital cost can be estimated at \$80,000 per MMBtu and installation cost can be around 40,000.

The engineering and planning cost is estimated around \$15,000.

The total implementation cost (IC) can be calculated as;

$$\begin{aligned} \text{IC} &= (\$2,490/\text{kW} \times 65 \text{ kW}) + \$80,000 + \$40,000 + \$15,000 \\ &= \$296,850 \end{aligned}$$

Simple Payback

The simple payback can be estimated based on the following formula:

$$\begin{aligned} \text{Payback Period} &= \{ \text{IC} (\$) / \text{NCS} (\$) \} \times 12 \text{ months} \\ &= (\$296,850 / \$197,853) \times 12 \\ &= 18.00 \text{ months} \\ &\cong 1.5 \text{ years} \end{aligned}$$

## ERP No.2: Replace the Incandescent Lamps with Compact Fluorescent Lamps

Resource	Annual Savings			Project Cost	Simple Payback
	Amount	CO <sub>2</sub> (lbs)*	Dollars		
Electricity	44,626 kWh (152 MMBtu)	42,484	\$9,081	-	-
Capital	-	-	-	\$1,608	-
Labor	-	-	-	\$1,860	-
<b>Total</b>	-	42,484	\$9,081	\$3,468	0.4 years

\*1 kWh  $\equiv$  0.952 lbs of CO<sub>2</sub> & 1 MMBtu  $\equiv$  293 kWh

### Recommended Action

Replace the existing incandescent lamps with compact fluorescent lamps in the building.

### Background

Compact fluorescent lamps are smaller versions of standard fluorescent lamps and have a brightness and color rendition that is comparable to incandescent lights. CFLs have the following advantages over incandescent light bulbs: they last up to 10 times longer, use about ¼ the energy, and produce 90% less heat, while producing more light per watt.

The existing lighting system in building consists of 100W and 60W incandescent bulbs. The proposed compact fluorescent lamp consists of 23W and 15W bulbs. The lumen outputs for the current and proposed bulbs are given in Table 4.2.1.

**Table 4.2.1: Lumen output for the current and proposed bulbs**

Lamp	Wattage	Lumen output
Current		
Incandescent	100	1,000
Incandescent	60	850
Proposed		
CFL	23	1,610
CFL	15	950

### Anticipated Savings

The existing lighting and proposed lighting in the building is shown in Table 4.2.2 and 4.2.3.

**Table 4.2.2: Existing lighting in the Building**

Area	Bulb Type	Number of Bulbs	Bulb Size (W)	Operation Hours/yr	Total Wattage (W)	Total Energy Usage (kWh/yr)
Inside Apartment	Incandescent	252	100	1,825	25,200	45,990
Inside Apartment	Incandescent	45	60	1,825	2,700	4,928
Restrooms	Incandescent	168	60	730	10,080	7,358
<b>Total</b>		<b>465</b>			<b>37,980</b>	<b>58,276</b>

**Table 4.2.3: Proposed lighting in the Building**

Area	Bulb Type	Number of Bulbs	Bulb Size (W)	Operation Hours/yr	Total Wattage (W)	Total Energy Usage (kWh/yr)
Inside Apartment	CFL	252	23	1,825	5,796	10,578
Inside Apartment	CFL	45	15	1,825	675	1,232
Restrooms	CFL	168	15	730	2,520	1,840
<b>Total</b>		<b>465</b>			<b>8,991</b>	<b>13,650</b>

Energy Cost Savings

The current and proposed energy usages (CEU and PEU) can be calculated as follows,

$$CEU = NB \times WOEB \times OH / 1,000$$

$$PEU = NB \times PWOEB \times OH / 1,000$$

Where,

- NB = number of bulbs in each fixture, no units
- WOEB = wattage of each bulb, W
- PWOEB = proposed wattage of each bulb, W
- OH = yearly operating hours, hours/year

For example, the annual lighting energy usage for current (Table 4.2.2) and proposed (Table 4.2.3) conditions for the Apartment is given as,

$$CEU_{Apt} = 252 \times 100 \times 1,825 / 1,000$$

$$= 45,990 \text{ kWh/yr}$$

$$\begin{aligned} \text{PEU}_{\text{Apt}} &= 252 \times 23 \times 1,825/1,000 \\ &= 10,578 \text{ kWh/yr} \end{aligned}$$

Therefore, the annual energy savings for the apartment lighting can be calculated as,

$$\begin{aligned} \text{ES}_{\text{Apt}} &= 45,990 \text{ kWh/yr} - 10,578 \text{ kWh/yr} \\ &= 35,412 \text{ kWh/yr} \end{aligned}$$

Similarly, from Tables 4.2.2 and 4.2.3, the total annual energy savings can be calculated as,

$$\begin{aligned} \text{ES} &= 58,276 \text{ kWh/yr} - 13,650 \text{ kWh/yr} \\ &= 44,626 \text{ kWh/yr} \end{aligned}$$

The annual energy cost savings ECS, to be realized can be estimated as follows:

$$\begin{aligned} \text{ECS} &= \text{ES} \times (\text{Average unit electricity cost}) \\ &= (44,626 \text{ kWh/yr}) \times (\$0.2035/\text{kWh}) \\ &= \$9,081/\text{yr} \end{aligned}$$

#### Implementation Cost

The implementation cost for replacing the incandescent bulbs with compact fluorescent lamps is:

**Table 4.2.4: Capital Cost Summary for the Building**

<b>Fixture Type</b>	<b>No. of Bulbs</b>	<b>Bulb Size (W)</b>	<b>Bulb Cost (\$/unit)</b>	<b>Total Costs (\$)</b>
CFL	252	23	3	756
CFL	213	15	4	852
<b>Total</b>	<b>465</b>			<b>1,608</b>

$$\text{Capital Cost} = \$1,608$$

It is estimated that each incandescent bulb requires a total of 10 minutes to replace with CFL bulb. Hence the labor cost for installation:

$$\begin{aligned} \text{LC}_{\text{installation}} &= (10/60) \text{ hrs/fixture} \times \$40/\text{hr} \times 465 \\ &= \$1,860 \end{aligned}$$

The total implementation cost (IC) is given as,

$$\begin{aligned} \text{IC} &= \text{Capital} + \text{Cost LC} \\ &= \$1,608 + \$1,860 \\ &= \$3,468 \end{aligned}$$

Payback = (Implementation cost / Savings) x months/yr  
= (\$3,468/\$9,081) x 12  
= 4.58 months  
≈ 0.4 years.

The annual cost savings of \$9,081 gives a simple payback on the investment of \$3,468 in 5 months.

**ERP No.3: Replace the Existing T12 Fluorescent Bulbs and Magnetic Ballasts with LED, T5, and T8 Fluorescent Bulbs and Electronic Ballasts with Reflectors in the Building**

Resource	Annual Savings			Project Cost	Simple Payback
	Amount	CO <sub>2</sub> (lbs)*	Dollars		
Electricity	25,018 kWh (85 MMBtu)	23,817	\$5,091	-	-
Capital	-	-	-	\$7,981	-
Labor	-	-	-	\$5,454	-
Total	-	23,817	\$5,091	\$13,435	2.6 years

\* 1 kWh = 0.952 lbs of CO<sub>2</sub> & 1 MMBtu = 293 kWh

Recommended Action

Replace the existing T12 fluorescent bulbs and magnetic ballasts with LED, T5, and T8 fluorescent bulbs with electronic ballasts and reflectors in the building. This will reduce the lighting energy usage while practically maintaining the same lighting levels (or better) in the building.

Background

Lighting technology has evolved rapidly in recent years. In commercial or residential buildings, significant reductions in energy use can be achieved by installing energy-efficient bulbs, fixtures, and controls. Retrofits to install new technologies such as electronic ballasts and specular reflectors are often cost effective, providing a payback within a few years. In some cases the number of bulbs can be reduced by adding reflectors. If the number of bulbs is reduced, the lumen output per fixture may also reduce, but the lighting levels will remain the same as the existing levels because the reflectors direct more light onto the working area.

The existing lighting system consists of T12 circular (32W), 2 ft T12 (20W), 8 ft T12 (75W), and 4 ft T12 (34W) lighting fixtures with magnetic ballasts (Table 4.3.1). The lumen outputs for the current and proposed bulbs are given in Table 4.3.1.

**Table 4.3.1: Lumen output for the current and proposed bulbs**

Lamp	Wattage	Lumen output
Current		
T12 Circular	32	1,800
2 ft T12	20	1,200
8ft T 12	75	6,700
4 ft T12	34	2,650
Proposed		
T5-Circular	22	1800
2ft LED	10	1,020
8ft T8	49	5,000
4ft T8	28	2,645

**Table 4.3.2: Existing lighting in the Building**

Area	Bulb Type	Number of Fixtures	Number of Bulbs	Total Number of Bulbs	Bulb Size (W)	Current Ballast Type*	Operation Hours/yr	Total Wattage (W)	Total Energy Usage (kWh/yr)
Inside Apartment	T12-Circular	129	1	129	32	M	1,825	4,128	8,664
Staircase	T12-2ft	44	1	44	20	M	8,760	880	8,865
Corridors	T12-Circular	99	1	99	32	M	8,760	3,168	31,914
Garage	T12 - 4ft	7	2	14	34	M	8,760	476	4,795
Lobby	T12-Circular	15	1	15	32	M	8,760	480	4,836
Laundry	T12 - 4ft	1	2	2	40	M	4,380	80	403
Laundry	T12 - 8ft	3	2	6	75	M	4,380	450	2,267
Outside Garage	T12 - 4ft	5	2	10	34	M	8,760	340	3,425
<b>TOTAL</b>	-	<b>303</b>	-	<b>319</b>	-		-	<b>10,002</b>	<b>65,169</b>

\*M- Magnetic, E-Electronic

Anticipated Savings

The proposed lighting and energy savings for the building summarized in Table 4.3.3 below.

**Table 4.3.3: Proposed Lighting and Energy Savings for the Building**

Area	Bulb Type	Proposed Ballast Type *	Proposed # of Fixtures (No.)	Proposed # of Bulbs/ Fixture (No.)	Bulb Size (W)	Total # of Bulbs	Total Wattage (W)	Operation Hours/yr	Total Energy Usage (kWh/yr)	Energy Savings (kWh/yr)
Inside Apartment	T5-Circular	E	129	1	22	129	2,838	1,825	5,438	3,226
Staircase	LED-2ft	-	44	1	10	44	440	8,760	3,854	5,011
Corridors	T5-Circular	E	99	1	22	99	2,178	8,760	20,033	11,881
Garage	T8 - 4ft	E	7	2	28	14	392	8,760	3,606	1,190
Lobby	T5-Circular	E	15	1	22	15	330	8,760	3,035	1,800
Laundry	T8 - 4ft	E	1	2	28	2	56	4,380	258	145
Laundry	T8 - 8ft	E	3	2	49	6	294	4,380	1,352	915
Outside Garage	T8 - 4ft	E	5	2	28	10	280	8,760	2,575	850
<b>Total</b>	-	-	<b>303</b>	-	-	<b>319</b>	<b>6,808</b>	-	<b>40,151</b>	<b>25,018</b>

\*M- Magnetic, E-Electronic

Energy Savings

The energy savings, ES, due to replacing the T12 bulbs with the efficient bulbs and adding reflectors are calculated as:

$$ES = CEU - PEU$$

The current and proposed energy usages (CEU and PEU) can be calculated as follows,

$$CEU = NF \times NB \times WOEB \times (1 + BF) \times OH / 1,000$$

$$PEU = NF \times NB \times PWOEB \times (1 + BF) \times OH / 1,000$$

Where,

NF	=	number of fixtures, no units
NB	=	number of bulbs in each fixture, no units
WOEB	=	wattage of each bulb, W
PWOEB	=	proposed wattage of each bulb, W
BF	=	ballast loss (15% for magnetic, 5% for electronic, 0 for LED)
OH	=	yearly operating hours, hours/year

For example, the annual lighting energy usage for current (Table 4.3.2) and proposed (Table 4.3.3) conditions for the Apartment is given as,

$$\begin{aligned} CEU_{apt} &= 129 \times 1 \times 32 \times (1+0.15) \times 1,825/1,000 \\ &= 8,664 \text{ kWh/yr} \end{aligned}$$

$$\begin{aligned} PEU_{apt} &= 129 \times 4 \times 22 \times (1+0.05) \times 1,825/1,000 \\ &= 5,438 \text{ kWh/yr} \end{aligned}$$

Therefore, the annual energy savings for the apartment lighting (Table 4.3.3) can be calculated as,

$$\begin{aligned} ES_{apt} &= 8,664 \text{ kWh/yr} - 5,438 \text{ kWh/yr} \\ &= 3,226 \text{ kWh/yr} \end{aligned}$$

Similarly, from Tables 4.3.1 and 4.3.3, the total annual energy savings are given as, 25,018 kWh/yr.

The annual energy cost savings ECS, to be realized can be estimated as follows:

$$\begin{aligned} ECS &= ES \times (\text{Average unit electricity cost}) \\ &= (25,018 \text{ kWh/yr}) \times (\$0.2035/\text{kWh}) \\ &= \$5,091/\text{yr} \end{aligned}$$

#### Implementation Cost

The implementation cost for replacing the existing T12 bulbs and magnetic ballasts with LED, T5, and T8 fluorescent bulbs, and electronic ballasts with reflectors is calculated as shown in Table 4.3.4.

**Table 4.3.4: Capital Cost Summary for the Building**

Fixture Type	No. of Fixtures	No. of Bulbs	Bulb Size (W)	Electronic Ballast Cost (\$/unit)	Total Ballast Costs (\$)	Bulb Cost (\$/unit)	Total Bulb Costs (\$)	Reflector Cost (\$/unit)	Total Reflector Cost	Total Costs (\$)
T5-Circular	243	243	22	15	3,645	10	2,430	0	0	6,075
LED -2ft	44	44	10	0	0	20	880	0	0	880
T8 - 4ft	13	26	28	15	195	5	130	14	182	507
T8 - 8ft	3	6	49	65	195	45	270	18	54	519
<b>Total</b>	<b>303</b>	<b>319</b>	<b>-</b>	<b>-</b>	<b>4,035</b>	<b>-</b>	<b>3,710</b>	<b>-</b>	<b>236</b>	<b>7,981</b>

It is estimated that each fixture requires a total of 30 minutes to replace the T12 bulbs with T5, LED, and T8 bulbs and replace the magnetic ballast with the electronic ballast and fix specular reflectors. Hence the labor cost for installation:

$$\begin{aligned}
 LC_{\text{installation}} &= 0.50 \text{ hrs/fixture} \times \$40/\text{hr} \times 303 \\
 &= \$5,454
 \end{aligned}$$

The total implementation cost (IC) is given as,

$$\begin{aligned}
 IC &= \text{Capital} + \text{Cost LC} \\
 &= \$7,981 + \$5,454 \\
 &= \$13,435
 \end{aligned}$$

Payback period (PP) can be calculated as,

$$\begin{aligned}
 PP &= (IC (\$) / \text{TACS} (\$/\text{yr})) \times 12 \text{ months/yr} \\
 &= (\$13,435 / \$5,091) \times 12 \\
 &\cong 31.7 \text{ months} \\
 &\cong 2.64 \text{ years}
 \end{aligned}$$

The total cost savings of \$5,091/yr will pay for the implementation cost of \$13,435 in 32 months.

**ERP No.4: Install Temperature Setback Controls on the AC units in the Apartments**

Resource	Annual Savings			Project Cost	Simple Payback
	Amount	CO <sub>2</sub> (lb)*	Dollars		
Electricity	21,139 kWh (72 MMBtu)	20,124	\$4,302	-	-
Capital	-	-	-	\$10,650	-
Labor	-	-	-	\$6,240	-
<b>Total</b>	-	20,124	\$4,302	\$16,890	3.9 years

\* 1 kWh = 0.92 lbs of CO<sub>2</sub> & 1 MMBtu = 293 kWh

**Recommended Action**

Install setback controls on the window ac units located in the apartments to allow for day time temperature setback. The setback will apply during the five cooling months (May - Sep).

**Background**

During the summer period, window ac units are on at all times, however during day times they may be set back. As per discussion with the maintenance personnel, the apartments are usually not occupied from 9 am to 5pm during weekdays, which makes it possible to setback ac units during day time.

Effective temperature setback will be achieved through the time of day. Energy savings will be achieved by using a control system to implement a deeper temperature setback for periods when the building is generally not occupied.

The control system will schedule the temperature setback to 78°F for the cooling months. It will automatically switch to the original temperature set points 30 minutes prior the beginning of the occupancy.

**Anticipated Savings**

Energy savings are calculated based on a reduction of cooling requirement during the cooling season. During the five cooling months (May - Sep), the energy savings calculations use a 10°F increase in space temperature (from current 68°F to 78°F). For the apartments, there will be 7 hrs/day x 5 days/week = 35 hours per week available for temperature setback.

The monthly average outside air temperature for the building is shown in Table 4.4.1. The average outside air temperature during the 5 months of the cooling season is 79°F and the cooling temperature set point in the building is around 68°F.

**Table 4.4.1 Average outside air temperature<sup>3</sup> in winter**

<b>Month</b>	<b>Avg. High °F</b>
May	71
Jun	81
Jul	85
Aug	84
Sept	76
<b>Average</b>	<b>79</b>

Setback controls could be implemented in the apartment window ac system with total capacity of about 1,704,000 Btu/hr (213 units x 8000 Btu/hr). The total amount of electricity spent on cooling (CEE) by these window units may approximately be estimated from electrical energy bills:

The total amount of electricity consumed during the five cooling months (May-Sep) and seven heating months (Oct-Apr) is 379,400 kWh and 374,000 kWh respectively.

**Table 4.4.2 Summary of electrical energy consumption in 2012-2013**

<b>Year (2012-2013)</b>	<b>Month</b>	<b>Electricity (kWh)</b>
Cooling Season	May	45,600
	Jun	60,200
	Jul	88,200
	Aug	98,400
	Sept	87,000
Heating Season	Oct	56,600
	Nov	52,200
	Dec	52,200
	Jan	58,200
	Feb	51,800
	Mar	51,200
	Apr	51,800
<b>Total</b>		<b>753,400</b>

Therefore, the total amount of current electrical energy (CEE) spent on the cooling during 2012-2013 was:

$$\begin{aligned} \text{CEE} &= 379,400 - 374,400 / 7 \times 5 \\ &= 111,971 \text{ kWh/yr} \end{aligned}$$

<sup>3</sup> [www.weather.com](http://www.weather.com) – Bronx, NY on Sep 12, 2013

The energy savings obtained from the implementation of the setback controls on the window ac units may be estimated as:

$$ES = CEE \times SBH / OH \times dT / (AOAT - CSP)$$

Where,

SBH = Setback Hours, 35hrs/week x 52 weeks/yr x 5/12 = 758 hrs/yr

OH = Operating hours of the heating, 8,760 x 5/12 = 3,650 hrs/yr

dT = Reduction in space temperature, 10°F

CSP = Current Set Point, 68°F

AOAT = Average outside air temperature for cooling season, 79°F

$$ES = 111,971 \text{ kWh/yr} \times (758/3650) \times 10^\circ\text{F} / (79 - 68)^\circ\text{F}$$

$$= 21,139 \text{ kWh/yr}$$

The total electrical cost savings (CS) for implementing the setback controls on the window ac units is calculated as:

$$CS = 21,139 \text{ kWh/yr} \times \$0.2035/\text{kWh}$$

$$= \$4,302 / \text{yr}$$

#### Implementation Cost

The implementation cost is based on manufacturers cost data and associated installation labor costs.

Setback Control System (\$50/unit x 213 units)	= \$10,650
Engineering Analysis Cost	= \$ 2,000
<u>Miscellaneous In-House Labor(106 hrs x \$40)</u>	<u>= \$ 4,240</u>
Total Cost	= \$16,890

$$\text{Payback period} = (\text{Investment} (\$) / \text{Energy cost savings} (\$/\text{yr})) \times 12 \text{ months/yr}$$

$$= (\$16,890 / \$4,302) \times 12$$

$$= 47.11 \text{ months}$$

$$\approx 3.92 \text{ years}$$

The annual cost savings of \$4,302 would pay for the implementation cost of \$16,890 in approximately 48 months.