SYRACUSE UNIVERSITY
College of Engineering and Computer Science
Department of Mechanical and Aerospace Engineering

INDUSTRIAL ASSESSMENT CENTER

ASSESSMENT REPORT

FOR

SU SAMPLE

SU0XXX

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Preface

The Syracuse University Industrial Assessment Center (IAC) performed the work described in this report. The IAC is funded by the United States Department of Energy's Advanced Manufacturing Office, with Rutgers (the State University of New Jersey), serving as program administration.

The objectives of the IAC are to identify and evaluate selected opportunities for energy conservation, productivity improvement, and waste minimization. The recommendations developed are the result of analyses performed on client-supplied data and through a site visit, and are therefore restricted in detail due to limitations on available time at the site. When energy conservation or waste minimization opportunities involving engineering design and capital investment are found to be the recommended course of action, it is advisable to engage the services of a consulting engineering firm or other experts to do the detailed engineering work involved.

Disclaimer

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Executive Summary

The following is a full summary of the report. Also contained in the report are assessment recommendations, additional considerations, utility billing information, best practices, and an implementation survey.

Resource Consumption

Utility	Annual Cost	Annual Usage		
		Billed		MMBtu
Electric Usage	*$2,370,757*	*56,064,161*	*kWh*	*191,347*
Electric Demand	*$664,089*	*169,892*	*kW*	*N/A*
Electric Reactive	*$6,070*	*7,782,360*	*RkVa*	*N/A*
Other Electric Charges	*($29,390)*	*N/A*		*N/A*
Natural Gas	*$100,620*	*140,316*	*Therms*	*14,032*
Water and Sewer	*$43,016*	*12,560,800*	*Gallons*	*N/A*
Trash	*$62,977*	*N/A*		*N/A*
Total	$3,218,139	N/A		205,379

The values used for electricity, natural gas, and argon were taken from utility bills spanning from January 2014 to December 2014. Water, sewer, and trash values were given in the pre-assessment survey.

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Executive Summary of Recommendations

Assessment Recommendations (AR)	Annual Resource Savings			Total Annual Savings	Capital Costs	Other Costs	Simple Payback
Reduce Compressed Air System Line Pressure	*Electricity:*	*137,819*	*kWh*	*$5,788*	*None*	*None*	*Immediate*
Reduce Lighting Levels	*Electricity:* *Demand:*	*28,641* *55.1*	*kWh* *kW*	*$1,418*	*None*	*None*	*Immediate*
Eliminate Use of Electric Space Heaters	*Electricity:* *Demand:*	*8,100* *45*	*kWh* *kW*	*$516*	*None*	*None*	*Immediate*
Implement a Regular Leak Maintenance Program	*Electricity:*	*251,288*	*kWh*	*$10,554*	*$500*	*$2,585*	*0.3 years*
Install Occupancy Sensors in Clean Room Hallway	*Electricity:*	*9,579*	*kWh*	*$402*	*$102*	*$56*	*0.4 years*
Duct Outside Air to Compressors	*Electricity:*	*112,643*	*kWh*	*$4,731*	*$1,034*	*$1,940*	*0.6 years*
Install Energy Efficient Exit Sign Bulbs	*Electricity:* *Demand:* *Labor Hours:* *Avoided Cost:*	*18,396* *25* *55* *$660*	*kWh* *kW* *h*	*$3,064*	*$1,800*	*$348*	*0.7 years*
Insulate Pipes	*Natural Gas:*	*16.6*	*MNMBtu*	*$119*	*$95*	*$27*	*1.0 years*
Install Occupancy Sensors on Vending Machines	*Electricity:*	*8,850*	*kWh*	*$372*	*$670*	*$134*	*2.2 years*
Replace CRT Computer Monitors with LCD	*Electricity:* *Demand:*	*5,431* *7.44*	*kWh* *kW*	*$257*	*$1,000*	*$70*	*4.2 years*
Totals	Electricity: Demand: Labor Hours: Avoided Cost: Natural Gas:	580,747 132.74 55 $660 16.6	kWh kW h MMBtu	$27,221	$5,201	$5,160	N/A

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Recommendation Explanations

Below is a brief explanation of each recommendation with respect to how energy will be saved. More information on each recommendation is included in the Assessment Recommendations section of this report.

1. **Reduce Compressed Air System Line Pressure**
   Having the compressors operate at a higher than required pressure results in increased energy consumption. Reducing this line pressure will lower the energy used by each compressor.

2. **Reduce Lighting Levels**
   Several areas throughout the facility currently have more lighting than is necessary for the tasks performed. De-lamping some of these fixtures will result in electricity savings.

3. **Eliminate Use of Electric Space Heaters**
   Personal electric space heaters are commonly found in office areas during winter months. Although small, these units consume a relatively large amount of energy. Removal of these space heaters often results in significant energy and cost savings.

4. **Implement a Regular Leak Maintenance Program**
   When compressor air lines contain leaks, the compressors have to work harder to maintain the required line pressure, resulting in an increase in energy consumption. Repairing these leaks will reduce the operating costs of the compressor system.

5. **Install Occupancy Sensors in Clean Room Hallway**
   Turning off lights when they are not needed can reduce energy costs. Occupancy sensors ensure that lights are turned off when they are not needed and automatically turn on when the hallway is occupied.

6. **Duct Outside Air to Compressor**
   Compressors take the ambient air and compress it for facility use. Typically the outside air is colder than the intake air of the compressors. This outside air is denser and therefore easier to compress, resulting in energy savings.

7. **Install Energy Efficient Exit Sign Bulbs**
   LED light bulbs require significantly less energy and last longer than fluorescent and incandescent bulbs. By switching out the current exit sign bulbs for LED ones, the company will save energy as well as labor hours associated with replacing burnt out bulbs.

8. **Insulate Pipes**
   Un-insulated steam piping results in heat loss to the surrounding environment. Insulating pipes will prevent the steam from losing energy and thus will result in fuel savings required to keep the steam at the needed temperature and energy level.

9. **Install Occupancy Sensors on Vending Machines**
   Snack and beverage (excluding dairy) vending machines run 24 hours per day, 7 days per week regardless if anyone is around to use them. Installing occupancy sensors on the machines will idle them when not in use but will automatically cycle the compressor to keep beverages cool.

10. Replace CRT Computer Monitors with LCD

Older CRT monitors demand more electricity than equivalent LCD flat screen monitors. By switching out the CRTs for LCDs, the company will save money every month on their electricity bill.

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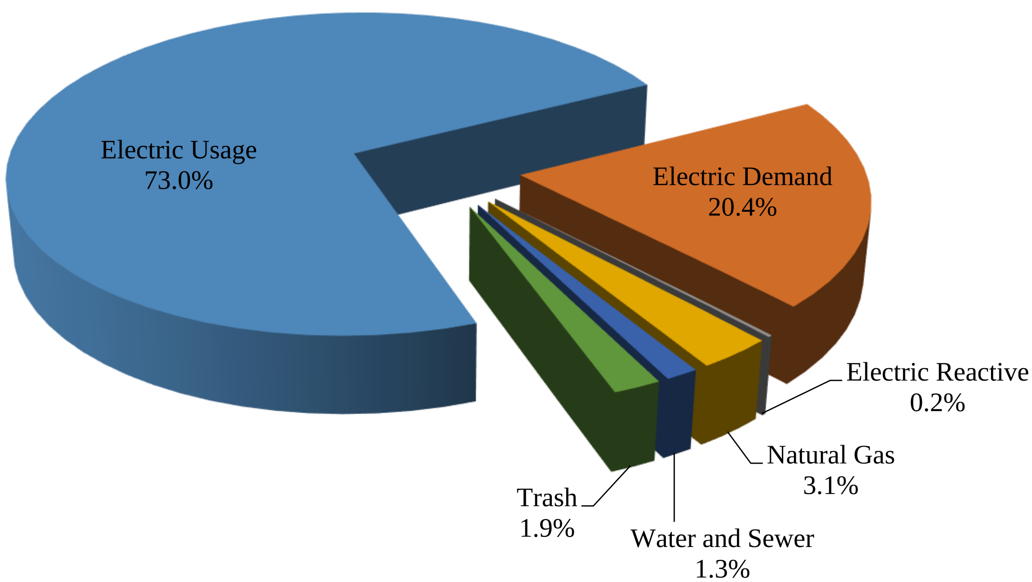
Annual Utility Summary

The following values are averaged from individual annual utility charges provided. All graphs and corresponding data have been included in electronic format on a CD packaged with this report.

Utility Summary

Utility	Annual Cost	Annual Usage		MMBtu	Average Cost		Cost per MMBtu
Electric Usage	*$2,370,757*	*56,064,161*	*kWh*	*191,347*	*$0.042*	*$/kWh*	*$12.39*
Electric Demand	*$664,089*	*169,892*	*kW*	*N/A*	*$3.91*	*$/kW*	*N/A*
Electric Reactive	*$6,070*	*7,782,360*	*RkVA*	*N/A*	*$0.001*	*$/RkVA*	*N/A*
Other Electric Charges	*-$29,390*	*N/A*		*N/A*	*N/A*		*N/A*
Natural Gas	*$100,620*	*140,316*	*Therms*	*14,032*	*$0.72*	*$/Therm*	*$7.17*
Water and Sewer	*$43,016*	*12,560,800*	*Gallons*	*N/A*	*$0.003*	*$/Gallon*	*N/A*
Trash	*$62,977*	*N/A*		*N/A*	*N/A*		*N/A*
Total	$3,218,139	N/A		205,379	N/A		N/A

The values used for electricity, natural gas, and argon were taken from utility data recorded from January 2014 through December 2014. Note that the average cost values presented in the above table were calculated by dividing the total cost by the total usage. This cost data is represented in the pie chart below.



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Assessment Recommendations

The following recommendations are arranged in order of shortest simple payback to longest simple payback.

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Assessment Recommendation # 1
Reduce Compressed Air System Line Pressure

Assessment Recommendation Summary					
ARC#	Annual Resource Savings	Total Annual Savings	Capital Cost	Other Cost	Simple Payback
2.4231.2	Electricity: 137,819 kWh	$5,788	None	None	Immediate

Current Practice

It was observed during the site visit that the plant's air compressors may be running at a higher pressure than the facility requires. The primary are where this was observed was in the South Plant. The following table provides important information for each of the compressor units that were identified as operating at a pressure well above the required for the facility.

Location	Compressor	Horsepower	Load Factor	Efficiency	Current Operating Pressure (psi)	Proposed Operating Pressure (psi)	Annual Operating Hours[1]
South Plant	*W1988*	*200*	*0.77*	*0.85*	*145*	*95*	*2,667*
South Plant	*W2237*	*40*	*0.91*	*0.85*	*148*	*95*	*2,667*
South Plant	*W2238*	*40*	*0.88*	*0.85*	*154*	*95*	*2,667*

The current annual energy usage (EU_c) associated with this practice can be determined by using the following equation. A sample calculation is done using the 200 hp compressor listed in the table above as an example.

$$EU_c = \frac{HP}{\eta} \times LF \times C_{kW,hp} \times HRS$$

Where,

HP	=	Compressor horsepower	*200 hp*
η	=	Efficiency of compressor motor[2]	*0.85*
LF	=	Load factor[3]	*0.77*
$C_{kW,hp}$	=	Conversion constant	$0.7459 \frac{kW}{hp}$
HRS	=	Annual operating hours[4]	*2,667 h*

Substituting,

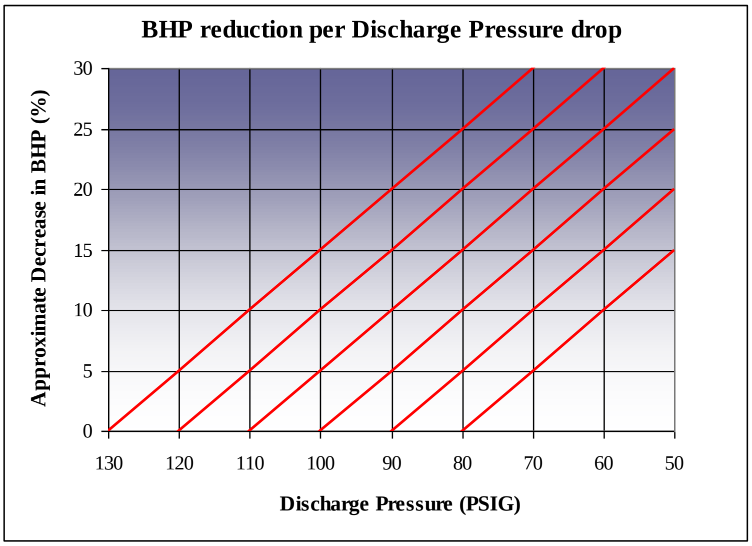
[1] Estimated based on the Pre-Assessment Survey, compressors operate lead-lag 8000 hours per year
[2] Estimated by IAC personnel
[3] Calculated by IAC personnel
[4] Estimated based on the Pre-Assessment Survey, compressors operate lead-lag 8000 hours per year

$$EU_c = \frac{200\ hp}{0.85} \times 0.77 \times 0.7459\, \tfrac{kW}{hp} \times 2{,}667\ h$$

$$EU_c \approx 360{,}417\ kWh$$

Recommended Action

It is recommended that the line pressure be reduced to the lowest pressure allowable for the plant. The following figure shows graphically the relationship between percentage brake horsepower (*BHP*) reduction and discharge pressure. The line pressure should be lowered gradually in order to prevent any unforeseeable problems that may result due to inadequate pressure. The best performance will be achieved if leaks are fixed and maintained in the compressed air lines. Although reducing to the lowest possible pressure is recommended, any reduction in pressure will result in savings. Tables in the next section show a breakdown of various amounts of reduction and the associated savings.



The proposed annual energy usage (EU_p) can be determined by using the following equation. The following calculation corresponds to the last row in the summary table, where the line pressure is lowered to 95 psi. A sample calculation is done using the 200 hp compressor listed in the table above.

$$EU_p = \frac{HP}{\eta} \times LF \times (1 - S) \times C_{kW,hp} \times HRS$$

Where,

HP	=	Compressor horsepower	*200 hp*
η	=	Efficiency of compressor motor	*0.85*
LF	=	Load factor	*0.77*
S	=	Power reduction[5]	*0.125*

[5] Based on a 2.5% power decrease for every 5 psi reduction.

$C_{kW,hp}$	=	Conversion constant	$0.7459\ \frac{kW}{hp}$
HRS	=	Annual operating hours	$2{,}667\ h$

Substituting,

$$EU_p = \frac{200\ hp}{0.85} \times 0.77 \times \left(1 - 0.25\right) \times 0.7459\ \tfrac{kW}{hp} \times 2{,}667\ h$$

$$EU_p \approx 270{,}313\ kWh$$

Anticipated Savings

The annual energy usage savings (AUS) associated with this recommendation can be determined by finding the difference between the current energy usage (EU_c) and the proposed energy usage (EU_p). Again, a sample calculation is done using the 200 hp compressor listed in the table above as an example.

$$AUS = EU_c - EU_p$$

Therefore,

$$AUS = 360{,}417\ kWh - 270{,}313\ kWh$$

$$AUS \approx 90{,}104\ kWh$$

The following tables show the breakdown for the percentage of power saved per unit reduction in pressure. They also calculate the total annual savings based on and average electricity cost of 0.042 $^{\$}/_{kWh}$.

For Compressor W1988 (200 hp),

Reduced Line Pressure	Est. Power Reduction	Annual Usage Savings (kWh)	Total Annual Savings
135	*5%*	*18,021*	*$757*
125	*10%*	*36,042*	*$1,514*
115	*15%*	*54,063*	*$2,271*
105	*20%*	*72,083*	*$3,027*
95	***25%***	***90,104***	***$3,784***

For Compressor W2237 (40 hp),

Reduced Line Pressure	Est. Power Reduction	Annual Usage Savings (kWh)	Total Annual Savings
135	*7%*	*5,963*	*$250*
125	*12%*	*10,223*	*$429*
115	*17%*	*14,482*	*$608*
105	*22%*	*18,742*	*$787*
95	***27%***	***23,001***	***$966***

For Compressor W2238 (40 hp),

Reduced Line Pressure	Est. Power Reduction	Annual Usage Savings (kWh)	Total Annual Savings
135	*10%*	*8,238*	*$346*
125	*15%*	*12,357*	*$519*
115	*20%*	*16,476*	*$692*
105	*25%*	*20,595*	*$865*
95	***30%***	***24,714***	***$1,038***

Reducing the compressed air line pressure to the recommended line pressure will result in an annual energy savings (*AES*) of 137,819 kWh.

The estimated total annual savings (*TAS*) associated with reducing the compressed air line pressure to the recommended pressure is determined as follows.

$$TAS \approx \$3{,}784 + \$966 + \$1{,}038$$

$$TAS \approx \$5{,}788$$

Implementation Costs

There are no implementation costs associated with this recommendation. It is assumed that maintenance personnel will perform the required action during normal plant hours. The simple payback period is immediate.

Assessment Recommendation # 2
Reduce Lighting Levels

Assessment Recommendation Summary					
ARC#	Annual Resource Savings	Total Annual Savings	Capital Cost	Other Cost	Simple Payback
2.7122.3	Electricity: 28,641 kWh Demand: 55.1 kW	$1,418	None	None	Immediate

Current Practice

It was observed during the site visit that several areas were over lit. The following table summarizes the important data.

Building	Location	Type of Fixture	Number of Fixtures	Bulbs per Fixture	Wattage per Bulb	Current Hours of Operation
East Plant	*Tool Room*	*T8*	*88*	*4*	*32*	*6,240*
East Plant	*Supersac Duracell*	*T5*	*3*	*4*	*54*	*6,240*
East Plant	*Mezzanine*	*T8*	*5*	*4*	*32*	*6,240*
West Plant	*Tool Room*	*T5*	*24*	*6*	*54*	*6,240*

The current annual energy usage (EU_c) associated with this practice can be determined by the following equation. A sample calculation is done using the East Plant Tool Room listed in the table above as an example.

$$EU_c = N_{fc} \times N_{bc} \times W \times C_{kW,W} \times AOH$$

Where,

N_{fc}	=	Current number of fixtures[6]	*88 fixtures*
N_{bc}	=	Current number of bulbs per fixture	$4\ \frac{bulbs}{fixture}$
W	=	Average wattage per bulb[7]	$32\ \frac{Watts}{bulb}$
$C_{kW,W}$	=	Conversion constant	$0.001\ \frac{kW}{W}$
AOH	=	Annual operating hours[8]	*6,240 h*

Substituting,

[6] Counted by IAC personnel.
[7] Standard wattage for T-8, 4’ fluorescent bulb.
[8] Based on plant operating hours obtained from the pre-assessment survey.

$$EU_c = 88\ fixtures \times 4\ \tfrac{bulbs}{fixture} \times 32\ \tfrac{Watts}{bulb} \times 0.001\ \tfrac{kW}{W} \times 6{,}240\ h$$

$$EU_c \approx 11.26\ kW \times 6{,}240\ h$$

$$EU_c \approx 70{,}262\ kWh$$

Note that 11.26 kW represents the current monthly energy demand (ED_c).

Recommended Action

Fixtures in these areas can be de-lamped to reduce the lighting levels. It is recommended that one bulb from each of the T8 fixtures in the East Plant Tool Room, one bulb from each of the T5 fixtures in the Supersac Duracell area, one bulb from each fixture in the Mezzanine, and one bulb from the West Plant Tool Room be removed to lower lighting levels. This will supply ample lighting to this area. The following tables contain a comparison of the net lumens for the current and proposed fixtures. This is provided to prove the viability when removing bulbs will emit ample lighting.

Bulb Type	Initial Lumens per Watt		Lumen Maintenance Factor		Mean Lumens per Watt
T8 Fluorescent	*90*	*x*	*0.9*	=	*81*
T5 Fluorescent	*82*	*x*	*0.9*	=	*74*

Location		Fixture Type	Mean Lumens per Watt		Ballast Factor		Fixture Efficiency		Bulbs per Fixture		Watts per Bulb		Net Lumens per Fixture
Tool Room (E)	*Current*	*T8 Fluorescent*	*81*	*x*	*1.15*	*x*	*0.9*	*x*	*4*	*x*	*32*	=	*10,731*
	Proposed	*T8 Fluorescent*	*81*	*x*	*1.15*	*x*	*0.9*	*x*	*3*	*x*	*32*	=	*8,048*
Supersac Duracell	*Current*	*T5 Fluorescent*	*74*	*x*	*1.15*	*x*	*0.9*	*x*	*4*	*x*	*54*	=	*16,543*
	Proposed	*T5 Fluorescent*	*74*	*x*	*1.15*	*x*	*0.9*	*x*	*3*	*x*	*54*	=	*12,408*
Mezzanine	*Current*	*T8 Fluorescent*	*81*	*x*	*1.15*	*x*	*0.9*	*x*	*4*	*x*	*32*	=	*10,731*
	Proposed	*T8 Fluorescent*	*81*	*x*	*1.15*	*x*	*0.9*	*x*	*2*	*x*	*32*	=	*5,365*
Tool Room (W)	*Current*	*T5 Fluorescent*	*74*	*x*	*1.15*	*x*	*0.9*	*x*	*6*	*x*	*54*	=	*24,815*
	Proposed	*T5 Fluorescent*	*74*	*x*	*1.15*	*x*	*0.9*	*x*	*5*	*x*	*54*	=	*20,679*

Since the area of the room, mounting height of the fixtures, number of fixtures per location, and the reflectance of the walls, ceiling, and floor remain constant for the current practice and proposed action, the current and proposed lighting level is proportional to the current and proposed net lumens per fixture. Therefore, the proposed lighting level can be calculated as shown in the following table.

SU Sample

Location	Current Lighting Level (ft-cd)		Proposed Net Lumens Per Fixture		Current Net Lumens Per Fixture		Proposed Lighting Level (ft-cd)
Tool Room (E)	*137*	*x*	*8,048*	÷	*10,731*	=	*103*
Supersac Duracell	*100*	*x*	*12,408*	÷	*16,543*	=	*75*
Mezzanine	*173*	*x*	*5,365*	÷	*10,731*	=	*87*
Tool Room (W)	*105*	*x*	*20,679*	÷	*24,815*	=	*88*

Note that the proposed lighting levels is above 70 ft-cd, which is more than adequate lighting level for normal manufacturing facilities and offices.[9] The Tool Room in the East Plant could be de-lamped further, but taking two bulbs from each fixture will leave the room with a lighting level of only 69 foot-candles. It was kept at one per fixture to keep the estimate conservative. The proposed annual energy usage (EU_p) associated with this recommendation can be determined by the following equation. The sample calculation is shown for the East Plant Tool Room.

$$EU_p = N_{fp} \times N_{bp} \times W \times C_{kW,W} \times AOH$$

Where,

N_{fp}	=	Proposed number of fixtures	*88 fixtures*
N_{bp}	=	Proposed number of bulbs per fixture	$3 \frac{bulbs}{fixture}$
W	=	Average wattage per bulb	*32 Watts*
$C_{kW,W}$	=	Conversion constant	$0.001 \frac{kW}{W}$
AOH	=	Annual operating hours	*6,240 h*

Substituting,

$$EU_p = 88 \text{ fixtures } \times 3 \frac{bulbs}{fixture} \times 32 \frac{Watts}{bulb} \times 0.001 \frac{kW}{W} \times 6{,}240 \text{ h}$$

$$EU_p \approx 8.45 \text{ kW} \times 6{,}240 \text{ h}$$

$$EU_p \approx 52{,}728 \text{ kWh}$$

Note that 8.45 kW represents the proposed monthly energy demand (ED_p).

The following table summarizes the current and proposed energy usage and demand for all four spaces.

[9] Based on the Abridged IES Recommended Illumination Levels

SU Sample

Location	Current Energy Demand (kW)	Current Energy Usage (kWh)	Proposed Energy Demand (kW)	Proposed Energy Usage (kWh)
Tool Room (E)	*11.26*	*70,262*	*8.45*	*52,728*
Supersac Durcaell	*0.65*	*4,056*	*0.49*	*3,058*
Mezzanine	*0.64*	*3,994*	*0.32*	*1,997*
Tool Room (W)	*7.78*	*48,547*	*6.48*	*40,435*
Total	20.33	126,859	15.74	98,218

Anticipated Savings

The annual usage savings (*AUS*) associated with this recommendation can be determined by finding the difference between the current energy usage (EU_c) and the proposed energy usage (EU_p). A sample calculation is done using the East Plant Tool Room listed in the table above as an example.

$$AUS = EU_c - EU_p$$

Therefore,

$$AUS = 70,262\ kWh - 52,728\ kWh$$

$$AUS \approx 17,534\ kWh$$

Likewise, monthly energy demand savings (*MDS*) associated with this recommendation can be determined by finding the difference between the current energy demand (ED_c) and the proposed energy demand (ED_p). Again, sample calculation is done using the old storage room listed in the table above as an example.

$$MDS = ED_c - ED_p$$

Therefore,

$$MDS = 11.26\ kW - 8.45 kW$$

$$MDS \approx 2.81\ kW$$

The following table summarizes the annual usage saving (AUS) and monthly energy demand savings (MDS).

SU Sample

Location	Annual Energy Usage Savings (kWh)	Monthly Energy Demand Savings (kW)
Tool Room (E)	*17,534*	*2.81*
Supersac Durcaell	*998*	*0.16*
Mezzanine	*1,997*	*0.32*
Tool Room (W)	*8,112*	*1.30*
Total	28,641	4.59

De-Lamping the over lit areas results in an annual usage savings (*AUS*) of 28,641 kWh and a Monthly Energy Demand Savings (MDS) if 4.59 kW.

Given an average demand cost of 3.91 $^{\$}/_{kW}$, and an average electricity cost of 0.042 $^{\$}/_{kWh}$, the estimated total energy cost savings (*TES*) associated with this recommendation is determined as follows.

$$TES = \left(4.59 \frac{kW}{month} \times 12 \frac{months}{year} \times 3.91 \frac{\$}{kW}\right) + \left(28{,}641 \frac{kWh}{year} \times 0.042 \frac{\$}{kWh}\right)$$

$$TES \approx \left(55.1 \frac{kW}{year} \times 3.91 \frac{\$}{kW}\right) + \$1{,}203$$

$$TES \approx \$215 + \$1{,}203$$

$$TES \approx \$1{,}418$$

Note that 55.1 kW represents the proposed yearly energy demand savings.

Implementation Costs

It is assumed that plant personnel will change the bulbs during regular operating hours. Therefore, there are no implementation costs associated with this recommendation. The simple payback period is immediate.

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Assessment Recommendation # 3
Eliminate Use of Electric Space Heaters

Assessment Recommendation Summary					
ARC#	Annual Resource Savings	Total Annual Savings	Capital Cost	Other Cost	Simple Payback
2.4322.2	Electricity: 8,100 kWh Demand: 45 kW	$516	None	None	Immediate

Current Practice

During the site visit, it was observed that 6 electric space heaters are used within the facility. The heater consumes approximately 1.5 kW. It is estimated that these heaters operate approximately 9 hours per day, 5 days per week, during the heating months.[10]

Recommended Action

It is recommended that the company eliminate the use of personal space heaters.

Anticipated Savings

The estimated annual energy savings (*AES*) for this recommendation is given by the following equation.

$$AES = N \times W \times HRS$$

Where,

N	=	Number of heaters[11]	$6\ heaters$
W	=	Wattage of each heater[12]	$1.5\ \frac{kW}{heater}$
HRS	=	Hours of operation	$900\ h$

Substituting,

$$AES = 6\ heaters \times 1.5\ \frac{kW}{heater} \times 900\ h$$

$$AES \approx 9\ kW \times 900\ h$$

$$AES \approx 8{,}100\ kWh$$

Please note that 9 kW represents the monthly demand.

[10] Estimating that office personnel turn the space heaters on during the work day from November to March (approx. 20 weeks)
[11] Provided by plant personnel
[12] Estimated by IAC personnel by means of vendor information

Given an average demand cost of 3.91 $^{\$}/_{kW}$, and an average electricity cost of 0.042 $^{\$}/_{kWh}$ the estimated total annual savings (*TAS*) are as follows.

$$TAS \approx \left(9\,\tfrac{kW}{month} \times 5\ months \times 3.91\,\tfrac{\$}{kW}\right) + \left(8{,}100\ kWh \times 0.042\,\tfrac{\$}{kWh}\right)$$

$$TAS \approx \left(45\ kW \times 3.91\,\tfrac{\$}{kW}\right) + \$340$$

$$TAS \approx \$176 + \$340$$

$$TAS \approx \$516$$

Implementation Cost

There is no implementation cost associated with this recommendation. The simple payback period is immediate.

Assessment Recommendation #4
Implement a Regular Leak Maintenance Program

Assessment Recommendation Summary					
ARC#	Annual Resource Savings	Total Annual	Capital Cost	Other Cost	Simple Payback
3.7312.2	Electricity: 251,288 kWh	$10,554	$500	$2,585	0.3 years

Current Practice

During the site visit, plant personnel mentioned that there was no scheduled leak maintenance program in place. For this reason, coupled with the plant operating continuously, they were unable to quantify the number of leaks within the system. A summary of the compressors in the facility is provided in the table below.

Location	Compressor	Type	Horsepower	Efficiency	Annual Hours of Operation[13]
South Plant	*W1988*	*Rotary Screw*	*200*	*0.85*	*2,667*
South Plant	*W2237*	*Rotary Screw*	*40*	*0.85*	*2,667*
South Plant	*W2238*	*Rotary Screw*	*40*	*0.85*	*2,667*
West Plant	*W0001*	*Rotary Screw*	*75*	*0.85*	*2,000*
West Plant	*W0002*	*Rotary Screw*	*75*	*0.85*	*2,000*
West Plant	*W1566*	*Rotary Screw*	*125*	*0.85*	*2,000*
West Plant	*W2407*	*Rotary Screw*	*150*	*0.85*	*2,000*
East Plant	*W1341*	*Rotary Screw*	*75*	*0.85*	*2,667*
East Plant	*W1877*	*Rotary Screw*	*200*	*0.85*	*2,667*
East Plant	*W1972*	*Rotary Screw*	*200*	*0.85*	*2,667*

The current annual energy consumption (AEC_c) of the compressed air system can be found using the following equation. The compressor "W1988" will be used as an example in the calculations because it is one of the larger compressors that were reported in the pre-assessment survey.

$$AEC_c = \frac{HP \times C_{kW,hp} \times HRS}{\eta}$$

[13] Estimated by IAC Personnel by dividing the 8,000 total lead-lag hours provided in the pre-assessment by the number of compressors in each location.

Where,

HP	=	Compressor horsepower[14]	$200\ hp$
$C_{kW,hp}$	=	Conversion factor	$0.7459\ \frac{kW}{hp}$
HRS	=	Annual hours of compressor operation[15]	$2{,}667\ h$
η	=	Compressor efficiency[16]	0.85

Substituting,

$$AEC_c = \frac{200\ hp \times 0.7459\ \frac{kW}{hp} \times 2{,}667\ h}{0.85}$$

$$AEC_c \approx 468{,}074\ kWh$$

The table below summarizes the current annual energy consumption of each compressor.

Location	Compressor	Horsepower	Efficiency	Annual Operating Hours	Current Annual Energy Consumption (kWh)
South Plant	*W1988*	*200*	*0.85*	*2,667*	*468,074*
South Plant	*W2237*	*40*	*0.85*	*2,667*	*93,615*
South Plant	*W2238*	*40*	*0.85*	*2,667*	*93,615*
West Plant	*W0001*	*75*	*0.85*	*2,000*	*131,629*
West Plant	*W0002*	*75*	*0.85*	*2,000*	*131,629*
West Plant	*W1566*	*125*	*0.85*	*2,000*	*219,382*
West Plant	*W2407*	*150*	*0.85*	*2,000*	*263,259*
East Plant	*W1341*	*75*	*0.85*	*2,667*	*175,528*
East Plant	*W1877*	*200*	*0.85*	*2,667*	*468,074*
East Plant	*W1972*	*200*	*0.85*	*2,667*	*468,074*
				Total	2,512,879

The total current annual energy consumption (AEC_c) of the compressed air system is 2,512,879 kWh. It is important to note that only the large compressors included in the pre-assessment survey were used in this recommendation in order to keep it conservative.

Recommended Action

It is recommended that a leak maintenance program be put in place in order to reduce the number of leaks in the compressed air system. It is estimated that a compressed air system that does

[14] Obtained from plant personnel
[15] Obtained from Pre-Assessment Survey.
[16] Estimated by IAC personnel.

not have a leak maintenance program can waste between 20 and 30 percent of the system's output. Conversely, a well maintained system can leak less than 10 percent of the system's output.[17]

Using a conservative estimate that 20 percent of the system air is wasted and assuming, with proper maintenance, the loss can be reduced to 10 percent, the following equation shows the proposed annual energy consumption (AEC_p).

$$AEC_p = AEC_c \times (1 - L)$$

Where,

AEC_c	=	Current compressed air energy consumption	*2,512,879 kWh*
L	=	Percentage of air savings[18]	*0.10*

Substituting,

$$AEC_p = 2{,}512{,}879\ kWh \times (1 - 0.10)$$

$$AEC_p \approx 2{,}261{,}591\ kWh$$

Anticipated Savings

The annual energy savings (AES) associated with this recommendation is found by finding the difference between the current and proposed energy consumptions of the compressed air system.

$$AES = AEC_c - AEC_p$$

$$AES = 2{,}512{,}879\ kWh - 2{,}261{,}591\ kWh$$

$$AES = 251{,}288\ kWh$$

Given an average electricity cost of 0.042 $^{\$}/_{kWh}$, the estimated annual cost savings (ACS) of fixing the air leaks found in the compressed air system is given in the equation below.

$$ACS = 251{,}288\ kWh \times 0.042\ \tfrac{\$}{kWh}$$

$$ACS \approx \$10{,}554$$

Recurring Implementation Cost

Implementation of this recommendation involves fixing the air leaks by the plant's machine maintenance staff. This may involve replacement of couplings or seals, or shutting off airflow during

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[17] Obtained from *Improving Compressed Air System Performance: a sourcebook for industry* produced by the U.S. DOE Office of Energy Efficiency and Renewable Energy.
[18] Conservatively estimating 20 percent air waste can be reduced to 10 percent air waste, yielding a savings of 10 percent.

lunch periods and repairing breaks in lines. The following table describes the estimated annual cost of a leak maintenance program.

Description	Unit Cost		Quantity		Total Cost
Yearly miscellaneous parts	*20*	*$/leak*	*50*[19]		*$500*
Labor & Burden	*$25.85*[20]	*$/hr*	*100*[21]	*hr*	*$2,585*
				Total	$3,085

The net annual savings (*NAS*) is determined as follows.

$$TAS = \$10{,}554 - \$3{,}085$$

$$TAS \approx \$7{,}469$$

The simple payback period is the length of time it will require each year for the cost and savings to balance out. The payback period shows a large estimate of the annual percentage of time required for the savings to completely pay for the cost of implementation. This payback period is calculated as follows.

$$Simple\ payback = \frac{\$3{,}085}{\$10{,}554}$$

$$Simple\ payback = 0.3\ years$$

Since implementation is a recurring annual cost, the benefit-cost ratio (*BCR*) is calculated in in addition to simple payback period. The benefit-cost ratio represents the value of the maintenance program and is a low estimate of the return on every dollar which goes into the maintenance program.

$$BCR = \frac{\$10{,}554}{\$3{,}085}$$

$$BCR = 3.4$$

[19] Estimate of the number of leaks repaired each year.
[20] Obtained from plant personnel
[21] Assuming that maintenance personnel will spend approximately two hours per week working on the compressed air system

Assessment Recommendation #5
Install Occupancy Sensors in Clean Room Hallway

Assessment Recommendation Summary					
ARC#	Annual Resource Savings	Total Annual Savings	Capital Cost	Other Cost	Simple Payback
2.7135.3	Electricity: 9,579 kWh	$402	$102	$56	0.4 years

Current Practice

It was observed during the site visit that several areas in the facility have relatively low traffic but have lights that operate continuously. The table below summarizes the rooms and their important characteristics.

Building	Location	Bulb Type	Number of Fixtures	Bulbs per Fixture	Wattage per Bulb	Current Operating Hours	Traffic Level
South Plant	*Clean Room Hallway*	*4' T-8*	*48*	*2*	*32*	*6,240*	*Low*

The current annual energy usage (EU_c) associated with this practice in the clean room hallway can be determined by the following equation.

$$EU_c = N \times n \times W \times C_{kW,W} \times HRS_c$$

Where,

N	=	Number of fixtures	*48 fixtures*
n	=	Number of bulbs per fixture	$2\ \frac{bulbs}{fixture}$
W	=	Wattage of each bulb	$32\ \frac{W}{bulb}$
$C_{kW,W}$	=	Conversion factor	$0.001\ \frac{kW}{W}$
HRS_C	=	Current annual hours that the lights are on[22]	*6,240 h*

Substituting,

$$EU_c = 48\ fixtures \times 2\ \frac{bulbs}{fixture} \times 32\ \frac{W}{bulb} \times 0.001\ \frac{kW}{W} \times 6{,}240\ h$$

$$EU_c \approx 3.07\ kW \times 6{,}240\ h$$

$$EU_c \approx 19{,}157\ kWh$$

[22] Based on annual production hours of the facility.

Recommended Action

It is recommended that the plant put the lights that are in these areas on occupancy sensors to reduce the amount of unnecessary operation. IAC personnel estimate that 1 occupancy sensor should sufficiently cover the areas.

The proposed annual energy usage (EU_p) associated with this recommendation can be determined by using the following equation.

$$EU_p = N \times n \times W \times C_{kW,W} \times HRS_p$$

Where,

N	=	Number of bulbs	*48 fixtures*
n	=	Number of bulbs per fixture	$2\ \frac{bulbs}{fixture}$
W	=	Wattage of each bulb	$32\ \frac{W}{bulb}$
$C_{kW,W}$	=	Conversion factor	$0.001\ \frac{kW}{W}$
HRS_p	=	Proposed annual hours that the lights are on[23]	*3,120 h*

Substituting,

$$EU_p = 48\ fixtures \times 2\ \tfrac{bulbs}{fixture} \times 32\ \tfrac{W}{bulb} \times 0.001\ \tfrac{kW}{W} \times 3{,}120\ h$$

$$EU_p \approx 3.07\ kW \times 3{,}120\ h$$

$$EU_p \approx 9{,}579\ kWh$$

Anticipated Savings

The annual energy usage savings (AUS) associated with this recommendation can be determined by finding the difference between the totaled current energy usage (EU_c) and the totaled proposed energy usage (EU_p).

$$AUS = EU_c - EU_p$$

Therefore,

$$AUS = 19{,}157\ kWh - 9{,}578\ kWh$$

$$AUS \approx 9{,}579\ kWh$$

Given an average electricity cost of 0.042 $^{\$}/_{kWh}$, the total annual savings (TAS) associated with this recommendation is determined as follows.

[23] Based on a multiplier of 0.5 for low traffic areas, and 0.75 for medium traffic areas, that was obtained from Energy Management Handbook by Wayne C. Turner, The Fairmont Press Inc., 2001.

$$TAS = 9{,}579\ kWh \times 0.042\ \tfrac{\$}{kWh}$$

$$TAS \approx \$402$$

Implementation Cost

Implementation of this recommendation involves purchasing and installing infrared occupancy sensor lighting control in the areas described. Quotes from McMaster-Carr at http://www.mcmaster.com were used to make all cost estimates, but are not necessarily recommended for use in implementation. Note that the McMaster-Carr Catalog Number is included for easy reference. The following table describes an estimation of implementation costs assuming that plant maintenance staff will perform all necessary installation.

Description	McMaster-Carr Part Number	Unit Cost	Quantity	Total Cost
Infrared Occupancy Sensor	*7704K34*	*51 $/each*	*2*[24]	*$102*
Labor & Burden	*N/A*	*27.85*[25] *$/hr*	*2 hr*	*$56*
			Total	$158

The simple payback period is as determined as follows.

$$Simple\ Payback = \frac{\$158}{\$402\ per\ year}$$

$$Simple\ Payback \approx 0.4\ years$$

[24] It is recommended that one sensor be placed on each end of the hallway
[25] Assuming that the facility's electrician will be responsible for the install

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Assessment Recommendation #6
Duct Outside Air to Compressors

Assessment Recommendation Summary					
ARC#	Annual Resource Savings	Total Annual Savings	Capital Cost	Other Cost	Simple Payback
2.4221.2	Electricity: 112,643 kWh	$4,731	$1,034	$1,940	0.6 years

Current Practice

It was observed during the site visit that the plant has multiple air compressors that currently draw air from the surrounding mechanical room. The following table details relevant compressor data that was taken at the time of the plant visit.

Location	Compressor	Horsepower	Intake Temperature (°F)	Outdoor Temperature (°F)	Load Factor	Efficiency	Annual Operating Hours[26]
South Plant	*W1988*	*200*	*72*	*48*	*0.77*	*0.85*	*2,667*
South Plant	*W2237*	*40*	*72*	*48*	*0.91*	*0.85*	*2,667*
South Plant	*W2238*	*40*	*72*	*48*	*0.88*	*0.85*	*2,667*
West Plant	*W0001*	*75*	*82*	*48*	*0.89*	*0.85*	*2,000*
West Plant	*W0002*	*75*	*82*	*48*	*0.36*	*0.85*	*2,000*
West Plant	*W1566*	*125*	*82*	*48*	*0.63*	*0.85*	*2,000*
West Plant	*W2407*	*150*	*82*	*48*	*0.90*	*0.85*	*2,000*
East Plant	*W1341*	*75*	*85*	*48*	*1.00*	*0.85*	*2,667*
East Plant	*W1877*	*200*	*85*	*48*	*0.93*	*0.85*	*2,667*
East Plant	*W1972*	*200*	*85*	*48*	*0.50*	*0.85*	*2,667*

The current annual energy usage (EU_c) associated with this practice can be determined by the following equation. A sample calculation is done for the "W1988" compressor.

$$EU_c = \frac{HP}{\eta} \times LF \times CF_{kW/hp} \times AOH$$

Where,

HP	=	Horsepower of the compressor	*200 hp*
η	=	Efficiency of the compressor motor	*0.85*
LF	=	Load factor of compressor[27]	*0.77*

[26] Estimated by IAC Personnel by dividing the 8,000 total lead-lag hours provided in the pre-assessment by the number of compressors in each location
[27] Estimated by IAC Personnel

$CF_{kW/hp}$	=	Conversion factor	$0.7459\ \frac{kW}{hp}$
AOH	=	Annual operating hours[28]	$2{,}667\ h$

Substituting,

$$EU_c = \frac{200\ hp}{0.85} \times 0.77 \times 0.7459\ \tfrac{kW}{hp} \times 2{,}667\ h$$

$$EU_c \approx 360{,}417\ kWh$$

The following table shows the result of this calculation for all of the compressors.

Location	Compressor	Current Energy Usage (kWh)
South Plant	*W1988*	*360,417*
South Plant	*W2237*	*85,190*
South Plant	*W2238*	*82,381*
West Plant	*W0001*	*117,150*
West Plant	*W0002*	*47,387*
West Plant	*W1566*	*138,211*
West Plant	*W2407*	*236,933*
East Plant	*W1341*	*175,528*
East Plant	*W1877*	*435,309*
East Plant	*W1972*	*234,037*
	Totals	1,912,543

Recommended Action

It is recommended that outside air be ducted directly into the intake of the compressor. Outside air is, on average, cooler and denser than indoor air. Using outdoor air in compression can reduce the energy requirements of the compressor.

The fractional reduction in compressor work (*WR*) resulting from the lower intake air temperature can be determined by the following equation. Again, a sample calculation is done for the "W1988" compressor.

$$WR = \frac{T_i - T_o}{T_i + 460}$$

Where,

T_i	=	Measured temperature of air at compressor inlet	$72\,°F$
T_o	=	Annual average outside air temperature[29]	$49\,°F$

[28] Estimated by IAC personnel by dividing the 8,000 total lead-lag hours provided in the pre-assessment by the number of compressors in each location

[29] Based on the average yearly temperature in Syracuse, NY from www.usclimatedata.com

Note that the constant 460 is a conversion factor from degrees Fahrenheit to an absolute temperature in degrees Rankine.

Substituting,

$$WR = \frac{72°F - 49°F}{72°F + 460}$$

$$WR \approx 0.04$$

The proposed annual energy usage (EU_p) associated with this recommendation can be determined by the following equation.

$$EU_p = EU_c \times (1 - WR)$$

Therefore,

$$EU_p = 360{,}417\ kWh \times (1 - 0.04)$$

$$EU_p \approx 346{,}000\ kWh$$

The following table shows the result of this calculation for all of the compressors.

Location	Compressor	Proposed Energy Usage (kWh)
South Plant	*W1988*	*346,000*
South Plant	*W2237*	*81,782*
South Plant	*W2238*	*79,086*
West Plant	*W0001*	*110,121*
West Plant	*W0002*	*44,544*
West Plant	*W1566*	*129,918*
West Plant	*W2407*	*222,717*
East Plant	*W1341*	*163,241*
East Plant	*W1877*	*404,837*
East Plant	*W1972*	*217,654*
	Totals	1,799,900

Anticipated Savings

The annual energy savings (AES) associated with this recommendation can be determined by finding the difference between the current energy usage (EU_c) and the proposed energy usage (EU_p).

$$AES = EU_c - EU_p$$

Therefore,

$$AES = 1{,}912{,}543\ kWh - 1{,}799{,}900\ kWh$$

$$AES \approx 112{,}643\ kWh$$

Given an average electricity cost of 0.042 $^{\$}/_{kWh}$, the estimated total annual savings (*TAS*) associated with this recommendation can be determined as follows.

$$TAS = 112{,}643\ kWh \times 0.042 \frac{\$}{kWh}$$

$$TAS \approx \$4{,}731$$

Note that this total annual savings is calculated for all of the compressors combined. The table below shows savings for individual compressors.

Location	Compressor	Annual Energy Savings (kWh)	Total Annual Savings ($)
South Plant	*W1988*	*14,417*	*606*
South Plant	*W2237*	*3,408*	*143*
South Plant	*W2238*	*3,295*	*138*
West Plant	*W0001*	*7,029*	*295*
West Plant	*W0002*	*2,843*	*120*
West Plant	*W1566*	*8,293*	*348*
West Plant	*W2407*	*14,216*	*597*
East Plant	*W1341*	*12,287*	*516*
East Plant	*W1877*	*30,472*	*1,280*
East Plant	*W1972*	*16,383*	*688*
	Totals	112,643	4,731

Implementation Cost

The following table describes an estimation of implementation costs based on vendor quotes, assuming that plant maintenance staff will perform all necessary installation.

SU Sample

Description	Unit Price		Quantity		Total
Air Duct, Hangers, Couplings	*5*	*$/ft*	*300*	*ft*	*$1,500*
Air Duct 90° Elbow Fitting	*12*	*$/ea*	*20*		*$240*
Air Duct Vent with Damper Fitting	*20*	*$/ea*	*10*		*$200*
Internal Labor & Burden	*25.85*	*$/h*	*40*[30]	*h*	*$1,034*
			Total Cost		$2,974

The simple payback period can be determined as follows.

$$Simple\ Payback = \frac{\$2{,}974}{\$4{,}731\ per\ year}$$

$$Simple\ Payback \approx 0.6\ years$$

[30] Estimating that it will take approximately four (4) hours per compressor for the machine maintenance personnel to install

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Assessment Recommendation # 7
Install Energy Efficient Exit Sign Bulbs

Assessment Recommendation Summary					
ARC#	Annual Resource Savings	Total Annual Savings	Capital Cost	Other Cost	Simple Payback
2.7143.3	Electricity: 18,396 kWh Demand: 25.2 kW Labor Hours: 55 h Avoided Cost: $660	$3,064	$1,800	$348	0.7 years

Current Practice

It was observed during the site visit that there are approximately 75 incandescent exit signs. These exit signs contain two incandescent bulbs with an estimated wattage rating of 15 watts each. Upgrading exit signs result in both energy and man-hour savings (due to the longer life of LED bulbs). Also, there is an unquantifiable increase in safety since there is a significant decrease in the likelihood an exit sign would be unlit during an emergency.

The current annual energy usage (EU_c) associated with exit signs can be determined by the following equation.

$$EU_c = \left(N_i \times n_i \times W_i\right) \times C_{kW,W} \times HRS$$

Where,

N_i	=	Number of incandescent exit sign fixtures[31]	*75 fixtures*
n_i	=	Number of bulbs per incandescent exit sign fixture	$2\ \frac{bulbs}{fixture}$
W_i	=	Wattage of each incandescent bulb	$15\ \frac{W}{bulb}$
$C_{kW,W}$	=	Conversion factor	$0.001\ \frac{kW}{W}$
HRS	=	Annual hours of operation[32]	*8,760 h*

Substituting,

$$EU_c = \left(75\ fix \times 2\,\tfrac{bulbs}{fix} \times 15\,\tfrac{W}{bulb}\right) \times 0.001\,\tfrac{kW}{W} \times 8{,}760\,h$$

$$EU_c \approx 2.3\,kW \times 8{,}760\,h$$

$$EU_c \approx 20{,}148\,kWh$$

Note that 2.3 kW represents the current monthly demand (D_c).

[31] Observed by IAC personnel.
[32] Estimated annual hours of operation based on 24 hours per day, 365 days per year.

Recommended Action

It is recommended that 1.2 W light emitting diode (LED) bulbs be installed by retrofitting the incandescent fixtures.

In addition to the energy savings associated with installing more energy efficient exit sign bulbs, there are also significant labor savings. LED bulbs have a life expectancy of 25 years,[33] compared to less than a year for traditional incandescent bulbs. Maintenance staff should spend less time changing exit sign bulbs and the company will incur less bulb replacement costs in the future.

The proposed annual energy usage (EU_p) associated with this recommendation can be determined by the following equation.

$$EU_p = \left(N_{LED} \times n_{LED} \times W_{LED}\right) \times C_{kW,W} \times HRS$$

Where,

N_{LED}	=	Number of exit sign fixtures[34]	*75 fixtures*
n_{LED}	=	Number of LED bulbs per exit sign	$2\ \frac{bulbs}{fixture}$
W_{LED}	=	Wattage of each LED bulb	$1.2\ \frac{W}{bulb}$
$C_{kW,W}$	=	Conversion factor	$0.001\ \frac{kW}{W}$
HRS	=	Annual hours of operation[35]	*8,760 h*

Substituting,

$$EU_p = \left(75\ fix \times 2\,\tfrac{bulbs}{fix} \times 1.2\,\tfrac{W}{bulb}\right) \times 0.001\,\tfrac{kW}{W} \times 8{,}760 h$$

$$EU_p \approx 0.2\ kW \times 8{,}760\ h$$

$$EU_p \approx 1{,}752\ kWh$$

Note that 0.2 kW represents the proposed monthly demand (D_p).

Anticipated Savings

The annual energy savings (AES) associated with this recommendation can be determined by finding the difference between the current energy usage (EU_c) and the proposed energy usage (EU_p).

$$AES = EU_c - EU_p$$

Therefore,

$$AES \approx 20{,}148\ kWh - 1{,}752\ kWh$$

$$AES \approx 18{,}396\ kWh$$

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33 Energy Management Handbook, 4th edition , Wayne C. Turner, Page 384
34 Observed by IAC personnel.
35 Estimated annual hours of operation based on 24 hours per day, 365 days per year.

Likewise, the monthly demand savings (MDS) associated with this recommendation can be determined by finding the difference between the current demand (D_c) and the proposed demand (D_p).

$$MDS = D_c - D_p$$

Therefore,

$$MDS \approx 2.3\,kW - 0.2\,kW$$

$$MDS \approx 2.1\,kW$$

Given an average demand cost of 3.91 $/kW , and an average electricity cost of 0.042 $/kWh, the estimated total energy savings (*TES*) of this recommendation is given by the following equation.

$$TES = \left(2.1\,\tfrac{kW}{month} \times 12\,months \times 3.91\,\tfrac{\$}{kW}\right) + \left(18{,}396\ kWh \times 0.042\,\tfrac{\$}{kWh}\right)$$

$$TES \approx \left(25.2\ kW \times 3.91\,\tfrac{\$}{kW}\right) + \$773$$

$$TES \approx \$99 + \$773$$

$$TES \approx \$872$$

In addition to the annual energy savings, there are also labor and capital savings. On average, LED bulbs last approximately 110 times longer than incandescent bulbs.[36] Theoretically, in the time that it takes for one LED bulb to burn out, 110 incandescent bulbs will be replaced. Annualizing this statement shows that approximately 4.4 incandescent bulbs will be replaced every year per LED bulb. Estimating the cost of an incandescent bulb as 1 $/ea , and assuming that it takes maintenance personnel 5 minutes to change a light bulb, the annual total labor and capital savings (*TLCS*) for replacing the bulbs can be determined as follows.

$$TLCS = \left(150\,incandescent \times 4.4 \times 1.00\,\tfrac{\$}{incan}\right) + \left(\left(150\ incandescent \times 4.4 \times 5\,\tfrac{min}{bulb} \times \frac{1}{60}\,\tfrac{h}{min}\right) \times 27.85\,\tfrac{\$}{hr}\right)$$

$$TLCS \approx \$660 + \left(55\ h \times 27.85\,\tfrac{\$}{hr}\right)$$

$$TLCS \approx \$660 + \$1{,}532$$

$$TLCS \approx \$2{,}192$$

[36] Assuming that the life expectancy of an incandescent bulb is 2,000 hours

Note that 27.85 $^{\$}/_{hr}$ labor and burden rate for an electrician who would be responsible for changing bulbs was obtained from plant personnel.

The estimated total annual savings (*TAS*) that will result from installing energy efficient LED exit signs is determined by summing both the total energy savings (*TES*) and the annual total labor and capital savings (*TLCS*).

$$TAS = TES + TLCS$$

$$TAS \approx \$872 + \$2{,}192$$

$$TAS \approx \$3064$$

Implementation Costs

The implementation costs for this recommendation are listed in the table below. It is assumed that the bulbs will be installed incrementally by the plant maintenance staff as old incandescent bulbs burn out.

Description	Unit Cost		Quantity		Total
LED Bulbs	*12*	*\$/ea*	*150*		*\$1,800*
Installation	*27.85*	*\$/h*	*12.5*	*h*	*\$348*
				Total	\$2,148

The simple payback period is determined as follows.

$$Simple\ Payback = \frac{\$2{,}148}{\$3{,}064\ per\ year}$$

$$Simple\ Payback \approx 0.7\ years$$

Assessment Recommendation #8
Insulate Pipes

Assessment Recommendation Summary					
ARC#	Annual Resource Savings	Total Annual Savings	Capital Cost	Other Cost	Simple Payback
2.2131.2	Natural Gas: 16.6 MMBtu	$119	$96	$27	1.0 years

Current Practice

The plant has a large number of pipes that are significantly hotter than the surrounding air temperature. Some of these pipes are un-insulated, resulting in unnecessary heat loss. Pipe and air temperature, total pipe length, diameter, and orientation are given in the following table.[37]

Pipe Description	Diameter (in)	Pipe Temperature (°F)	Air Temperature (°F)	Length (ft)	Pipe Orientation
Copper Boiler Pipe 1 (vert)	*3*	*106*	*75*	*6*	*vertical*
Copper Boiler Pipe 1 (horiz)	*3*	*106*	*75*	*8*	*horizontal*
Copper Boiler Pipe 2 (vert)	*3*	*110*	*75*	*6*	*vertical*
Copper Boiler Pipe 2 (horiz)	*3*	*110*	*75*	*8*	*horizontal*
Copper Boiler Pipe 3 (vert)	*3*	*116*	*75*	*6*	*horizontal*
Copper Boiler Pipe 3 (horiz)	*3*	*116*	*75*	*8*	*horizontal*
Copper Boiler Pipe 4 (vert)	*3*	*96*	*75*	*6*	*horizontal*
Copper Boiler Pipe 4 (horiz)	*3*	*96*	*75*	*8*	*horizontal*

Recommended Action

The pipes should be insulated to reduce heat loss and energy costs.

Anticipated Savings

The annual energy savings will result from the reduction of heat loss from the insulated pipes. Heat loss from the pipes occurs by two heat transfer methods, free convection and radiation.

The first operation that needs to be performed is to find the convective heat transfer coefficient (h_{cv}) [38] using the following equation. Calculations in this section are shown for "Copper Boiler Pipe 1 (vert)" and the results of the same calculations for the other pipes are presented in a table at the end.

$$h_{cv} = C \times \left(\frac{1}{d}\right)^{0.2} \times \left(\frac{1}{t_{avg}}\right)^{0.181} \times (\Delta t)^{0.266} \times \sqrt{1 + 1.277 \times Wind}$$

Where,

[37] Observed by IAC Personnel.
[38] Formula given in ASHRAE Fundamentals 1993. Equation 4, [22.17]. h_{cv} has given units of [Btu / (h·ft^2·°F)].

C	=	Orientation constant[39]	*1.235*
d	=	Pipe diameter	*3 in*
t_{avg}	=	Average temperature between pipe and air	*90.5 ºF*
Δt	=	Temperature difference between pipe and air	*31 ºF*
$Wind$	=	Average wind speed at the pipe surface[40]	*0 mph*

Substituting,

$$h_{cv} = 1.235 \times \left(\frac{1}{3\ in.} \right)^{0.2} \times \left(\frac{1}{90.5\ ^{o}F} \right)^{0.181} \times \left(31\ ^{o}F \right)^{0.266} \times \sqrt{1 + 1.277 \times 0\ mph}$$

$$h_{cv} = 1.09 \frac{Btu}{h \cdot ft^2 \cdot ^{o}F}$$

Using the convective heat transfer coefficient, the convective heat loss per foot from the pipe (q_{cv}') can be calculated using the following equation.

$$q_{cv}' = h_{cv} \times 2\pi r \times C_{in,ft} \times \left(T_{pipe} - T_{air} \right)$$

Where,

h_{cv}	=	Convective heat transfer coefficient	$1.09\ \frac{Btu}{h \cdot ft^2 \cdot ^{o}F}$
r	=	Pipe radius	*1.5 in.*
$C_{in,ft}$	=	Conversion factor	$0.08333\ \frac{ft}{in}$
T_{pipe}	=	Pipe temperature	*106 ºF*
T_{air}	=	Air temperature	*75 ºF*

Substituting,

$$q_{cv}' = 1.09 \frac{Btu}{h \cdot ft^2 \cdot ^{o}F} \times 2\pi \times 1.5\ in \times 0.08333 \frac{ft}{in} \times \left(106^{o}\ F - 75^{o}\ F \right)$$

$$q_{cv}' = 1.06 \frac{Btu}{h \cdot ft^2 \cdot ^{o}F} \times 2\pi \times 1.5\ in \times 0.08333 \frac{ft}{in} \times 31^{o}\ F$$

$$q_{cv}' = 26.54 \frac{Btu}{h \cdot ft}$$

The radiative heat loss per foot from the pipe (q_{rad}') can be calculated using the following equation.

---

[39] Orientation constant: 1.016 for a horizontal cylinder, 1.235 for a vertical cylinder, from ASHRAE Fundamentals 1993. Equation 4, [22.17].

[40] This problem was considered as free convection. Wind speed is negligible.

$$q_{rad}' = \varepsilon \times 2\pi r \times C_{in,ft} \times \sigma \times \left(T_{pipe}^4 - T_{air}^4\right)$$

Where,

ε	=	Surface emissivity[41]	0.90
r	=	Pipe radius	$1.5\ in.$
$C_{in,ft}$	=	Conversion factor	$0.08333\ \frac{ft}{in}$
σ	=	Stefan-Boltzman constant	$0.1713 \times 10^{-8}\ \frac{Btu}{h \cdot ft^2 \cdot {}^oR^4}$
T_{pipe}	=	Pipe temperature[42]	$566\ {}^oR$
T_{air}	=	Air temperature[43]	$535\ {}^oR$

Substituting,

$$q_{rad}' = 0.90 \times 2\pi \times 1.5\ in \times 0.08333\ \frac{ft}{in} \times 0.1713 \times 10^{-8}\ \frac{Btu}{h \cdot ft^2 \cdot {}^oR^4} \times \left[\left(566^o\ R\right)^4 - \left(535^o\ R\right)^4\right]$$

$$q_{rad}' = 25.07\ \frac{Btu}{h \cdot ft}$$

The total heat loss per foot from the pipe (q_{tot}') can be calculated by summing the convective and radiative heat losses per foot from the pipe.

$$q_{tot}' = q_{cv}' + q_{rad}'$$

Where,

q_{cv}'	=	Convective heat loss per foot	$26.54\ \frac{Btu}{h \cdot ft}$
q_{rad}'	=	Radiative heat loss per foot	$25.07\ \frac{Btu}{h \cdot ft}$

Substituting,

$$q_{tot}' = 26.54\ \frac{Btu}{h \cdot ft} + 25.07\ \frac{Btu}{h \cdot ft}$$

$$q_{tot}' = 51.61\ \frac{Btu}{h \cdot ft}$$

The total heat loss per year from the pipe (Q) can be calculated using the following equation.

$$Q = q_{tot}' \times L \times C_{Btu,MMBtu} \times H$$

Where,

[41] Estimated by IAC Personnel.
[42] Temperature has been converted from Fahrenheit to Rankine by adding 460º.
[43] Temperature has been converted from Fahrenheit to Rankine by adding 460º.

q_{tot}'	=	Total heat loss per unit length	$51.61 \frac{Btu}{h \cdot ft}$
L	=	Length of the pipe	*6 ft.*
$C_{Btu,MMBtu}$	=	Conversion factor	$10^{-6} \frac{Btu}{MMBtu}$
H	=	Annual hours of boiler operation[44]	*6,240 h*

Substituting,

$$Q = 51.61 \tfrac{Btu}{h \cdot ft} \times 6 \ \ ft \times 10^{-6} \tfrac{Btu}{MMBtu} \times 6,240\, h$$

$$Q = 1.9 \ MMBtu$$

These same calculations were performed for the remaining pipes. The results are shown in the following table.

Pipe Description	Total Heat Loss per Year from the Pipe
Copper Boiler Pipe 1 (vert)	*1.9 MMBtu*
Copper Boiler Pipe 1 (horiz)	*2.3 MMBtu*
Copper Boiler Pipe 2 (vert)	*1.9 MMBtu*
Copper Boiler Pipe 2 (horiz)	*2.3 MMBtu*
Copper Boiler Pipe 3 (vert)	*2.4 MMBtu*
Copper Boiler Pipe 3 (horiz)	*3.2 MMBtu*
Copper Boiler Pipe 4 (vert)	*1.1 MMBtu*
Copper Boiler Pipe 4 (horiz)	*1.5 MMBtu*
Total	16.6 MMBtu

Given that the average unit cost of natural gas is 7.17 $/MMBtu the estimated total annual savings (*TAS*) are as follows.

$$TAS \approx 16.6 \ MMBtu \times 7.17 \tfrac{\$}{MMBtu}$$

$$TAS \approx \$119$$

Implementation Cost

The total implementation costs are listed in the table below. All costs were determined from the 2011 RS Means Mechanical Cost Data Handbook. Note that the RS Means line number is included for easy reference.

[44] Based on plant operating hours.

SU Sample

Description	RS Means Line Number	Unit Cost		Quantity		Total Cost
Fiberglass Insulation with all service jacket (3"pipe size)	*220719.106920*	*1.72*	*$/ft*	*56*	*ft*	*$96*
				RS Means Subtotal		*$96*
				Location Adjustment Factor		*0.994*
				RS Means Total		*$95*
Installation	*N/A*	*14.31* [45]	*$/h*	*2*	*h*	*$27*
				Total		$122

The simple payback is calculated as follows.

$$Simple\ Payback = \frac{\$122}{\$119\ per\ year}$$

$$Simple\ Payback \approx 1.0\ years$$

[45] Assuming that preventative maintenance personnel would be responsible for installation.

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Additional Consideration # 9
Install Occupancy Sensors on Vending Machines

Assessment Recommendation Summary					
ARC#	Annual Resource Savings	Total Annual Savings	Capital Cost	Other Cost	Simple Payback
2.6211.3	Electricity: 8,850 kWh	$372	$670	$134	2.2 years

Current Practice

It was observed during the site visit that the facility has 5 beverage vending machines that are lit and running continuously. Beverage machines are also refrigerated in order to keep the contents cool.

The current annual energy usage (EU_c) of the vending machines is determined by using the following equation.

$$EU_c = \left[\left(N_b \times W_b\right) + \left(N_s \times W_s\right)\right] \times C_{kW,W} \times HRS_c$$

Where,

N_b	=	Number of beverage machines	*5 machines*
W_b	=	Wattage per beverage machine[46]	$400 \frac{W}{machine}$
$C_{kW,W}$	=	Conversion factor	$0.001 \frac{kW}{W}$
HRS_c	=	Current annual hours of operation[47]	*8,760 h*

Substituting,

$$EU_c = \left(5\ mach \times 400 \tfrac{W}{mach}\right) \times 0.001 \tfrac{kW}{W} \times 8{,}760\ h$$

$$EU_c \approx 17{,}520\ kWh$$

Recommended Action

It is recommended that occupancy sensors be installed on vending machines that dispense soda or other non-perishable goods. This recommendation does not include machines containing dairy products of any kind. The occupancy sensors power down the vending machines to an idle state after 15 consecutive minutes of inactivity. Beverage vending machines will power down, but continue to run one compressor cycle every 1 to 3 hours depending on room temperatures. This is done in order to keep the product cold. The sensors will power up the machine instantly, once occupancy is detected.

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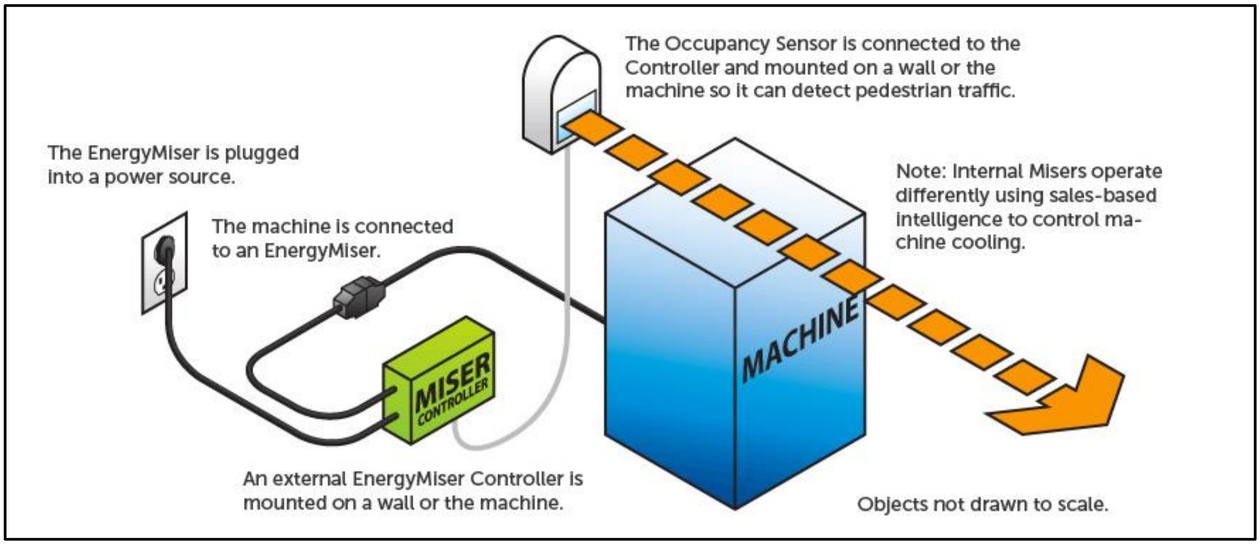
[46] A generic machine wattage was used. Actual wattage can vary based on make, model and manufacturing date of your machines.

[47] Estimating vending machines are lit and running 24 hours per day, 7 days per week for a total of 52 weeks per year.

It is important to note that these sensors do not alter the vending machine in any way; therefore permission from the vending machine owner is not required. Below is a description of the installation of a vending machine occupancy sensor[48].



The proposed annual energy usage (EU_p) associated with this recommendation can be determined by using the following equation.

$$EU_p = \left[\left(N_b \times W_b \right) + \left(N_s \times W_s \right) \right] \times C_{kW,W} \times HRS_p + \left(N_b \times W_b \times C_{kW,W} \times HRS_b \right)$$

Where,

N_b	=	Number of beverage machines	*5 machines*
W_b	=	Wattage per beverage machine	$400\ \frac{W}{machine}$
$C_{kW,W}$	=	Conversion factor	$0.001\ \frac{kW}{W}$
HRS_p	=	Proposed hours of operation[49]	*4,320 h*
HRS_b	=	Additional beverage cooling hours[50]	*15 h*

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[48] Image obtained from http://www.vendingmiserstore.com/

[49] Based on a multiplier of 0.5 times the annual plant hours for low traffic areas obtained from Energy Management Handbook by Wayne C. Turner, Fairmount Press Inc., 2001.

[50] Based on beverage machines running 15 minutes, every two hours to keep contents cold during non-plant hours.

Substituting,

$$EU_p = \left(5\ mach \times 400\ \tfrac{W}{mach}\right) \times 0.001\ \tfrac{kW}{W} \times 4{,}320\ h + \left(5\ mach \times 400\ \tfrac{W}{mach} \times 0.001\ \tfrac{kW}{W} \times 15\ h\right)$$

$$EU_p \approx 8{,}670\ kWh$$

Anticipated Savings

The annual energy savings (*AES*) associated with this recommendation can be determined by finding the difference between the current energy usage (EU_c) and the proposed energy usage (EU_p).

$$AES = EU_c - EU_p$$

Therefore,

$$AES = 17{,}520\ kWh - 8{,}670\ kWh$$

$$AES = 8{,}850\ kWh$$

Given an average electricity cost of 0.042 $^{\$}/_{kWh}$, the estimated total annual savings (*TAS*) are as follows.

$$TAS = 8{,}850\ kWh \times 0.042\ \tfrac{\$}{kWh}$$

$$TAS \approx \$372$$

Implementation Cost

The total implementation costs are based on vendor quotes listed in the table below. It is recommended that the two beverage vending machines be placed next to each other so a master-slave system can be installed.

Description	Unit Price		Quantity	Incentives		Total
Beverage Occupancy Master Sensor	*189*	*$/ea*	*5*	*-55*	*$/ea*	*$670*
Installation	*27.85*	*$/h*	*5*			*$139*
			Total			$809

The simple payback period is determined as follows.

$$Simple\ payback = \frac{\$809}{\$372\ per\ year}$$

$$Simple\ payback \approx 2.2\ years$$

The incentives shown in the table are based on a National Grid rebate program. Information on this may be found at:

https://www1.nationalgridus.com/files/AddedPDF/POA/EE4761_EMS_UNY_3_14.pdf

The corresponding rebate form and info sheet may be found at the link below and is provided on a CD along with the electronic version of the report.

https://www1.nationalgridus.com/files/AddedPDF/POA/Final_PIF_EMS_2014_Fillable.pdf

Additional Consideration # 10
Replace CRT Computer Monitors with LCD

Assessment Recommendation Summary					
ARC#	Annual Resource Savings	Total Annual Savings	Capital Cost	Other Cost	Simple Payback
2.4321.3	Electricity: 5,431 kWh Demand: 7.44 kW	$257	$1,000	$70	4.2 years

Current Practice

The facility uses approximately 10 computers that use Cathode Ray Tube (CRT) monitor technology[51]. Each of the computer monitors consumes approximately 75 watts or 0.075 kW.[52] These computer monitors are on during operating hours.

The current annual energy usage (EU_c) associated with this practice can be determined by the following equation.

$$EU_c = N \times W_{CRT} \times HRS$$

Where,

N	=	Number of computer monitors	*10 monitors*
W_{CRT}	=	Wattage of each CRT monitor[53]	$0.075 \frac{kW}{monitor}$
HRS	=	Annual hours of operation[54]	*8,760 h*

Substituting,

$$EU_c = 10 \text{ monitors} \times 0.075 \frac{kW}{monitor} \times 8{,}760 \text{ h}$$

$$EU_c \approx 0.75 \text{ kW} \times 8{,}760 \text{ h}$$

$$EU_c \approx 6{,}570 \text{ kWh}$$

Note that 0.75 kW represents the current monthly energy demand (ED_c).

Recommended Action

It is recommended that the facility replace the CRT monitors with energy efficient Liquid Crystal Display (LCD) monitors in order to reduce energy consumption.

The proposed annual energy usage (EU_p) associated with this recommendation can be determined by the following equation.

$$EU_p = N \times W_{LCD} \times HRS$$

[51] Estimate provided by plant personnel
[52]Conservatively estimated from http://www.eu-energystar.org/en/en_023.shtml
[53]Obtained from vendor data.
[54]All monitors were found in the production area which operates 24/7/365

Where,

N	=	Number of computer monitors	*10 monitors*
W_{LCD}	=	Wattage of each LCD monitor[55]	$0.013\ \frac{kW}{monitor}$
HRS	=	Annual hours of operation	*8,760 h*

Substituting,

$$EU_p = 10\ monitors\ \times\ 0.013\frac{kW}{monitor} \times 8{,}760\ h$$

$$EU_p \approx 0.13\ kW \times 8{,}760\ h$$

$$EU_p \approx 1{,}139\ kWh$$

Note that 0.13 kW represents the proposed monthly energy demand (ED_p).

Anticipated Savings

The annual usage savings (*AUS*) associated with this recommendation can be determined by finding the difference between the current energy usage (EU_c) and the proposed energy usage (EU_p).

$$AUS = EU_c - EU_p$$

Therefore,

$$AUS = 6{,}570\ kWh - 1{,}139\ kWh$$

$$AUS \approx 5{,}431\ kWh$$

Likewise, the monthly demand savings (*MDS*) associated with this recommendation can be determined by finding the difference between the current energy demand (ED_c) and the proposed energy demand (ED_p).

$$MDS = ED_c - ED_p$$

Where,

ED_c	=	Current energy demand	*0.75 kW*
ED_p	=	Proposed energy demand	*0.13 kW*

Substituting,

$$MDS = 0.75\ kW - 0.13\ kW$$

$$MDS \approx 0.62\ kW$$

[55]Obtained from vendor data.

Given an average electricity cost of 0.042 $/kWh and an average demand cost of 3.91 $/kW the estimated total annual savings *(TAS)* are as follows.

$$TAS = \left(5{,}431\ kWh \times 0.042\,\tfrac{\$}{kWh}\right) + \left(0.62\ kW \times 12\ months \times 3.92\,\tfrac{\$}{kW}\right)$$

$$TAS \approx \$228 + \left(7.44\ kW \times 3.91\,\tfrac{\$}{kW}\right)$$

$$TAS \approx \$228 + \$29$$

$$TAS \approx \$257$$

Implementation Cost

Implementation of this recommendation involves purchasing new LCD monitors for each computer. The following is a table summarizing the required implementation costs.

Description	Unit Price		Quantity	Total
Acer V173DJb Black 17" LCD Monitor	*100*	$/*ea*	*10*	*$1,000*
Installation	*27.85*	$/*hr*	*2.5*	*$70*
			Total	$1,070

The simple payback period is determined as follows.

$$Simple\ Payback = \frac{\$1{,}070}{\$257\ per\ year}$$

$$Simple\ Payback = 4.2\,years$$

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Additional Considerations

The following ideas can help to save your company energy and money. However, it was determined that each idea met one of the following criteria: the savings were too difficult to quantify, the payback period was too long, or the savings were too small.

1. **Replace T8 Fluorescent Task Lights with LED**
   Calculations shown in Additional Consideration #1
   LED task lights are more efficient and last longer than the T8 Fluorescent bulbs. LED bulbs also produce a higher quality of light than fluorescent. This is ideal for inspection tables and other areas where intricate work is done.

2. **Shut off Computer Monitors when Not in Use**
   Computer monitors use power while in sleep mode. A test was performed by IAC personnel to test how much energy could be saved by shutting off computer monitors instead of allowing them to remain in sleep mode while not in use. For the facility's 400 monitors, it is estimated that the facility would save 3.9 kWh, which is about $0.17 per year.

3. **Utilize Setback Timers in Office Space**
   Programmable setback timers provide efficient control of thermostat settings in office areas. Such control will automatically adjust thermostat temperature settings at a time when office spaces are unoccupied to reduce the load on HVAC systems. This adjustment can directly decrease heating costs in the winter months and cooling costs in the summer. This should be implemented in conjunction with locks on the thermostat controls in the office spaces.

4. **Correct for Power Factor in the South Plant**
   Utilities require companies to use the power they are being supplied at 95% efficiency. If this is not being achieved than the utility company adds a reactive charge to the utility bills each month. This can easily be repaired by installing capacitor banks at the facility.

5. **Utilize Synthetic Lubricants**
   Compared to petroleum based lubricants, synthetic lubricants have a greater ability to maintain viscosity over extended temperature ranges and greater resiliency. The energy normally lost in the operation of motors, gearboxes, and mechanical joints can be partially recovered by changing from petroleum based to synthetic lubricants.

6. **Utilize Energy Efficient Belts**
   Newer cogged V-belts are more efficient than their older counterparts. By switching out older belts as they wear down with cogged V-belts, the motor will experience less slip and will run with greater efficiency.

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Additional Consideration # 1
Install More Efficient Task Lighting

Assessment Recommendation Summary					
ARC#	Annual Resource Savings	Total Annual Savings	Capital Cost	Other Cost	Simple Payback
2.7142.3	Electricity: 1,248 kWh Demand: 5.8 kW	$75	$480	$19	6.7 years

Current Practice

It was observed during the site visit that the facility was supplementing lit areas with T8 fluorescent task lights. The facility could reduce energy costs by replacing these fixtures with more efficient lighting. The following table details relevant data on this lighting that was taken at the time of the plant visit.

Location	Bulb Type	Wattage per Bulb	Current Number of Fixtures	Number of Bulbs per Fixture	Operating Hours
Mold Room	*4' T8*	*32*	*10*	*2*	*2,600*
Tip Room	*4' T8*	*32*	*2*	*2*	*2,600*
Upper PMO	*4' T8*	*32*	*8*	*2*	*2,600*

The current annual energy usage (EU_c) associated with this practice can be determined by using the following equation. A sample calculation is done for the Mold Room.

$$EU_c = N_c \times W_c \times C_{kW,W} \times HRS$$

Where,

N_c	=	Current number of fixtures	*10 fixtures*
W_c	=	Current wattage per fixture	$64 \frac{W}{fixture}$
$C_{kW,W}$	=	Conversion constant	$0.001 \frac{kW}{W}$
HRS	=	Annual operating hours[56]	*2,600 h*

Substituting,

[56]Operating hours based on conservative pre-assessment survey analysis where the task lights were assumed to be used for 10 hours per day, 5 days per week, 52 weeks per year.

$$EU_c = 10\ fixtures \times 64 \tfrac{W}{fixture} \times 0.001 \tfrac{kW}{W} \times 2{,}600\ h$$

$$EU_c \approx\ 0.64\ kW \times 2{,}600\ h$$

$$EU_c \approx 1{,}664\ kWh$$

The current energy usage and demand was found using the same calculations for all locations. The following table displays the results.

Location	Current Monthly Demand (kW)	Current Energy Usage (kWh)
Mold Room	*0.64*	*1,664*
Tip Room	*0.13*	*338*
Upper PMO	*0.51*	*1,326*
Total	1.28	3,328

Note that 1.28 kW represents the current monthly energy demand (ED_c).

Recommended Action

It is recommended that all fluorescent task lights and incandescent bulbs be replaced with LED fixtures. The newer fixtures will operate more efficiently than the fluorescent fixtures. According to the pre-assessment survey, employees and management are happy with the existing lighting levels. The following table outlines the purposed lighting.

Location	Bulb Type	Wattage per Bulb	Current Number of Fixtures	Number of Bulbs per Fixture	Operating Hours
Mold Room	*LED*	*20*	*10*	*2*	*2,600*
Tip Room	*LED*	*20*	*2*	*2*	*2,600*
Upper PMO	*LED*	*20*	*8*	*2*	*2,600*

The proposed annual energy usage (EU_p) associated with this recommendation can be determined by using the following equation. A sample calculation for the Assembly room is shown below.

$$EU_p = N_p \times W_p \times C_{kW,W} \times HRS$$

Where,

N_p	=	Proposed number of fixtures	*10 fixtures*
W_p	=	Proposed wattage per fixture	$40 \tfrac{W}{fixture}$
$C_{kW,W}$	=	Conversion constant	$0.001 \tfrac{kW}{W}$
HRS	=	Annual operating hours	*2,600 h*

Substituting,

$$EU_p = 10\ fixtures \times 40\ \tfrac{W}{fixture} \times 0.001\ \tfrac{kW}{W} \times 2{,}600\ h$$

$$EU_p \approx 0.4\ kW \times 2{,}600\ h$$

$$EU_p \approx 1{,}040\ kWh$$

Note that 0.4 kW represents the proposed monthly energy demand (ED_p).

The proposed energy usage and demand was found using the same calculations for all locations. The following table displays the results.

Location	Proposed Monthly Demand (kW)	Proposed Energy Usage (kWh)
Mold Room	*0.4*	*1,040*
Tip Room	*0.08*	*208*
Upper PMO	*0.32*	*832*
Total	0.8	2,080

Anticipated Savings

The annual energy usage savings (*AUS*) can be determined by finding the difference between the current energy usage (EU_c) and the proposed energy usage (EU_p).

$$AUS = EU_c - EU_p$$

Therefore,

$$AUS = 3{,}328\ kWh - 2{,}080\ kWh$$

$$AUS \approx 1{,}248\ kWh$$

Likewise, monthly energy demand savings (*MDS*) associated with Option 2 can be determined by finding the difference between the current energy demand (ED_c) and the proposed energy demand (ED_p).

$$MDS = ED_c - ED_p$$

Therefore,

$$MDS = 1.28\ kW - 0.8\ kW$$

$$MDS \approx 0.48\ kW$$

Given an average demand cost of 3.91 $^{\$}/_{kW}$, and an average electricity cost of 0.042 $^{\$}/_{kWh}$, the estimated total annual savings (*TAS*) is given by the following equation.

$$TAS = \left(0.48\,\tfrac{kW}{month} \times 12\,months \times 3.91\,\tfrac{\$}{kW}\right) + \left(1{,}248\ kWh \times 0.042\,\tfrac{\$}{kWh}\right)$$

$$TAS \approx \left(5.8\ kW \times 3.91\,\tfrac{\$}{kW}\right) + \$52$$

$$TAS \approx \$23 + \$52$$

$$TAS \approx \$75$$

These calculations were repeated for each area individually. A table outlining the results of these calculations is shown below.

Location	Energy Savings (kWh)	Monthly Demand Savings (kW)	Total Annual Savings
Mold Room	*624*	*0.24*	*$37*
Tip Room	*130*	*0.05*	*$9*
Upper PMO	*494*	*0.19*	*$29*
Total	1,248	0.48	$75

Note that, on average, LED tubes have a much longer lamp life than metal halides bulbs. Over time, labor and capital savings for replacing the bulbs may be realized. However, these savings are minimal due to the high cost of LED tubes, and have not been considered in this estimate to remain conservative.

Implementation Cost

The following table describes an estimation of required implementation costs, including vendor quotes. It is assumed that plant personnel will perform the required action during routine maintenance, which will not result in production losses.

Description	Unit Cost		Quantity		Total Cost
48” T8 LED 20 W Tube	*12*	*$/each*	*40*		*$480*
Labor & Burden	*27.85*	*$/h*	*0.7*[57]	*h*	*$19*
			Total		$499

[57] Estimating it takes approximately two minutes to replace each bulb.

The simple payback period is determined as follows.

$$Simple\ Payback = \frac{\$499}{\$75\ per\ year}$$

$$Simple\ Payback \approx 6.7\ years$$

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NYSERDA Funding Opportunities

NYSERDA (New York State Energy Research and Development Authority, www.NYSERDA.org) funding assistance is available for most manufacturing facilities in New York State. Funding for projects that reduce electrical consumption can be provided to facilities that are paying a system benefits charge (SBC) to their electricity delivery company. Funding for projects that reduce natural gas consumption can be provided to facilities that pay a monthly rate adjustment (MRA) charge. Grants can be provided using pre-qualified or performance based measures. For more information or to begin applying for funding, please visit:

http://www.nyserda.ny.gov/Funding-Opportunities/Current-Funding-Opportunities.aspx

Other NYSERDA funding programs are available for:

Industrial and Process Efficiently
Small Wind & Solar Technologies
FlexTech Program
Combined Heat and Power (CHP) Performance Program

For a full list of NYSERDA funding opportunities please visit:

http://www.nyserda.ny.gov/Funding-Opportunities.aspx

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Secondary Effects of Energy Efficiency on Air Pollution

Reductions in air pollution are projected due to the proposed energy efficiency opportunities. In general the electric energy savings will decrease carbon dioxide (CO_2), carbon (C), sulfur dioxide (SO_2), and oxides of nitrogen (NO_x) emissions at the utility's power generating station. Natural gas savings will decrease mainly CO_2 emissions at the plant. The emission reductions are products of the energy reductions and the following emissions factors:

For Electric Energy Savings:
CO_2 reductions of 0.7321 lbs/kWh[58]
NO_x reductions of 0.0011 lbs/kWh
SO_2 reductions of 0.0007 lbs/kWh

The emission factors for electric power generating plants are aggregates for EPA Region II. The mix of generation modes for the local utility (i.e., hydroelectric power plants, coal-burning power plants, etc.) should be used to determine the specific emission factors, but these average factors provide a suitable starting point.

Because the energy usage of this facility will increase, emissions will increase. For an increase in electric energy usage of 575,791 kWh/year presented in this report, the emissions are estimated as follows.

$$CO_2 :\ 575{,}791 \tfrac{kWh}{year} \times 0.7321\, lbs\ of\ \tfrac{CO_2}{kWh} \approx 421{,}537\ lbs\left(210.8\ tons\right) of\ \tfrac{CO_2}{year}$$

$$NO_x : 575{,}791 \tfrac{kWh}{year} \times 0.0011\, lbs\ of\ \tfrac{NO_x}{kWh} \approx 633\ lbs\left(0.32\ tons\right) of\ \tfrac{NO_x}{year}$$

$$SO_2 : 575{,}791 \tfrac{kWh}{year} \times 0.0007\ lbs\ of\ \tfrac{SO_2}{kWh} \approx 403\ lbs\left(0.20\ tons\right) of\ \tfrac{SO_2}{year}$$

For more information on the relationship between energy reduction and greenhouse gas emissions please visit: http://www.epa.gov/cleanenergy/energy-resources/calculator.html

[58] Emissions information obtained from:
http://www3.dps.ny.gov/e/energylabel.nsf/ViewCat?ReadForm&View=LabelInfo&Cat=January+1,+2011+-+December+31,+2011&Count=80

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General Plant Information

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Audit Data

Audit Report Number:	SU0XXX
Plant Location:	New York
Analysts:	Mark Seibel, Lead Analyst Suresh Santanam, Sc.D., P.E., Director Jillian Burgoyne, Safety Officer Michael Garrett, Reviewer Riley Gourde, Analyst Patrick Ostoyich, Analyst
Assessment Date:	--/--/----
Total Plant Area:	900,173 ft^2
Principal Products:	Injection Molded Plastic Component Parts
SIC Code:	----
NAICS Code:	------
Annual Sales[59]:	$123,000,000
Invoiced Quantity Sold[60]:	2,275,000,000 parts
Number of Employees:	907
Operating Schedule:	1st Shift: 7:00 AM – 3:00 PM, 5 $^{days}/_{week}$, 52 $^{weeks}/_{year}$ 2nd Shift: 3:00 PM – 11:00 PM, 5 $^{days}/_{week}$, 52 $^{weeks}/_{year}$ 3rd Shift: 11:00 PM – 7:00 AM, 5 $^{days}/_{week}$, 52 $^{weeks}/_{year}$ Office: 7:00 AM – 4:00 PM, 5 $^{days}/_{week}$, 52 $^{weeks}/_{year}$
Annual Shutdown:	N/A
Peak Production Period:	N/A
Annual Plant Operation:	6,240 hours
Energy Sources:	Electricity Natural Gas

[59] Total Annual Sales of $218,774,547 for all five plants was provided by plant personnel. Annual Sales for the three facilities assessed during the site visit (East, West, and South) were estimated by comparing plant production area square footage.

[60] Total Invoiced Quantity Sold of 4,045,715,224 parts was provided by plant personnel. Invoiced Quantity Sold for the three facilities assessed during the site visit was estimated by comparing plant production area square footage.

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Plant Description

The combined are of all five buildings is 900,173 square feet. During the site visit, only three of the five buildings were visited; the East, West, and South buildings. These buildings are 108,841, 215,726, and 195,170 square feet respectively. Each building is divided between manufacturing, storage, and office space.

Process Description

The following is a brief description of the manufacturing process. The company generates different products from the raw material so the process description given below and further outlined in the general process flow chart.

1. Receiving

   Raw materials are received and unpacked

2. Staging and Inspection

   Resin is sorted to resin truck or stored in a silo until needed

3. Resin is Prepared

   Resin is dried and heated to prepare for the molding process

4. Injection Molding

   Resin is injected into molds, provided by the customer, to create the ordered part

5. Testing

   Completed parts are tested. If they fail, they are reground, and if they pass, they are packaged and shipped

6. Shipping

   Completed Products are packaged and shipped

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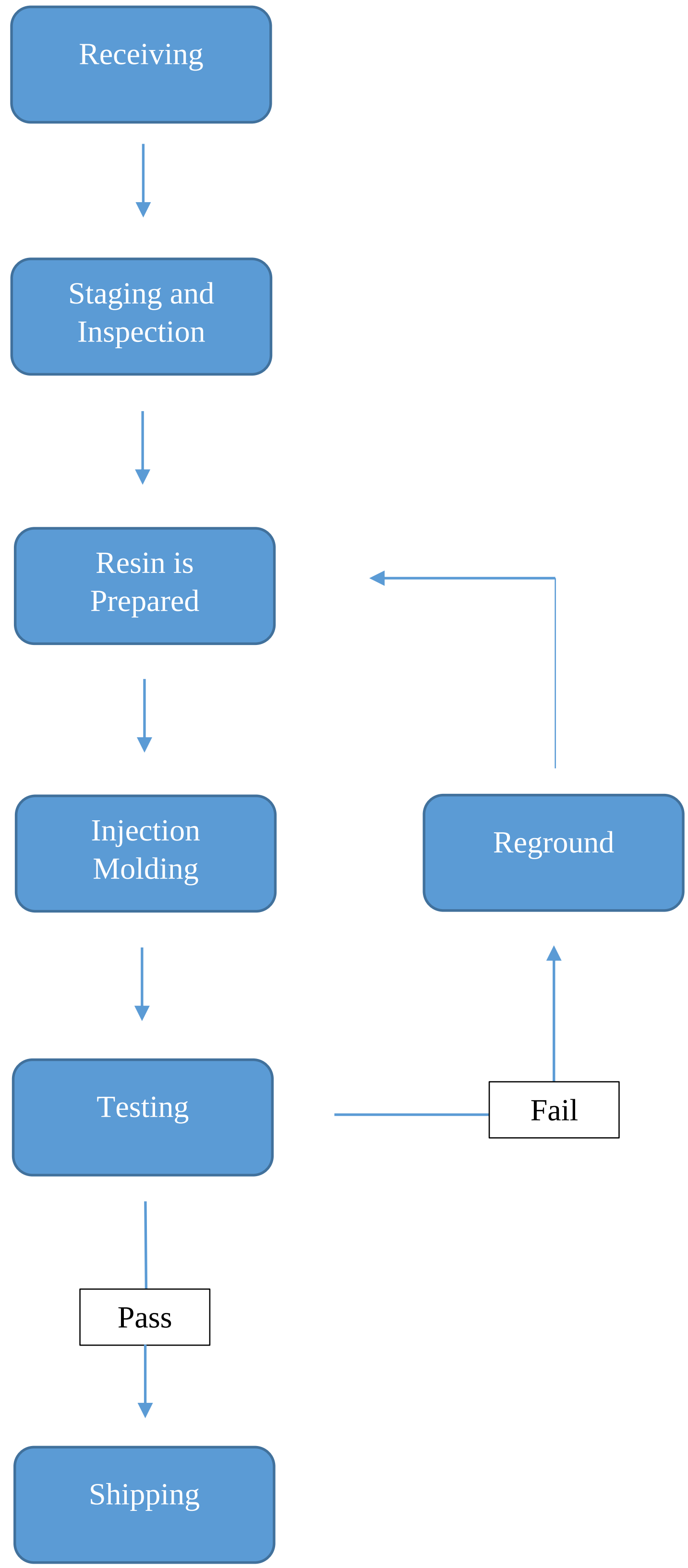
General Process Flow Chart



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Best Practices

The company has already adopted many sensible “best practice” methods to reduce energy and improve productivity, including:

- *Open Minded Attitude*
  Company management has an open minded attitude when it comes to energy and waste reduction ideas.

- *Startup Protocol in Place*
  Company has a protocol for plant startup in order to standardize procedure and equipment sequencing.

- *Lighting Retrofit*
  The company has installed efficient fluorescent lighting throughout some of the facility. These require a lower wattage than traditional incandescent or metal halide lights and can be used in conjunction with motion sensors.

- *ISO Certified*
  The facility has obtained an ISO certification. This certification shows that the facility meets the quality standards set by the international standards organization. As a result, the facility presumably attracts more business.

- *Closed Loop Regrind*
  The company has a policy for regrinding extra plastic as well as parts that do not pass quality specifications. This reduces the amount of waste leaving the facility.

- *Occupancy Sensors in Warehouses*
  The facility has installed occupancy sensors in the warehouse areas. This reduces unnecessary usage of electricity.

- *Recycling Program*
  The company has a comprehensive recycling program that drastically reduces the amount of unusable waste that leaves the facility.

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Other Resources

The U.S. Department of Energy (DOE) has many resources available to assist manufacturers with energy issues. Most of the information is available online; otherwise, publications and software can be obtained from the OIT (Office of Industrial Technologies) Clearinghouse at 1-800-862-2086.

Software (https://ecenter.ee.doe.gov/Pages/default.aspx)

- *AirMaster*
  This software helps assess compressed air systems, including evaluating the effectiveness of energy saving measures and evaluating system upgrades.

- *MotorMaster*
  This software contains tools to manage motor inventory and evaluate motor efficiency.

- *Pumping System Assessment Tool (PSAT)*
  This software helps assess the efficiency of pumping systems and can calculate potential energy savings.

- *Steam System Scoping Tool*
  This software is used to profile existing steam system operations and evaluate best practices available for steam systems.

- *3E Plus*
  This software evaluates whether boiler systems can be optimized by insulating steam lines, and can calculate the most economical thickness of insulation.

- *ASD Master*
  This program helps evaluate the potential savings using an Adjustable Speed Drive (ASD) and includes a searchable database of standard drives.

Databases

- *Allied Partners Database*
  This database allows you to search for providers in your geographic area of energy analyses and plant upgrades.

- *IAC Database*
  This database includes the results of all IAC assessments throughout the history of the program. The data includes plant demographic information, recommended energy improvements, and projected savings from these recommendations.

Publication

There are a variety of technical publications, case studies, and training materials available from the Department of Energy. The DOE also publishes a bimonthly newsletter, *Energy Matters*, which is available online and in print.

The DOE's Best Practices website (http://www.energy.gov/eere/amo/business-case-sep#case-studies) contains all of the above resources, as well as a number of information sheets targeted at specific energy-saving measures that you can put into effect in your company.

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Appendices

Contents

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Billing Data

Comparing Energy Costs

As energy costs rise, companies that want to survive must become more aware of their energy usage and must develop ways to analyze and control the associated costs. The best way to keep track of energy usage is to keep up-to-date spreadsheets and bar graphs of monthly consumption and costs. As utility bills are received each month, it is recommended that the billing data be immediately entered into a spreadsheet and plotted on a bar graph; each type of energy used requires its own set of graphs. From these graphs, it is much easier to track trends in energy usage and to evaluate the effects of conservation efforts.

Comparing data from different energy sources is best done by converting all energy used to a common energy unit, such as the British thermal unit (Btu). The conversion factors required for this are as follows.

Conversion Factors

Energy Unit	Btu Equivalent
1 KJ	*0.94782 Btu*
1 kWh	*3,413 Btu*
1 Therm	*100,000 Btu*
1 CCF Natural Gas	*100,000 Btu**
1 Gallon #2 Fuel Oil	*140,000 Btu**
1 Gallon #4 Fuel Oil	*144,000 Btu**
1 Gallon #6 Fuel Oil	*152,000 Btu**
1 Gallon Propane	*91,600 Btu**
1 Ton Coal	*27,800,000 Btu**
1 Ton Refrigeration	*12,000 Btu/h*
1 Boiler Horsepower	*33,475 Btu/h*

* Values may vary slightly with supplier

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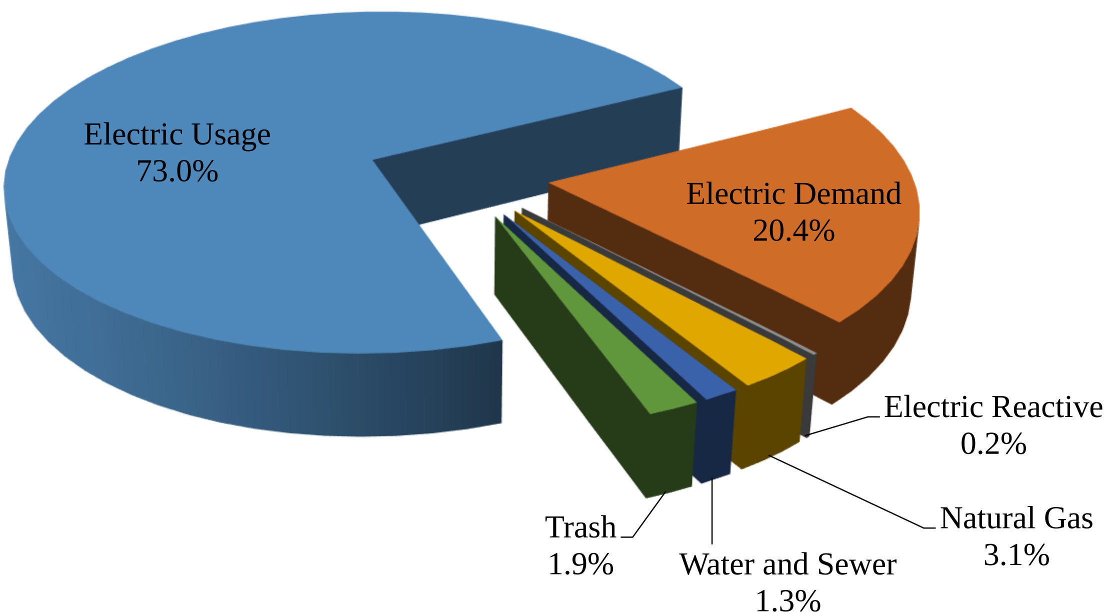
Annual Utility Data

The following graphs and their corresponding data have been included on an attached CD ROM disk in electronic format.

Utility Summary

Utility	Annual Cost	Annual Usage		MMBtu	Average Cost		Cost per MMBtu
Electric Usage	*$2,370,757*	*56,064,161*	*kWh*	*191,347*	*$0.042*	*$/kWh*	*$12.39*
Electric Demand	*$664,089*	*169,892*	*kW*	*N/A*	*$3.91*	*$/kW*	*N/A*
Electric Reactive	*$6,070*	*7,782,360*	*RkVA*	*N/A*	*$0.001*	*$/RkVA*	*N/A*
Other Electric Charges	*-$29,390*	*N/A*		*N/A*	*N/A*		*N/A*
Natural Gas	*$100,620*	*140,316*	*Therms*	*14,032*	*$0.72*	*$/Therm*	*$7.17*
Water and Sewer	*$43,016*	*12,560,800*	*Gallons*	*N/A*	*$0.003*	*$/Gallon*	*N/A*
Trash	*$62,977*	*N/A*		*N/A*	*N/A*		*N/A*
Total	$3,218,139	N/A		205,379	N/A		N/A



Electrical Billing Data

Billing Period	Electric Billing Data – Invoice 1 – Integrys (Supply) – NY- --_----- -							
	Usage			Demand			"8% Sales Tax"	Total
	Usage (kWh)	Rate ($/kWh)	Cost	Demand (kW)	Rate ($/kW)	Cost		
Jan-14	1,796,387	$0.071	$127,497	2,402	$3.90	$9,368	$1,095	$136,865
Feb-14	1,692,457	$0.062	$95,211	2,410	$4.30	$10,361	$845	$105,572
Mar-14	1,840,830	$0.063	$108,302	2,449	$3.00	$7,346	$925	$115,647
Apr-14	1,878,492	$0.050	$88,249	2,478	$1.94	$4,798	$744	$93,048
May-14	1,912,266	$0.056	$86,652	3,898	$5.38	$20,988	$861	$107,640
Jun-14	2,001,176	$0.059	$93,011	3,910	$6.56	$25,666	$949	$118,677
Jul-14	2,006,644	$0.059	$94,336	3,916	$6.22	$24,368	$950	$118,704
Aug-14	2,009,116	$0.057	$90,802	3,930	$5.96	$23,417	$914	$114,219
Sep-14	1,986,991	$0.055	$87,241	3,939	$5.76	$22,676	$879	$109,917
Oct-14	1,975,838	$0.055	$87,699	3,949	$5.50	$21,714	$875	$109,413
Nov-14	1,721,612	$0.053	$81,680	4,203	$2.35	$9,870	$732	$91,550
Dec-14	1,704,866	$0.021	$25,947	4,115	$2.55	$10,492	$292	$36,439
Average	1,877,223	$0.055	$88,886	3,467	$4.45	$15,922	$838	$104,808
Total	22,526,675	N/A	$1,066,628	41,599	N/A	$191,064	$10,062	$1,257,692

Billing Period	Electric Billing Data – Invoice 1 – Integrys (Supply) – NY- --_----- -							
	Usage			Demand			"8% Sales Tax"	Total
	Usage (kWh)	Rate ($/kWh)	Cost	Demand (kW)	Rate ($/kW)	Cost		
Jan-14	1,330,002	$0.094	$125,142	2,178	$3.90	$8,492	$1,069	$133,635
Feb-14	1,275,239	$0.076	$96,671	2,184	$4.30	$9,392	$849	$106,064
Mar-14	1,441,567	$0.077	$110,426	2,220	$3.00	$6,659	$937	$117,085
Apr-14	1,260,048	$0.047	$59,238	2,246	$1.94	$4,350	$509	$63,588
May-14	1,254,328	$0.046	$57,492	2,451	$5.38	$13,193	$565	$70,685
Jun-14	1,426,136	$0.047	$66,605	2,458	$6.56	$16,134	$662	$82,739
Jul-14	1,341,175	$0.047	$62,942	2,462	$6.22	$15,318	$626	$78,260
Aug-14	1,569,588	$0.044	$68,699	2,470	$5.96	$14,720	$667	$83,418
Sep-14	1,436,145	$0.043	$62,459	2,476	$5.76	$14,254	$614	$76,714
Oct-14	1,605,923	$0.042	$68,003	2,482	$5.50	$13,650	$653	$81,653
Nov-14	1,334,307	$0.046	$61,084	2,642	$2.35	$6,204	$538	$67,288
Dec-14	1,370,202	$0.049	$67,787	2,587	$2.55	$6,595	$595	$74,382
Average	1,387,055	$0.055	$75,546	2,405	$4.45	$10,747	$690	$86,293
Total	16,644,660	N/A	$906,549	28,856	N/A	$128,962	$8,284	$1,035,511

Billing Period	Electric Billing Data — Invoice 2 — NYPA (Delivery)							
	Usage			Demand			"8% Sales Tax"	Total
	Usage (kWh)	Rate ($/kWh)	Cost	Demand (kW)	Rate ($/kW)	Cost		
Jan-14	739,897	$0.023	$17,077	1,265	$7.32	$9,260	$2,634	$26,337
Feb-14	656,519	$0.025	$16,354	1,265	$7.32	$9,260	$2,561	$25,614
Mar-14	753,277	$0.025	$18,764	1,265	$7.32	$9,260	$2,802	$28,024
Apr-14	698,261	$0.025	$17,394	1,265	$7.32	$9,260	$2,665	$26,653
May-14	697,855	$0.028	$19,456	1,265	$7.77	$9,829	$2,929	$29,285
Jun-14	732,610	$0.022	$16,125	1,265	$7.77	$9,829	$2,595	$25,954
Jul-14	693,440	$0.023	$15,824	1,265	$7.77	$9,829	$2,565	$25,653
Aug-14	706,979	$0.019	$13,652	1,265	$7.77	$9,829	$2,348	$23,481
Sep-14	710,362	$0.019	$13,554	1,265	$7.77	$9,829	$2,338	$23,383
Oct-14	714,468	$0.022	$15,554	1,265	$7.77	$9,829	$2,538	$25,383
Nov-14	666,177	$0.025	$16,894	1,265	$7.77	$9,829	$2,672	$26,723
Dec-14	676,568	$0.019	$12,659	1,265	$7.77	$9,829	$2,249	$22,488
Average	703,868	$0.023	$16,109	1,265	$7.62	$9,639	$2,575	$25,748
Total	8,446,413	N/A	$193,306	15,180	N/A	$115,672	$30,898	$308,978

Billing Period	Electric Billing Data — Invoice 4 — NYSEG (Delivery) — ---- ---- ---					
	Usage			Other kWh Based Charges		
	Usage (kWh)	Rate ($/kWh)	Cost	kWh	Rate ($/kWh)	Cost
Jan-14	2,536,284	$0.002	$5,717	1,479,79	-$0.006	-$8,717
Feb-14	2,348,976	$0.001	$2,572	1,313,03	-$0.006	-$7,735
Mar-14	2,594,107	$0.001	$3,227	1,506,55	-$0.006	-$8,875
Apr-14	2,576,753	-$0.011	-$27,597	1,396,52	-$0.006	-$8,227
May-14	2,610,121	-$0.004	-$9,845	1,395,71	-$0.006	-$8,222
Jun-14	2,733,786	-$0.001	-$2,069	1,465,21	-$0.006	-$8,632
Jul-14	2,700,084	$0.008	$20,421	1,386,87	-$0.006	-$8,170
Aug-14	2,716,095	$0.012	$32,161	1,413,95	-$0.006	-$8,330
Sep-14	2,697,353	$0.013	$33,774	1,420,72	-$0.006	-$8,369
Oct-14	2,690,306	$0.012	$32,585	1,428,93	-$0.006	-$9,058
Nov-14	2,387,789	$0.009	$21,798	1,332,35	-$0.006	-$8,446
Dec-14	2,381,434	$0.007	$16,699	1,353,13	-$0.006	-$8,578
Average	2,581,091	$0.004	$10,787	1,407,735	-$0.006	-$8,447
Total	30,973,088	N/A	$129,441	16,892,819	N/A	-$101,359

Billing Period	Electric Billing Data – Invoice 4 – NYSEG (Delivery) – ---- ---- ---							
	Demand			Reactive			Other Charges	Total
	Demand (kW)	Rate ($/kW)	Cost	Reactive (RkVah)	Rate ($/RkVah)	Cost		
Jan-14	4,336	$2.56	$11,11	376,029	$0.00078	$293	$977	$9,388
Feb-14	4,526	$2.64	$11,95	338,856	$0.00078	$264	$977	$8,028
Mar-14	4,356	$2.63	$11,47	395,873	$0.00078	$309	$977	$7,116
Apr-14	4,668	$2.64	$12,34	414,912	$0.00078	$324	$977	-$22,178
May-14	4,731	$2.65	$12,52	431,070	$0.00078	$336	$977	-$4,234
Jun-14	4,720	$2.65	$12,49	468,753	$0.00078	$366	$977	$3,132
Jul-14	4,926	$2.65	$13,06	470,179	$0.00078	$367	$977	$26,655
Aug-14	4,860	$2.65	$12,87	419,276	$0.00078	$327	$977	$38,014
Sep-14	4,803	$2.77	$13,29	442,162	$0.00078	$345	$977	$40,023
Oct-14	4,763	$2.77	$13,18	456,523	$0.00078	$356	$977	$38,041
Nov-14	4,534	$2.70	$12,23	390,053	$0.00078	$304	$977	$26,869
Dec-14	4,453	$2.70	$12,01	357,341	$0.00078	$279	$977	$21,388
Average	4,640	$2.67	$12,381	413,419	$0.00078	$322	$977	$16,020
Total	55,678	N/A	$148,567	4,961,027	N/A	$3,870	$11,723	$192,242

Billing Period	Electric Billing Data – Invoice 4 – NYSEG (Delivery) – ---- ---- ---					
	Usage			Demand		
	Usage (kWh)	Rate ($/kWh)	Cost	Demand (kW)	Rate ($/kW)	Cost
Jan-14	1,330,002	$0.002	$2,998	2,189	$2.71	$5,933
Feb-14	1,275,240	$0.001	$1,396	2,121	$2.78	$5,896
Mar-14	1,441,567	$0.001	$1,793	2,163	$2.78	$6,013
Apr-14	1,260,048	-$0.011	-$13,495	2,181	$2.78	$6,063
May-14	1,254,328	-$0.004	-$4,731	2,198	$2.78	$6,109
Jun-14	1,426,135	-$0.001	-$1,080	2,440	$2.78	$6,784
Jul-14	1,341,175	$0.008	$10,143	2,443	$2.78	$6,792
Aug-14	1,569,589	$0.012	$18,586	2,618	$2.78	$7,277
Sep-14	1,436,145	$0.013	$17,982	2,520	$2.90	$7,308
Oct-14	1,605,923	$0.012	$19,451	2,695	$2.90	$7,817
Nov-14	1,334,306	$0.009	$12,181	2,516	$2.76	$6,943
Dec-14	1,370,202	$0.007	$9,608	2,496	$2.76	$6,889
Average	1,387,055	$0.004	$6,236	2,382	$2.79	$6,652
Total	16,644,660	N/A	$74,832	28,580	N/A	$79,824

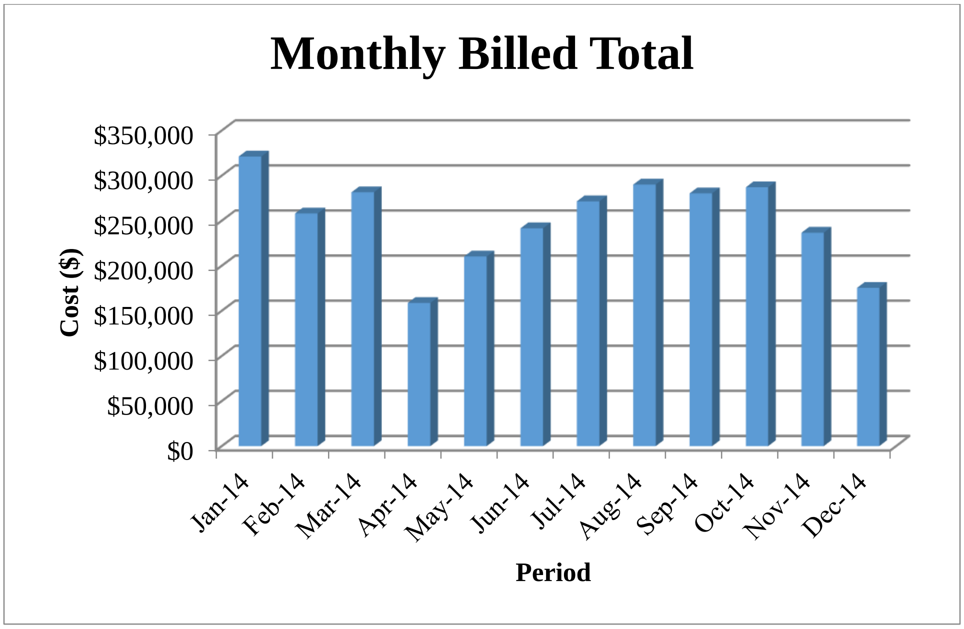
SU Sample

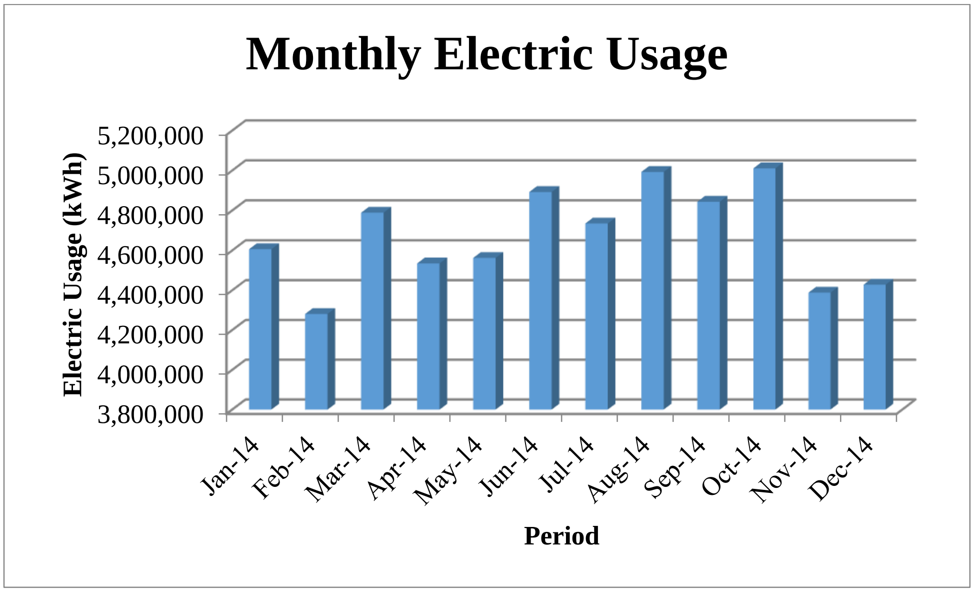
Billing Period	Electric Billing Data				
	Invoice 4				
	NYSEG (Delivery)				
	---- ---- ---				
	Reactive			Other Charges	Total
	Reactive (RkVah)	Rate ($/RkVah)	Cost		
Jan-14	262,499	$0.00078	$205	$917	$10,052
Feb-14	234,190	$0.00078	$183	$917	$8,392
Mar-14	227,608	$0.00078	$178	$917	$8,901
Apr-14	220,488	$0.00078	$172	$917	-$6,344
May-14	239,418	$0.00078	$187	$917	$2,482
Jun-14	196,466	$0.00078	$153	$917	$6,774
Jul-14	210,706	$0.00078	$164	$917	$18,017
Aug-14	230,603	$0.00078	$180	$917	$26,959
Sep-14	214,964	$0.00078	$168	$917	$26,375
Oct-14	323,019	$0.00078	$252	$917	$28,436
Nov-14	208,923	$0.00078	$163	$917	$20,204
Dec-14	252,449	$0.00078	$197	$917	$17,610

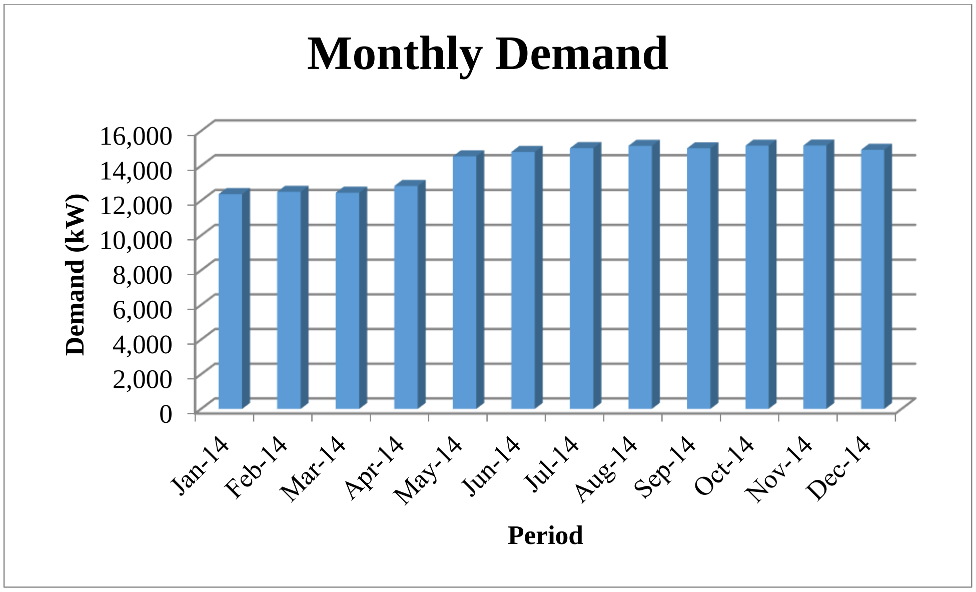
Average	235,111	$0.00078	$183	$917	$13,988
Total	2,821,333	N/A	$2,201	$11,003	$167,860

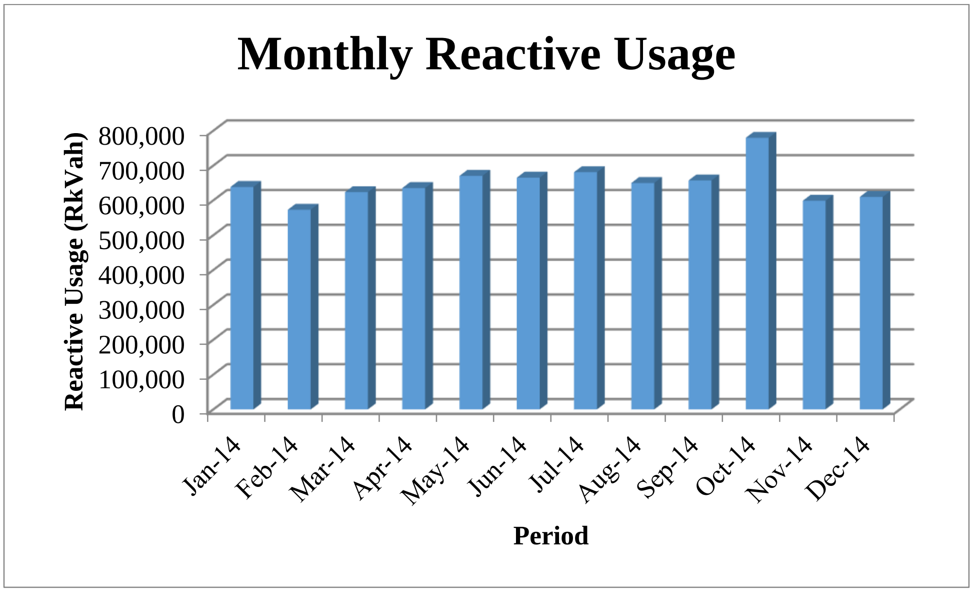
Billing Period	Electric Billing Data								
	Total Usage (kWh)	Total Demand (kW)	Total Reactive (RkVah)	Total Usage Cost	Total Demand Cost	Total Reactive Cost	Total Other kWh Based Charges	Total Other Charges	Billed Total
Jan-14	4,606,183	12,370	638,528	$278,4	$44,172	$498	-$8,717	$6,691	$321,074
Feb-14	4,280,735	12,506	573,046	$212,2	$46,859	$447	-$7,735	$6,148	$257,925
Mar-14	4,788,951	12,453	623,481	$242,5	$40,756	$486	-$8,875	$6,558	$281,437
Apr-14	4,535,062	12,838	635,400	$123,7	$36,816	$496	-$8,227	$5,812	$158,686
May-14	4,562,304	14,543	670,488	$149,0	$62,640	$523	-$8,222	$6,249	$210,213
Jun-14	4,892,531	14,794	665,219	$172,5	$70,902	$519	-$8,632	$6,101	$241,482
Jul-14	4,734,699	15,012	680,885	$203,6	$69,369	$531	-$8,170	$6,035	$271,431
Aug-14	4,992,663	15,143	649,879	$223,8	$68,121	$507	-$8,330	$5,823	$290,020
Sep-14	4,843,860	15,004	657,126	$215,0	$67,365	$513	-$8,369	$5,725	$280,243
Oct-14	5,010,697	15,155	779,542	$223,2	$66,190	$608	-$9,058	$5,961	$286,994
Nov-14	4,388,272	15,160	598,976	$193,6	$45,082	$467	-$8,446	$5,837	$236,578
Dec-14	4,428,204	14,915	609,790	$132,6	$45,816	$476	-$8,578	$5,029	$175,443

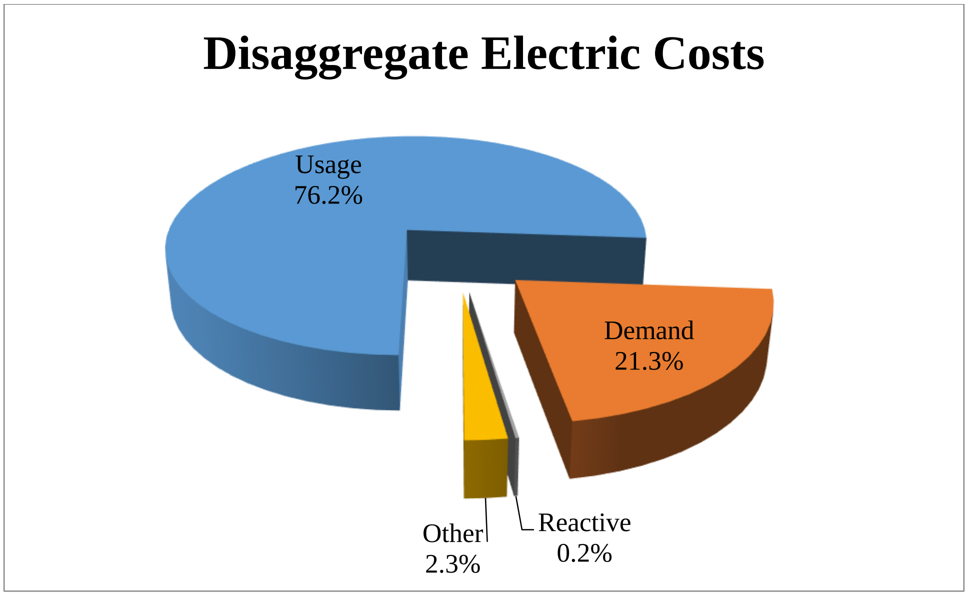
Average	4,672,013	14,158	648,530	$197,56	$55,341	$506	-$8,447	$5,997	$250,96
Total	56,064,161	169,892	7,782,36	$2,370,75	$664,08	$6,070	-$101,359	$71,969	$3,011,52


Monthly Billed Total
$350,000
$300,000
$250,000
$200,000
$150,000
$100,000
$50,000
$0
Cost ($)
Jan-14
Feb-14
Mar-14
Apr-14
May-14
Jun-14
Jul-14
Aug-14
Sep-14
Oct-14
Nov-14
Dec-14
Period


Monthly Electric Usage
5,200,000
5,000,000
4,800,000
4,600,000
4,400,000
4,200,000
4,000,000
3,800,000
Electric Usage (kWh)
Jan-14
Feb-14
Mar-14
Apr-14
May-14
Jun-14
Jul-14
Aug-14
Sep-14
Oct-14
Nov-14
Dec-14
Period


Monthly Demand
Demand (kW)
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
Jan-14
Feb-14
Mar-14
Apr-14
May-14
Jun-14
Jul-14
Aug-14
Sep-14
Oct-14
Nov-14
Dec-14
Period


Monthly Reactive Usage
Reactive Usage (RkVah)
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
Jan-14
Feb-14
Mar-14
Apr-14
May-14
Jun-14
Jul-14
Aug-14
Sep-14
Oct-14
Nov-14
Dec-14
Period


Disaggregate Electric Costs
Usage
76.2%
Demand
21.3%
Other
2.3%
Reactive
0.2%

Natural Gas Billing Data

Natural Gas Billing Data								
Billing Period	NYSEG ---- ---- --- NY							
	Delivery - NYSEG				Supply - Blue Rock Energy			Total
	Usage (therms)	Rate ($/therm)	Cost	Other Delivery Charges	Usage (therms)	Rate ($/therm)	Cost	
Jan-14	1,305	$ 0.27	$348	$24	1,305	$ 0.52	$674	$1,04
Feb-14	1,023	$ 0.27	$275	$24	1,023	$ 0.62	$630	$92
Mar-14	1,539	$ 0.24	$375	$24	1,539	$ 0.57	$872	$1,27
Apr-14	941	$ 0.27	$257	$24	941	$ 0.54	$508	$78
May-14	529	$ 0.33	$175	$24	529	$ 0.55	$291	$49
Jun-14	0	N/A	$0	$24	0	N/A	$0	$2
Jul-14	0	N/A	$0	$24	0	N/A	$0	$2
Aug-14	1,395	$ 0.25	$345	$24	1,395	$ 0.46	$646	$1,01
Sep-14	1,621	$ 0.24	$387	$24	1,621	$ 0.47	$760	$1,17
Oct-14	679	$ 0.30	$205	$24	679	$ 0.38	$256	$48
Nov-14	40	$ 0.31	$13	$24	40	$ 0.36	$14	$5
Dec-14	131	$ 0.34	$45	$24	131	$ 0.40	$52	$12
Average	767	$ 0.28	$202	$24	767	$ 0.49	$392	$618
Total	9,202	$ 2.83	$2,425	$283	9,202	$ 4.86	$4,705	$7,413

Natural Gas Billing Data								
Billing Period	NYSEG ---- ---- --- NY							
	Delivery - NYSEG				Supply - Blue Rock Energy			Total
	Usage (therms)	Rate ($/therm)	Cost	Other Delivery Charges	Usage (therms)	Rate ($/therm)	Cost	
Jan-14	7,706	$ 0.21	$1,586	$24	7,706	$ 0.52	$3,982	$5,591
Feb-14	9,657	$ 0.19	$1,832	$24	9,657	$ 0.62	$5,952	$7,807
Mar-14	8,046	$ 0.17	$1,356	$24	8,046	$ 0.57	$4,560	$5,939
Apr-14	5,906	$ 0.19	$1,146	$24	5,906	$ 0.54	$3,189	$4,359
May-14	4,098	$ 0.21	$858	$24	4,098	$ 0.55	$2,256	$3,137
Jun-14	3,329	$ 0.22	$742	$24	3,329	$ 0.54	$1,805	$2,571
Jul-14	1,851	$ 0.23	$435	$24	1,851	$ 0.52	$962	$1,421
Aug-14	1,315	$ 0.25	$329	$24	1,315	$ 0.46	$609	$961
Sep-14	1,240	$ 0.25	$312	$24	1,240	$ 0.47	$582	$918
Oct-14	1,182	$ 0.27	$316	$24	1,182	$ 0.38	$446	$786
Nov-14	3,346	$ 0.21	$708	$24	3,346	$ 0.36	$1,200	$1,931
Dec-14	6,123	$ 0.22	$1,347	$24	6,123	$ 0.40	$2,429	$3,800
Average	4,483	$ 0.22	$914	$24	4,483	$ 0.49	$2,331	$3,268
Total	53,797	$ 2.63	$10,966	$283	53,797	$ 5.92	$27,972	$39,221

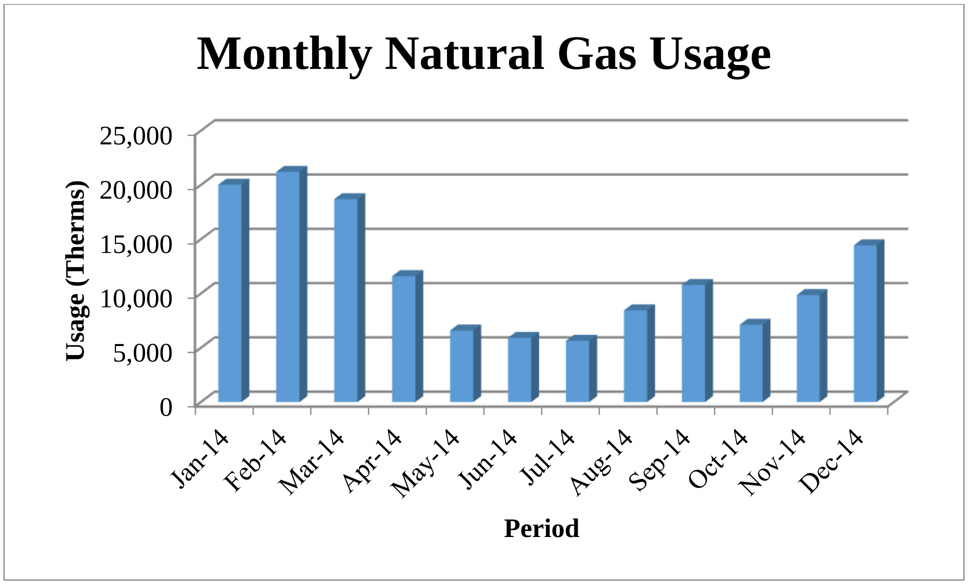
Billing Period	Natural Gas Billing Data – NYSEG – ---- ---- --- – NY							
	Delivery - NYSEG				Supply - Blue Rock Energy			Total
	Usage (therms)	Rate ($/therm)	Cost	Other Delivery Charges	Usage (therms)	Rate ($/therm)	Cost	
Jan-14	3,132	$ 0.22	$702	$24	3,132	$ 0.52	$1,618	$2,343
Feb-14	3,085	$ 0.21	$649	$24	3,085	$ 0.62	$1,902	$2,574
Mar-14	2,045	$ 0.21	$421	$24	2,045	$ 0.57	$1,159	$1,604
Apr-	1,065	$ 0.25	$271	$24	1,065	$ 0.54	$575	$870
May-14	923	$ 0.27	$251	$24	923	$ 0.55	$508	$783
Jun-14	943	$ 0.27	$256	$24	943	$ 0.54	$511	$791
Jul-14	729	$ 0.29	$214	$24	729	$ 0.52	$379	$617
Aug-14	833	$ 0.28	$234	$24	833	$ 0.46	$385	$643
Sep-14	899	$ 0.27	$246	$24	899	$ 0.47	$422	$691
Oct-14	1,388	$ 0.25	$350	$24	1,388	$ 0.38	$524	$898
Nov-14	1,832	$ 0.23	$429	$24	1,832	$ 0.36	$657	$1,110
Dec-	1,863	$ 0.25	$457	$24	1,863	$ 0.40	$739	$1,220
Average	1,561	$ 0.25	$373	$24	1,561	$ 0.49	$782	$1,179
Total	18,736	$ 3.02	$4,480	$283	18,736	$ 5.92	$9,380	$14,14

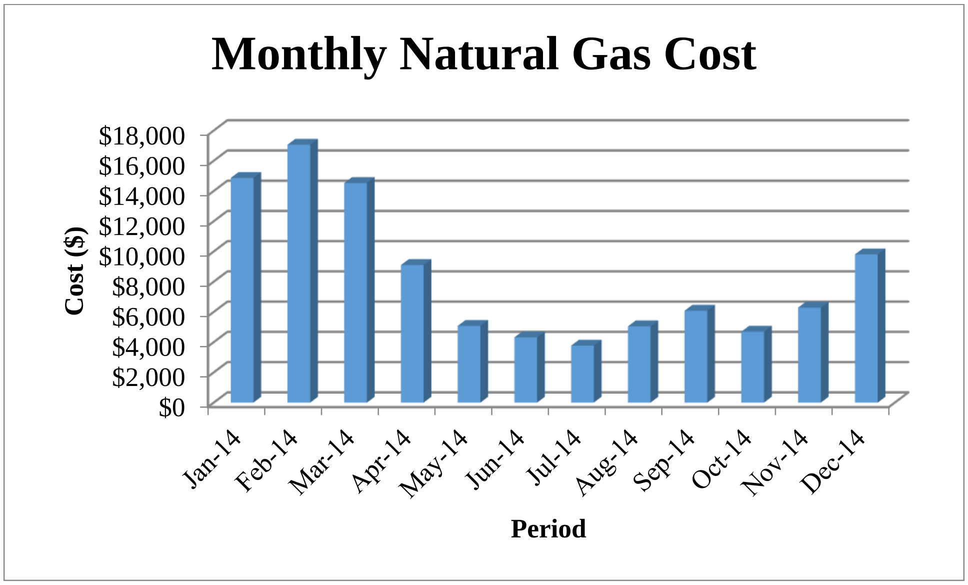
Billing Period	Natural Gas Billing Data – NYSEG – ---- ---- --- – NY								
	Delivery - NYSEG				Supply - NYSEG			Other Charges	Total
	Usage (therms)	Rate ($/therm)	Cost	Other Delivery Charges	Usage (therms)	Rate ($/therm)	Cost		
Jan-14	1,434	$ 0.27	$391	$24	1,434	$ 0.52	$752	$1	$1,167
Feb-14	1,091	$ 0.28	$300	$24	1,091	$ 0.56	$615	$1	$940
Mar-14	1,697	$ 0.25	$424	$24	1,697	$ 0.61	$1,041	$1	$1,489
Apr-14	1,110	$ 0.29	$318	$29	1,110	$ 0.61	$679	$1	$1,028
May-14	766	$ 0.08	$58	$13	766	$ 0.55	$418	$1	$489
Jun-14	1,588	$ 0.07	$113	$24	1,588	$ 0.53	$842	$1	$980
Jul-14	2,977	$ 0.08	$224	$17	2,977	$ 0.50	$1,482	$1	$1,723
Aug-14	4,877	$ 0.08	$367	$17	4,877	$ 0.43	$2,106	$1	$2,490
Sep-14	6,841	$ 0.08	$514	$20	6,841	$ 0.40	$2,711	$1	$3,246
Oct-14	3,150	$ 0.24	$759	$19	3,150	$ 0.41	$1,293	$1	$2,072
Nov-14	1,682	$ 0.27	$461	$24	1,682	$ 0.45	$760	$1	$1,245
Dec-14	2,837	$ 0.26	$734	$24	2,837	$ 0.49	$1,392	$1	$2,150
Average	2,504	$ 0.19	$389	$21	2,504	$ 0.51	$1,174	$1	$1,585
Total	30,049	$ 2.23	$4,664	$256	30,049	$ 6.07	$14,091	$10	$19,021

Natural Gas Billing Data										
Billing Period	NYSEG									
	---- ---- ---									
	NY									
	Delivery - NYSEG				Supply - NYSEG			Other Charges	Total
	Usage (therms)	Rate ($/therm)	Cost	Other Delivery Charges	Usage (therms)	Rate ($/therm)	Cost		
Jan-14	6,445	$ 0.22	$1,431	$24	6,445	$ 0.52	$3,378	$387	$5,220
Feb-14	6,352	$ 0.21	$1,322	$24	6,352	$ 0.56	$3,583	$395	$5,324
Mar-14	5,361	$ 0.19	$1,034	$24	5,361	$ 0.61	$3,288	$348	$4,693
Apr-14	2,577	$ 0.23	$581	$24	2,577	$ 0.61	$1,578	$175	$2,358
May-14	280	$ 0.34	$96	$24	280	$ 0.59	$164	$23	$307
Jun-14	55	$ 0.33	$18	$24	55	$ 0.56	$31	$7	$79
Jul-14	86	$ 0.34	$29	$24	86	$ 0.53	$45	$9	$107
Aug-14	30	$ 0.32	$9	$24	30	$ 0.46	$14	$5	$51
Sep-14	187	$ 0.36	$67	$24	187	$ 0.43	$80	$14	$185
Oct-14	721	$ 0.34	$245	$24	721	$ 0.41	$298	$46	$613
Nov-14	2,957	$ 0.24	$707	$24	2,957	$ 0.45	$1,336	$166	$2,232
Dec-14	3,483	$ 0.26	$897	$24	3,483	$ 0.49	$1,709	$211	$2,840

Natural Gas Billing Data				
Billing Period	Total Usage (therms)	Total Usage Cost	Total Other Charges	Billed Total
Jan-14	20,023	$14,863	$506	$15,369
Feb-14	21,207	$17,060	$514	$17,574
Mar-14	18,688	$14,529	$467	$14,996
Apr-14	11,598	$9,102	$300	$9,403
May-14	6,595	$5,074	$132	$5,206
Jun-14	5,914	$4,318	$125	$4,444
Jul-14	5,643	$3,770	$121	$3,891
Aug-14	8,450	$5,045	$117	$5,161
Sep-14	10,786	$6,080	$131	$6,210
Oct-14	7,119	$4,693	$160	$4,854
Nov-14	9,857	$6,285	$285	$6,570
Dec-14	14,436	$9,801	$330	$10,131

Average	11,693	$8,385	$266	$8,651
Total	140,316	$100,620	$3,187	$103,807


Monthly Natural Gas Usage
Usage (Therms)
25,000
20,000
15,000
10,000
5,000
0
Jan-14
Feb-14
Mar-14
Apr-14
May-14
Jun-14
Jul-14
Aug-14
Sep-14
Oct-14
Nov-14
Dec-14
Period

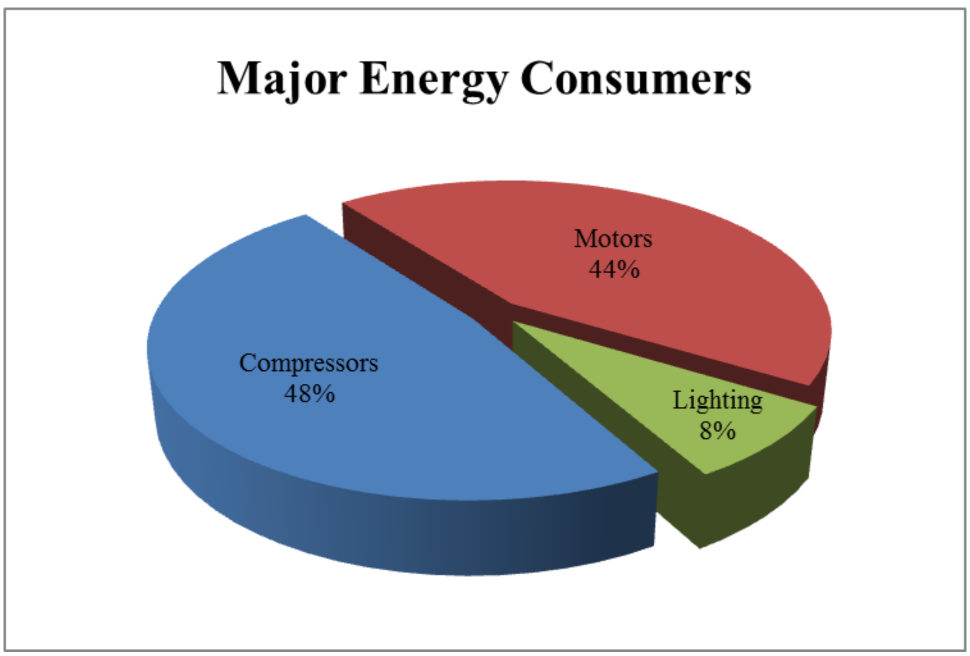

Monthly Natural Gas Cost
Cost ($)
$18,000
$16,000
$14,000
$12,000
$10,000
$8,000
$6,000
$4,000
$2,000
$0
Jan-14
Feb-14
Mar-14
Apr-14
May-14
Jun-14
Jul-14
Aug-14
Sep-14
Oct-14
Nov-14
Dec-14
Period

Major Energy Consumers

The following table lists estimates of the plant's major sources of energy consumption. The information in this table can be used to determine possible target areas for energy improvements.

Description	Power Rating	Percent of Energy Consumed
Compressors	*1,585 [hp]*	*48%*
Motors	*1,440[hp]*	*44%*
Lighting	*194 [kW] (260 [hp])*	*8%*

The pie chart below describes the plant's electrical usage divided up into the individual operation performed within the plant.



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Implementation Survey
Syracuse University
Industrial Assessment Center

Phone: 315-443-1523
Fax: 315-443-9099
Email: iac@ecs.syr.edu
http://iac.syr.edu/

Thank you for participating in the Industrial Assessment program with our team from Syracuse University.

Please take a few minutes to fill out the following implementation survey. This information is very important to our team and to the U.S. Department of Energy for evaluation purposes. Please return the completed material at the earliest possible date to:

Suresh Santanam Sc.D., P.E., Director
S.U. Industrial Assessment Center
263 Link Hall, Syracuse University
Syracuse, NY 13244

Company name: ______________________________
Assessment number: SU0XXX______________________________
Assessment date: --/--/----______________________________
Report date: --/--/----______________________________
Contact person: ______________________________
Title: ______________________________
Mailing address: ______________________________
Phone: ______________________________
Signature: ______________________________
Date: ______________________________

General comments: ______________________________
____
____
____

Have you or do you intend to share the results of this study with anyone else?

____
____

Did our visit result in any other energy saving projects or activities which were not part of the recommendations listed in our report?

____
____

AR #1
Recommendation name: Reduce Compressed Air System Line Pressure

Implementation status (please circle one):
Was completely implemented as of the following date:
Will be implemented by the following date:
Will not be implemented

If the recommendation has been or will be implemented, please estimate:

Implementation cost: ____
Savings, if different from estimated above: _________________________________

If the recommendation will not be implemented please choose a reason and provide further explanation below:

Code	Reason	Code	Reason
1	Unsuitable return on investment	10	Material restrictions
2	Too expensive initially	11	Bureaucratic restrictions
3	Cash flow prevents implementation	14	Lack of staff for analysis and/or implementation
4	Unacceptable operating charges	15	Not worthwhile
5	Impractical	16	Disagree
6	Process and/or equipment changes	17	Risk or inconvenience to personnel
7	Facility change	18	Suspected risk or problem with equipment or product
8	Personnel changes	19	Rejected after implementation failed
9	Production schedule changes	22	Other

If the recommendation will not be implemented please provide detailed reasoning why:

____
____

Additional Comments:

____
____
____

AR #2
Recommendation name: Reduce Lighting Levels

Implementation status (please circle one):
Was completely implemented as of the following date:
Will be implemented by the following date:
Will not be implemented

If the recommendation has been or will be implemented, please estimate:

Implementation cost: ____
Savings, if different from estimated above: ________________________________

If the recommendation will not be implemented please choose a reason and provide further explanation below:

Code	Reason	Code	Reason
1	Unsuitable return on investment	10	Material restrictions
2	Too expensive initially	11	Bureaucratic restrictions
3	Cash flow prevents implementation	14	Lack of staff for analysis and/or implementation
4	Unacceptable operating charges	15	Not worthwhile
5	Impractical	16	Disagree
6	Process and/or equipment changes	17	Risk or inconvenience to personnel
7	Facility change	18	Suspected risk or problem with equipment or product
8	Personnel changes	19	Rejected after implementation failed
9	Production schedule changes	22	Other

If the recommendation will not be implemented please provide detailed reasoning why:

____
____

Additional Comments:

____
____
____

AR #3
Recommendation name: Eliminate Use of Electric Space Heaters

Implementation status (please circle one):
Was completely implemented as of the following date:
Will be implemented by the following date:
Will not be implemented

If the recommendation has been or will be implemented, please estimate:

Implementation cost: ____
Savings, if different from estimated above: ________________________________

If the recommendation will not be implemented please choose a reason and provide further explanation below:

Code	Reason	Code	Reason
1	Unsuitable return on investment	10	Material restrictions
2	Too expensive initially	11	Bureaucratic restrictions
3	Cash flow prevents implementation	14	Lack of staff for analysis and/or implementation
4	Unacceptable operating charges	15	Not worthwhile
5	Impractical	16	Disagree
6	Process and/or equipment changes	17	Risk or inconvenience to personnel
7	Facility change	18	Suspected risk or problem with equipment or product
8	Personnel changes	19	Rejected after implementation failed
9	Production schedule changes	22	Other

If the recommendation will not be implemented please provide detailed reasoning why:

____
____

Additional Comments:
____
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____

AR #4
Recommendation name: Implement a Regular Leak Maintenance Program

Implementation status (please circle one):
Was completely implemented as of the following date:
Will be implemented by the following date:
Will not be implemented

If the recommendation has been or will be implemented, please estimate:

Implementation cost: ____
Savings, if different from estimated above: ________________________________

If the recommendation will not be implemented please choose a reason and provide further explanation below:

Code	Reason	Code	Reason
1	Unsuitable return on investment	10	Material restrictions
2	Too expensive initially	11	Bureaucratic restrictions
3	Cash flow prevents implementation	14	Lack of staff for analysis and/or implementation
4	Unacceptable operating charges	15	Not worthwhile
5	Impractical	16	Disagree
6	Process and/or equipment changes	17	Risk or inconvenience to personnel
7	Facility change	18	Suspected risk or problem with equipment or product
8	Personnel changes	19	Rejected after implementation failed
9	Production schedule changes	22	Other

If the recommendation will not be implemented please provide detailed reasoning why:

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Additional Comments:

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AR #5
Recommendation name: Install Occupancy Sensors in Clean Room Hallway

Implementation status (please circle one):
Was completely implemented as of the following date:
Will be implemented by the following date:
Will not be implemented

If the recommendation has been or will be implemented, please estimate:

Implementation cost: ____
Savings, if different from estimated above: _____________________________

If the recommendation will not be implemented please choose a reason and provide further explanation below:

Code	Reason	Code	Reason
1	Unsuitable return on investment	10	Material restrictions
2	Too expensive initially	11	Bureaucratic restrictions
3	Cash flow prevents implementation	14	Lack of staff for analysis and/or implementation
4	Unacceptable operating charges	15	Not worthwhile
5	Impractical	16	Disagree
6	Process and/or equipment changes	17	Risk or inconvenience to personnel
7	Facility change	18	Suspected risk or problem with equipment or product
8	Personnel changes	19	Rejected after implementation failed
9	Production schedule changes	22	Other

If the recommendation will not be implemented please provide detailed reasoning why:

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Additional Comments:

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AR #6
Recommendation name: Duct Outside Air to Compressors

Implementation status (please circle one):

Was completely implemented as of the following date:
Will be implemented by the following date:
Will not be implemented

If the recommendation has been or will be implemented, please estimate:

Implementation cost: ____
Savings, if different from estimated above: ______________________________

If the recommendation will not be implemented please choose a reason and provide further explanation below:

Code	Reason	Code	Reason
1	Unsuitable return on investment	10	Material restrictions
2	Too expensive initially	11	Bureaucratic restrictions
3	Cash flow prevents implementation	14	Lack of staff for analysis and/or implementation
4	Unacceptable operating charges	15	Not worthwhile
5	Impractical	16	Disagree
6	Process and/or equipment changes	17	Risk or inconvenience to personnel
7	Facility change	18	Suspected risk or problem with equipment or product
8	Personnel changes	19	Rejected after implementation failed
9	Production schedule changes	22	Other

If the recommendation will not be implemented please provide detailed reasoning why:

____

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Additional Comments:

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AR #7
Recommendation name: Install Energy Efficient Exit Sign Bulbs

Implementation status (please circle one):
Was completely implemented as of the following date:
Will be implemented by the following date:
Will not be implemented

If the recommendation has been or will be implemented, please estimate:

Implementation cost: ____
Savings, if different from estimated above: ____________________________________

If the recommendation will not be implemented please choose a reason and provide further explanation below:

Code	Reason	Code	Reason
1	Unsuitable return on investment	10	Material restrictions
2	Too expensive initially	11	Bureaucratic restrictions
3	Cash flow prevents implementation	14	Lack of staff for analysis and/or implementation
4	Unacceptable operating charges	15	Not worthwhile
5	Impractical	16	Disagree
6	Process and/or equipment changes	17	Risk or inconvenience to personnel
7	Facility change	18	Suspected risk or problem with equipment or product
8	Personnel changes	19	Rejected after implementation failed
9	Production schedule changes	22	Other

If the recommendation will not be implemented please provide detailed reasoning why:

____
____

Additional Comments:

____
____
____

AR #8
Recommendation name: Insulate Pipes

Implementation status (please circle one):
Was completely implemented as of the following date:
Will be implemented by the following date:
Will not be implemented

If the recommendation has been or will be implemented, please estimate:

Implementation cost: ____
Savings, if different from estimated above: _________________________________

If the recommendation will not be implemented please choose a reason and provide further explanation below:

Code	Reason	Code	Reason
1	Unsuitable return on investment	10	Material restrictions
2	Too expensive initially	11	Bureaucratic restrictions
3	Cash flow prevents implementation	14	Lack of staff for analysis and/or implementation
4	Unacceptable operating charges	15	Not worthwhile
5	Impractical	16	Disagree
6	Process and/or equipment changes	17	Risk or inconvenience to personnel
7	Facility change	18	Suspected risk or problem with equipment or product
8	Personnel changes	19	Rejected after implementation failed
9	Production schedule changes	22	Other

If the recommendation will not be implemented please provide detailed reasoning why:

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Additional Comments:

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AR #9
Recommendation name: Install Occupancy Sensors on Vending Machines

Implementation status (please circle one):
- Was completely implemented as of the following date:
- Will be implemented by the following date:
- Will not be implemented

If the recommendation has been or will be implemented, please estimate:

Implementation cost: ____
Savings, if different from estimated above: ______________________________

If the recommendation will not be implemented please choose a reason and provide further explanation below:

Code	Reason	Code	Reason
1	Unsuitable return on investment	10	Material restrictions
2	Too expensive initially	11	Bureaucratic restrictions
3	Cash flow prevents implementation	14	Lack of staff for analysis and/or implementation
4	Unacceptable operating charges	15	Not worthwhile
5	Impractical	16	Disagree
6	Process and/or equipment changes	17	Risk or inconvenience to personnel
7	Facility change	18	Suspected risk or problem with equipment or product
8	Personnel changes	19	Rejected after implementation failed
9	Production schedule changes	22	Other

If the recommendation will not be implemented please provide detailed reasoning why:

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Additional Comments:

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AR #10
Recommendation name: Replace CRT Computer Monitors with LCD

Implementation status (please circle one):
Was completely implemented as of the following date:
Will be implemented by the following date:
Will not be implemented

If the recommendation has been or will be implemented, please estimate:

Implementation cost: ____
Savings, if different from estimated above: ______________________________

If the recommendation will not be implemented please choose a reason and provide further explanation below:

Code	Reason	Code	Reason
1	Unsuitable return on investment	10	Material restrictions
2	Too expensive initially	11	Bureaucratic restrictions
3	Cash flow prevents implementation	14	Lack of staff for analysis and/or implementation
4	Unacceptable operating charges	15	Not worthwhile
5	Impractical	16	Disagree
6	Process and/or equipment changes	17	Risk or inconvenience to personnel
7	Facility change	18	Suspected risk or problem with equipment or product
8	Personnel changes	19	Rejected after implementation failed
9	Production schedule changes	22	Other

If the recommendation will not be implemented please provide detailed reasoning why:

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Additional Comments:

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AC #1
Recommendation name: Install More Efficient Task Lighting

Implementation status (please circle one):
Was completely implemented as of the following date:
Will be implemented by the following date:
Will not be implemented

If the recommendation has been or will be implemented, please estimate:

Implementation cost: ____
Savings, if different from estimated above: ______________________________

If the recommendation will not be implemented please choose a reason and provide further explanation below:

Code	Reason	Code	Reason
1	Unsuitable return on investment	10	Material restrictions
2	Too expensive initially	11	Bureaucratic restrictions
3	Cash flow prevents implementation	14	Lack of staff for analysis and/or implementation
4	Unacceptable operating charges	15	Not worthwhile
5	Impractical	16	Disagree
6	Process and/or equipment changes	17	Risk or inconvenience to personnel
7	Facility change	18	Suspected risk or problem with equipment or product
8	Personnel changes	19	Rejected after implementation failed
9	Production schedule changes	22	Other

If the recommendation will not be implemented please provide detailed reasoning why:

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Additional Comments:

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