

FACILITY ENERGY SURVEY

by

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A Research Paper

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ABSTRACT

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Company XYZ assembles electronic industrial products in an 89,000 square foot building. The assembly area is a temperature-controlled environment. In an effort to establish a means of reducing the overall energy use throughout the facility this report will evaluate various energy usages throughout the facility.

The type of audit performed was a walk-through audit. An initial walk through was performed to document the areas of high-energy consumers. The information compiled during the audit was then analyzed for potential savings and if possible an estimated payback time was calculated. Overall, the report addresses a variety of areas such as lighting, heating, ventilation, air-conditioning, hot water heating, compressors and others in which Company XYZ can save energy and ultimately reduce their energy cost. Some areas may provide minimal savings but others may provide substantial return on investments.

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Chapter 1

Statement of the Problem

Purpose

The purpose of this research is to analyze the energy consumption within the facility of XYZ Company located in Eau Claire, WI. This energy audit will provide detailed calculations of XYZ Company's current consumption potential savings.

Objective

- Analyze various areas with significant energy consumption at the XYZ facility.
- Provide specific areas in which XYZ can reduce their energy consumption.

Facility Overview

Company XYZ covers approximately 89,000 square feet of building. The breakdown of the area is as follow:

<u>Area</u>	<u>Square footage</u>
Office/Conference/Cafeteria	9,000
Warehouse/Assembly/Dock	80,000

The initial 42,000 square foot building was constructed in 1994. Three years later an additional 47,000 square foot addition was constructed. The office building is a concrete block structure, and the factory is a steel structure. The building envelop is well insulated and in excellent condition. The assembly operation is considered to be light industrial.

Limitations

There are several ways of performing an energy audit. By choosing to use a mixture between functional and process audit, we are not considering the energy used per unit of production. In future audits it would be beneficial to add this to the objective. The major limitation throughout the audit was tooling. Items such as an infra red camera to determine heat given off by equipment or escaping from building were not used. The cost associated with the equipment could not be justified so the study was limited to in house resources and the knowledge from within the company. The study is not intended for companies other than XYZ, since the information contained within the study comes from data accumulated from XYZ Company.

Chapter 2

Literature Review

Historical

The term energy audit was first used in the Federal Register vol. 42, no. 25, June 29, 1977, dealing with Energy Audit Procedures (Thurmann 1979). The Federal Register defined Energy Audit as: “an energy audit serves to identify all of the energy streams into a facility and to quantify energy use according to discrete functions (Thumann 1979).” In simpler terms, an energy audit is defined as: “an energy audit serves the purpose of identifying where a building or plant facility uses energy and identifies energy conservation opportunities” (Thurmann 1979).

In an effort to get the message of conserving energy out to each state, the Federal Register set guidelines for all the states, which they need to follow in order to receive financial assistance. For each State Energy Office to qualify for financial assistance they needed to submit a Supplemental State Energy Conservation Program (SSEP) which encompasses the following: (Thumann 1979).

- a) ongoing public education effort consisting of ways to implement Energy conservation measures.
- b) Insuring effective inter-governmental conditions
- c) Encouraging and carrying out energy audits for building and industrial plants.

Classes of Energy Audit

Energy Audit section 420. 104 © (s) of the Federal Register specifies that the minimum eligibility required for financial assistance is that states offer mini-energy audits described as Class A Energy Audits. Two additional classes of audits are the “Do-it-yourself” Energy Audits

(Class C audits) and the Class B audit which is an information audit. (Thumann 1979). Each of the Classes listed below will meet the guidelines set forth by the Federal Register.

- Class A a site visit, by an auditor and an auditor's evaluation.
- Class B through a questionnaire, which the building owner completes. The questionnaire is then evaluated by the state.
- Class C completed by building owner with the help of a "do-it-yourself" Work book.

Types of Audits

According to Thurman (1979) there are three types of energy audits within each class. Depending on the nature of the energy audit to be performed one may choose to use any of the following types of audits.

The first type is the functional audit. This audit determines the amount of energy required for a particular function and identifies energy conservation opportunities which include HVAC, lighting, and domestic hot water.

The second type is a Process audit. This audit determines the amount of energy required for each process function and identifies energy conservation opportunities, which include process machinery, HVAC, furnaces, etc.

The third type is the Utility audit. This audit basically analyzes the monthly, daily and yearly energy usage for each utility.

To reduce costs to the minimum, management's energy conservation plan must involve every member of the organization. A diverse team would consist of members from the Plant Manger to the Supervision and the workforce.

The roles of the project team according to Thurman (1979), at a minimum, are as follows:

Roles of Energy Project Team

Plant Manager

Responsible for ensuring that appropriate facility study are conducted, that the needed resources are provided of that satisfactory sustained results are achieved.

Engineer

Identification and development of practical ways in which energy can be saved will be, in the final analysis, primarily an engineering function.

Supervision and the work force

This group is the closest to the use of energy. The members of this group know and understand the equipment and system more than do others. Therefore it is not uncommon that the most productive energy conservation ideas and initiatives comes from this group.

Outside Resources

Energy consultant's can usually increase the effectiveness of an Energy audit.

Equipment Vendors

Vendors know the equipment capability and it would be difficult for the plant energy study to be successful without their assistance and participation.

Energy Records

One should obtain the entire years worth of energy consumption. An evaluation on the seasonal differences and trends in energy consumption should be taken into consideration. One of the key elements of an energy management program is the collection of energy cost and consumption information. Precise records also must be kept as the program develops such as the meetings held, projects initiated and all other activities falling within the scope of the program (Smith 1979). According to Griffin (1974), “Conservation of energy at the individual user's level presents an opportunity to decrease energy expenditures and reduce operating expenses while efforts are made to preserve our fast depleting resources.”

Smith (1979) states plotting the rate of energy consumption per unit of production for a portion of a facility or an entire plant is essential in gauging the effectiveness of a program over a period of time (same production level in next year). Energy audit processes must be carried out accurately enough to identify and qualify the energy and cost savings that are likely to be realized through investments in an energy savings measure (Thumann 1979).

An Energy Conservation team will determine which audit is best suited for the particular facility. The information that is available initially is one of the main factors that determine the type of audit to be performed. From the outset of the project it is important to assemble a team that covers all areas within and outside of the facility. Energy audits can prove to be very beneficial for all types of business from health care facility to a high tech manufacturing facility.

Chapter 3

Research Methodology

The research methodology used for the facility energy audit included literature review, the use of function and process audits, and the analysis of the information obtained during the audit.

The objective of the research is to:

- Analyze various areas with significant energy consumption at the XYZ facility.
- Provide specific areas in which XYZ can reduce their energy consumption.

The literature review was the initial phase in the research. The literature review clearly defines three types of energy audits, which can be performed. The three types of energy audits are functional, process and utility audits. The literature review sets the parameters for each type and where it can be used.

The second phase of the research consisted of an analysis of possible energy savings within the XYZ facility. The analysis consists of overall Kw/hour savings as well as annual energy savings. For each area analyzed a spreadsheet is used to show the formula and how the final numbers were calculated.

Recommendations were derived from analyzing the results and estimating which of the researched items could be done with minimal capital cost. The remaining areas could be phased in over a period of time for as the capital budget concerns.

Chapter 4

The Study

XYZ Company OPPORTUNITIES SUMMARY TABLE

Opportunity Description	kWh Savings	KW Savings	Therm Savings	Annual Energy Cost Savings	Simple Payback* (estimated years)
1.0 Reduce compressed air generation pressure	5,539		0	\$310	Immediate
2.0 Replace air powered equipment with electric driven	2122		0	\$119	~2
3.0 Manufacturing lighting retrofit (metal halide to fluorescent)	297,024	48	0	\$16,633	3
4.0 Turn off metal halide lighting in 1997 building	119,691	19	0	\$6,703	Immediate
5.0 Upgrade 4' T12 lighting to 4' T8 lighting	3,005		0	\$168	7
6.0 Consider Occupancy Sensors in Conf Rm and Restrooms	9,810		0	\$549	1.5
7.0 Upgrade 90W floods to 15W CFL by employee PC station	2,340		0	\$131	.3
8.0 Continue LED exit light retrofit	1,202		0	\$67	1.4
9.0 Replace older 15 hp motor with high efficiency 15 hp motor	1,265		0	\$71	Immediate
10.0 Consider use of weekend & night setback for electric entry heaters	4,053		0	\$227	.5
11.0 Programmable thermostat for loading dock area	0		119	\$54	1
12.0 Programmable thermostats for manufacturing area	294,031	47	1,048	\$16,937	<1
13.0 Seal air leaks around overhead doors by dock area	0		188	\$84	<1
14.0 Electric consumption information for office equipment	18,615		0	\$1,042	Immediate
15.0 Convert electric water heaters to natural gas	6,337	5	(351)	\$215	3.5
TOTALS	765,034	119	1004	\$43,310.00	

* Simple paybacks are based on material estimates with no labor used in the calculations

UTILITY BILL ANALYSIS:

Utility total consumption for the year 2000-01 is as follows:

Electric: 2,004,390 kWh

Gas: 15,235 therms

Utility total costs for the year 2000-01 are as follows:

Electric: \$108,538

Total cost per kWh is \$0.056

Gas: \$12,803

Total cost per therm is \$0.62*

* For savings calculations a figure of \$0.40/therm was used instead of the \$0.62/therm identified since this would be the rate at which the facility would be charged when the energy savings are implemented.

Summary of Energy Saving Opportunities

1.0 Compressed Air Pressure Reduction:

During the survey, 112 psi was the air pressure being provided by the fifteen hp compressor. The air tools used throughout the plant require approximately 80 to 90 psi to operate and machine controls normally require similar pressures to function properly. Since producing compressed air is a very inefficient process, substantial savings can be realized by running systems at the minimum pressure required for the tooling.

Estimated Potential Savings: \$856.00 per year for the compressed air system, see chart page 25

2.0 Replace air powered equipment with electric driven:

As mentioned above, producing compressed air is a very inefficient process (ie. 90% of energy is lost to heat). Energy savings can be realized by running equipment with electric drives instead of air. It should be cautioned that not all applications would work with this option. For instance, electric tools can have less precise torque control, shorter lives, and lack the safety features of air-powered equipment.

Estimated Potential Savings: \$119.00 per year, see chart page 26

3.0 Manufacturing lighting retrofit:

400 W HID metal halide fixtures provide lighting throughout the manufacturing plant. This type of lighting has been the primary lighting option for a manufacturing setting for the past decade. In recent years, a new lighting fixture incorporating fluorescent lighting has been designed to replace HID lighting. This fixture allows for instant on/off, extended lamp life, and better lumen quality as well as higher efficiency.

Estimated Potential Savings: \$16,633.00 per year, see chart page 27

4.0 Turn off metal halide lighting in 1997 building:

It was noted during the survey that the 1997 building has very little occupancy after 3:00pm. In an effort to save electricity, it was felt that this area could have the lighting reduced to a minimum. A 110-fixture shutdown was used to estimate the savings. There are a total of 120 fixtures, but it was felt some lamps would need to be left on for safety reasons. This would require some additional wiring and control.

Estimated Potential Savings: \$6,703.00 per year, see chart page 28

5.0 Upgrade 4' T12 lighting to 4' T8 lighting:

The survey revealed some T-12 magnetic ballast lighting throughout the facility. Currently, the most energy efficient fluorescent lighting source is T-8 electronic ballast technology. This type of fluorescent fixture uses nearly 20% less energy while providing more light output than the T-12 predecessor. Many T-8's also have useful life expectancies of nearly 10,000 hours, which is almost 8 times that of a normal T-12 lamp. Additional benefits of T-8 technology include: higher quality of light, cooler operating temperatures, more disposal options, and higher lumen levels.

Estimated Potential Savings: \$168.00 per year for (30) two-lamp, four-foot fixtures, see chart page 29 and 30

6.0 Consider Occupancy Sensors in Conference Room(s) and Restrooms:

Often times, areas like this have infrequent use. By incorporating sensors to control the lighting, you can take full advantage of savings opportunities as compared to manual operation. The sensors are relatively inexpensive and are quite easy to install.

Estimated Potential Savings: \$549.00 per year, see chart page 31

7.0 Upgrade 90W floods to 15W CFL by employee room pc station:

CFL or compact fluorescent lighting is the primary replacement for incandescent lighting both in a residential setting and in commercial and industrial applications. Their low energy requirement and long life make them an excellent choice for areas that are hard to reach or have extended run times.

Estimated Potential Savings: \$131.00 per year, see chart page 32

8.0 LED Exit Light Retrofit:

The facility currently has a number of exit lamps located throughout the building. Most fixtures are LED with a few fluorescent/incandescent fixtures mixed in. LED technology uses very little electricity to provide a bright and safe exit lamp. The LED lamp is also very reliable, so much in fact that many manufacturers offer 25-50 year limited warranties on lamp failure. LED technology is the lamp of choice for all new construction and remodeling applications. The technology comes in a variety of options including retrofit packages that fit into existing fixtures or outright fixture replacement.

Estimated Potential Savings: \$93.00 per year based on 4 fixtures replaced, see page 33

9.0 Premium Efficiency Motors:

At XYZ Company, many electric motors are being used to operate manufacturing equipment. Motors run everything from the compressed air system to the dust collection unit. As part of normal operations and maintenance, the plant should consider purchasing only premium efficiency motors when replacement is necessary. Premium efficiency motors cost slightly more than energy efficient motors; however, they pay for themselves in a relatively short period of time through electrical savings.

Estimated Potential Savings: \$71.00 per year for each 15-hp motor at 3000 EFLH (estimated Full Load Hours), see chart page 34

10.0 Consider use of weekend & night setback for electric entry heaters:

Left unchecked, a facility electric heating system in vestibules can cost a company tremendous amounts of money. Installing electronic controls can dramatically reduce overall consumption. Some of the heating units are controlled manually and if this were done on a regular basis the savings identified wouldn't be as high as listed below.

Estimated Potential Savings: \$71.00 per year, see chart page 35

11.0 Programmable thermostat for loading dock area:

During the survey, it was observed that the loading dock thermostat was set at 75 degree F with no setback options. Normally, 75F would be quite high for this area and 68F would probably be sufficient. However, it was determined that a water line runs through the area. One should proceed with caution, for this particular project to avoid below freezing temperatures in the area of the water line..

Estimated Potential Savings: \$48.00 per year, see chart page 36

12.0 Programmable thermostats for manufacturing area:

Incorporating a stringent manual control option or installing electronic controls can dramatically reduce overall consumption. A simple PLC could control everything from the HVAC units to the lighting system. It would be a good place to showcase the capabilities of the equipment manufactured at the facility not to mention reduce operational expenses. If any of the heating units were being controlled manually the savings identified below wouldn't be as high as listed.

Estimated Potential Savings: \$16,885.00 per year, see chart page 37

13.0 Seal air leaks around overhead doors by dock area:

Dock doors are notorious for having leaks. The loading area at XYZ Company was in very good shape, however some leaks did surface. Once again, the savings for this option are quite low,

but it could improve comfort for the area, and also allow for thermostat turn down as mentioned in option # 12.

Estimated Potential Savings: \$75.00 per year, see chart page 38

14.0 Electric consumption information for office equipment:

The following data was obtained from APS home page, APS.com, regarding office equipment.

The calculations were an aggregation of all office equipment.

Computers, printers, fax machines and copiers consume energy even while they are not in use.

The following table provides a summary of typical electrical power requirements and annual energy use for common office equipment. The table compares the annual energy cost of equipment that is turned off at night and over the weekends and equipment that is left on around the clock.

Table 1

Typical Power Requirements and Energy Use of Office Equipment

Equipment	Typical Power Requirements (Watts)	Annual Energy Cost – Off at Night	Annual Energy Cost – On 24 Hours/Day
Computer	55	\$9	\$39
Monitor (15")	75	\$12	\$54
Laser Printer	60	\$14	\$44
Fax Machine	35	\$9	\$27
Copier (small)	115	\$30	\$83
Copier (large)	310	\$80	\$224

Estimated Potential Savings: \$1,042.00 per year for all office equipment except the fax machines, see chart page 39

In addition, Energy-efficient office equipment has been developed and promoted through a partnership between the U.S. Environmental Protection Agency (EPA) and the office equipment manufacturing industry. The Energy Star Office Equipment Program promotes and labels energy-efficient computers, monitors, printers, fax machines, scanners, copiers and multi-

function devices. This energy-efficient equipment automatically powers down when not used for a period of time and can be recognized by looking for the familiar Energy Star label. With Energy Star equipment, energy use can be reduced by 50 percent or more. This also helps reduce the load on air conditioning equipment and it helps to protect the environment. The power management features of different types of office equipment are summarized below.

Table 2

Energy Cost Savings with Energy Star Office Equipment

Equipment	Annual Energy Cost Savings – Off at Night	Annual Energy Cost Savings – On 24 Hours
Computer	\$2	\$20
Monitor (15")	\$4	\$40
Laser Printer	\$4	\$25
Fax Machine	\$3	\$15
Copier (small)	--	\$50
Copier (large)	--	\$140

15.0 Convert electric water heaters to natural gas:

Generally speaking, natural gas water heaters are far more cost effective to operate than standard electric units. Based on the information provided, it may make sense to change the two units if natural gas lines are available at the specified locations.

Table 3

Water Heater: Natural Gas v. Electricity			
Natural Gas	Electricity	Price per kilowatt-hour	Yearly Cost
Price per therm	Yearly Cost	\$0.04	\$195
\$0.40	\$108	\$0.06	\$293
\$0.50	\$136	\$0.08	\$390
\$0.60	\$163		

*40 gallon water heater example

Tankless water heater option:

Also called demand water heaters, these provide hot water right where it is needed, when needed, without a storage tank. Using electricity, gas, or propane as a heat source, tankless water heaters, in some cases, can cut water-heating bills by 10 to 20 percent. The savings come from eliminating standby losses - energy wasted by heating unused water in a tank.

A tankless water heater can supplement a regular water heater in a distant location, or it can be used for all hot water needs. However, they are not appropriate for all applications and sometimes they won't save much energy or money when compared to the increased cost of the equipment. Equipment life may be longer than tank-type heaters because they are less subject to corrosion. Expected life of tankless water heaters is 20 years, compared to 10 to 15 years for tank-type water heaters. Tankless water heaters range in price from \$200 for a small under-sink unit up to \$1000 for a gas-fired unit that delivers 5 gallons per minute. Typically, the more hot water the unit produces, the higher the cost. Tankless gas water heaters require a direct vent or conventional flue if gas fueled.

Estimated Potential Savings: \$215.00 per year if both units are replaced, see chart on p. 40

Other Items Considered During the Energy Survey:

Manufacturing Equipment Scheduling:

In an effort to control electrical consumption, XYZ Company could consider using electronic controls to schedule startup and shut down of critical high-energy using equipment including the (5) mold presses and (12) burn-in ovens. By programming start-up over time, there may be opportunities to decrease overall kWh consumption, however at this time it is unknown as to how that would affect production.

Compressed Air Leak Repair:

Compressed air is considered industry's fourth utility, but it is seldom considered as a contributing cost of production. Inefficiencies in a compressed air system can secretly cost a business thousands of dollars.

XYZ Company currently uses (2) fifteen horsepower screw compressor(s) for all the compressed air requirements. Normal operation for a compressor is 95% capacity however; at times the compressor may run continually.

A fairly inexpensive way to improve the efficiency of a compressed air system is to schedule and conduct routine leak checks and maintenance. Also, complete mapping of the compressed air lines can provide a good visual diagram and point out any leaks that occur in the system. Leak detection, leak repair won't totally eliminate inefficiencies but will help to control them.

Although there were no leaks in the system, the associated savings calculations are based on a single leak that is left undetected throughout a full year of operation.

Continue Yearly Coil Cleaning of RTU's:

Roof top units require special care to operate at the highest efficiency. If left unattended, these units can quickly deteriorate in efficiency. Continued regular maintenance inspection and annual

coil cleaning will ensure proper operating and provide for the highest achievable efficiency.

Efficiency of a RTU can degrade by up to 20% if left unchecked over time.

Electronic Control or Fast Track Loading Dock Door:

At this point, savings for this project would be minimal based on the number of times the door would be left open vs. closed.

Coffee Machine Control:

Most commercial grade coffee machines have a 1000 W element to warm the water and keep it hot. Often, these units are on continuously, by leasing a machine that uses a thermally insulated pot; the 1000 W draw could be reduced substantially.

**FACT SHEETS ASSOCIATED WITH ENERGY SAVING
OPPORTUNITIES IDENTIFIED**

1.0 Reduce Compressed Air Generation Pressure

Assumptions		Comments
Facility operating hours		
<i>hours per day</i>	18	provided
<i>days per week</i>	5	provided
<i>weeks per year</i>	52	provided
Compressor #1		
<i>Compressor #1 horsepower</i>	15	observed
<i>Present idle time for compressor #1 (% of facility hours)</i>	10	observed
<i>Average load during idle time as a percent of the compressor horsepower (%)</i>	20	assuming sump blowdown
<i>Present loaded time for compressor #1 (% of facility hours)</i>	90	observed
<i>Average load during run time as a percent of the compressor horsepower (%)</i>	95	assumed average due to modulation
<i>Time compressor is operating as a percent of facility hours</i>	50	observed
Compressor #2		
<i>Compressor #1 horsepower</i>	15	observed
<i>Present idle time for compressor #2 (% of facility hours)</i>	10	observed
<i>Average load during idle time as a percent of the compressor horsepower (%)</i>	20	assuming sump blowdown
<i>Present loaded time for compressor #2 (% of facility hours)</i>	90	observed
<i>Average load during run time as a percent of the compressor horsepower (%)</i>	95	assumed average due to modulation
<i>Time compressor is operating as a percent of facility hours</i>	50	observed
<i>Compressor generation pressure at present (psig)</i>	112	assumed avg. based on observed pressure
<i>Minimum compressor generation pressure reasonable (psig)</i>	90	minimum psig needed to run equipment
<i>Motor efficiency(ies):</i>	91	assumed for all motors
<i>% savings/2 psi pressure reduction</i>	1	typical
<i>Electricity cost (\$/kWh)</i>	\$0.056	average from electric bill summary
Calculations		
<i>Estimate the facility operating hours per year ((hr/d)*(d/wk)*(wk/yr)=</i>	4,680	hours
<i>Estimate the energy to operate compressor #1 at present ((idle hp)*(% time idle)+(loaded hp)*(% time loaded))*(0.746 kW/hp)*(facility operating hours) *(% of facility hours compressor is operating/100)*(1/motor eff)=</i>	25,178	kWh per year
<i>Estimate the energy to operate compressor #2 at present ((idle hp)*(% time idle)+(loaded hp)*(% time loaded))*(0.746 kW/hp)*(facility operating hours) *(% of facility hours compressor is operating/100)*(1/motor eff)=</i>	25,178	kWh per year
<i>Estimate the total compressor energy consumed (compressor #1 energy consumed+compressor #2 energy consumed)=</i>	50,355	kWh per year
<i>Estimate the energy savings from pressure reduction (total compressor energy consumed)*(typical % reduction/2 psi pressure reduction)=</i>	5,539	kWh per year
<i>Estimate the annual energy cost savings (energy savings)*(electricity \$/kWh)=</i>	\$310	total savings per year

2.0 Replace Air Powered Equipment with Electric Driven Versions Where Possible

Assumptions	Comments	
Facility operating hours		
<i>average hours per day</i>	18	provided
<i>days per week</i>	5	provided
<i>weeks per year</i>	52	provided
Data on existing air powered tools		
<i>Basis number of equipment requiring compressed air</i>	2	per work station
<i>Existing motor horsepower (hp)</i>	0.13	1/8 horsepower
<i>Air powered equipment motor efficiency (%)</i>	16	estimated
<i>Time tools are used as % of facility hours (%)</i>	50	estimated
Data on electrical tools		
<i>Number of tools to be replaced</i>	2	per work station
<i>Replacement electric motor (hp)</i>	0.13	equivalent replacement
<i>Electric motor efficiency (%)</i>	75	estimated
<i>Estimated cost of electricity (\$/kWh)</i>	\$0.056	average from electric bills
Calculations		
<i>Estimate the facility operating hours per year (hr/d)*(d/wk)*(wk/yr)=</i>	4,680	hours
<i>Estimate the energy required to operate the air powered tools (hp)*(0.746 kW/hp)*(1/(motor effic./100))*(facility operating hours)*(% operation/100)*(# of tools)=</i>	2,728	kWh/yr
<i>Estimate the energy consumed by the electric tools (hp)*(0.746 kW/hp)*(1/(motor effic./100))*(facility operating hours)*(% operation/100)*(# of tools)=</i>	605	kWh/yr
<i>Estimate energy savings (air powered tool energy consumption-electric tool energy consumption)=</i>	2,122	kWh/yr
<i>Estimate the energy cost savings (energy savings)*(electrical \$/kWh)=</i>	\$119	dollar savings per year

3.0 Manufacturing Lighting Retrofit

Assumptions	Comments
Facility operating hours	
<i>hours per day</i>	20
<i>days per week</i>	5
<i>weeks per year</i>	52
Data on existing metal halide lamps and fixtures	
<i>Number of lamps per fixture</i>	1
<i>Watts per lamp</i>	400
<i>Power consumption per fixture (watts)</i>	465
<i>Number of fixtures (basis for savings)</i>	240
<i>Ballast</i>	magnetic
Data on replacement pulse start metal halide lamps and fixtures	
<i>Number of lamps per fixture</i>	1
<i>Watts per lamp</i>	200
<i>Power consumption per fixture (watts)</i>	227
<i>Number of fixtures (basis for savings)</i>	240
<i>Ballast</i>	electronic
Electricity cost (\$/kWh)	\$0.056
Calculations	
Estimate total hours of operation (hr/d)*(d/wk)*(wk/yr)=	5,200
Estimate energy consumption for existing metal halide fixtures (# watts/fixture)*(# fixtures)*(1 kW/1,000 watts)*(facility hours)=	580,320
Estimate energy consumption for pulse start metal halide fixtures (# watts/fixture)*(# fixtures)*(1 kW/1,000 watts)*(facility hours)=	283,296
Estimate energy savings (metal halide consumption-pulse start metal halide consumption)=	297,024
Estimate the energy cost savings (energy savings)*(electrical \$/kWh)=	\$16,633

4.0 Turn Off Metal Halide Lighting in 1997 Building (110 fixtures)

Assumptions		Comments
Facility operating hours		
<i>hours per day</i>	20	provided
<i>days per week</i>	5	provided
<i>weeks per year</i>	52	provided
Data on existing metal halide lighting		
<i>Number of lamps per fixture</i>	1	observed
<i>Watts per lamp</i>	400	observed
<i>Power consumption per fixture (watts)</i>	465	observed
<i>Number of fixtures to be turned off (basis for savings)</i>	110	observed
<i>Ballast</i>	magnetic	typical
Time 1997 Bld is used as a percent of facility operating hours	55	operation during use hours only
Electricity cost (\$/kWh)	\$0.056	average from electric bills
Calculations		
Estimate total hours of operation (hr/d)*(d/wk)*(wk/yr)=	5,200	hours
Estimate energy consumption for metal halide lighting operating while not needed (# watts consumed/fixture)*(# fixtures)*(1 kW/1,000 watts)*(facility hours)=	265,980	kWh/yr
Estimate energy consumption for metal halide lights operating only when building is in use (# watts consumed/fixture)*(# fixtures)*(1 kW/1,000 watts)*(facility hours)*(% building use/100)=	146,289	kWh/yr
Estimate energy savings (total consumption -consumption during use times)=	119,691	kWh/yr
Estimate the energy cost savings (energy savings)*(electrical \$/kWh)=	\$6,703	dollar savings per year
Total of 120 fixtures but assuming 10 would be left on for safety reasons		

5.0 Upgrade 4' T12 Lighting to 4' T8 Lighting

Assumptions		Comments
Facility operating hours		
<i>hours per day</i>	18	provided
<i>days per week</i>	5	provided
<i>weeks per year</i>	52	provided
Data on existing T12 fixtures and lamps		
<i>Number of lamps per fixture</i>	2	observed
<i>Watts per lamp</i>	34	observed
<i>Number of fixtures (basis for savings)</i>	50	estimated
<i>Power consumption per fixture (watts)</i>	77	actual
<i>Ballast</i>	magnetic	typical
Data on replacement T8 lamps and fixtures		
<i>Number of lamps per fixture</i>	2	observed
<i>Watts per lamp</i>	32	observed
<i>Number of fixtures (basis for savings)</i>	50	estimated
<i>Power consumption per fixture (watts)</i>	64	est. for single 2-lamp ballasts
<i>Ballast</i>	electronic	typical
Electricity cost (\$/kWh)	\$0.056	average from electric bills
Calculations		
Estimate total hours of operation (hr/d)*(d/wk)*(wk/yr)=	4,680	hours
Estimate energy consumption for T12 fixtures (# watts consumed/fixture)*(# fixtures)*(1 kW/1,000 watts)*(facility hours)=	17,981	kWh/yr
Estimate energy consumption for T8 fixtures (# watts consumed/fixture)*(# fixtures)*(1 kW/1,000 watts)*(facility hours)=	14,976	kWh/yr
Estimate energy savings (T12 consumption-T8 consumption)=	3,005	kWh/yr
Estimate the energy cost savings (energy savings)*(electrical \$/kWh)=	\$168	dollar savings per year

XYZ Company Guide to Energy Efficient Fluorescent Lighting

Lighting	Existing Wattage	Lum / Fix.*	Lighting	Proposed Wattage	Lumens / Fix.	Op. Hrs. / Yr.	Annual kWh Savings per fixture	Annual Savings per fixture	Lumen Output % of existing fixture
4-lamp 2' 20W T12 w/magnetic ballast	84	4,960	4-lamp 2' 17W T8 w/electronic ballast	62	5400	2,340	51	\$2.88	109%
2-lamp 3' 30W T12 w/magnetic ballast	75	4,400	2-lamp 3' 25W T8 w/electronic ballast	48	4300	2,340	63	\$3.54	98%
1-lamp 4' 34W T12 w/magnetic ballast	50	2,700	1-lamp 4' 32W T8 w/electronic ballast	31	2900	2,340	44	\$2.49	107%
2-lamp 4' 40W T12 w/magnetic ballast	86	6100	2-lamp 4' 32W T8 w/electronic ballast	61	5800	2340	59	\$3.28	95%
4-lamp 4' 34W T12 w/magnetic ballast	160	10800	4-lamp 4' 32W T8 w/electronic ballast	110	11600	2340	117	\$6.55	107%
1-lamp 8' 75W T12 w/magnetic ballast	100	6100	1-lamp 8' 56W T8 w/electronic ballast	73	5800	2340	63	\$3.54	95%
2-lamp 8' 60W T12 w/magnetic ballast	138	10800	2-lamp 8' 56W T8 w/electronic ballast	118	11600	2340	47	\$2.62	107%
4-lamp 8' 60W T12 w/magnetic ballast	276	21600	4-lamp 8' 56W T8 w/electronic ballast	236	23200	2340	94	\$5.24	107%

Average cost per kWh:	\$0.0560
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6.0 Consider Occupancy Sensors in the Conf. Rooms and Restrooms

Assumptions		Comments
Facility operating hours		
<i>hours per day</i>	18	provided
<i>days per week</i>	5	provided
<i>weeks per year</i>	52	assumed
Data on existing fluorescent lighting		
<i>Number of lamps per fixture</i>	2	Conf Rm have 3 lamps
<i>Watts per lamp</i>	34	T12 lighting observed
<i>Power consumption per fixture (watts)</i>	77	actual
<i>Number of fixtures (basis for savings)</i>	35	observed
<i>Ballast</i>	magnetic	typical
Operating time with occupancy sensors installed (hr/d)		
	4	assumed
Electricity cost (\$/kWh)	\$0.056	from electric bills
Calculations		
Estimate total hours of operation		
$(\text{hr/d}) * (\text{d/wk}) * (\text{wk/yr}) =$	4,680	assumed from above
Estimate energy consumption for T8 lighting at present		
$((\# \text{ watts/fixture}) * (\# \text{ fixtures}) * (1 \text{ kW}/1,000 \text{ watts}) * (\text{facility hours}) =$	12,613	kWh/yr
Estimate energy consumption for lighting with occupancy sensors		
$(\# \text{ watts/fixture}) * (\# \text{ fixtures}) * (1 \text{ kW}/1,000 \text{ watts}) * (\text{op. hr/d with occupancy sensors}) * (\text{d/wk}) * (\text{wk/yr}) =$	2,803	kWh/yr
Estimate the energy savings		
$(\text{consumption at present} - \text{consumption with occupancy sensors}) =$	9,810	kWh/yr
Estimate the energy cost savings		
$(\text{energy savings}) * (\text{electrical cost/kWh}) =$	\$549	dollar savings per year

7.0 Upgrade 90-watt Incandescent Floods to 15 -watt Compact Fluorescent Lights (PC lunchroom)

Assumptions		Comments
Facility operating hours		
<i>Hours per day</i>	20	provided
<i>days per week</i>	5	provided
<i>weeks per year</i>	52	provided
Data on existing incandescent bulbs		
<i>Number of lamps per fixture</i>	1	observed
<i>Watts per bulb</i>	90	observed
<i>Number of bulbs (basis for savings)</i>	6	observed
<i>Power consumption per fixture (watts)</i>	90	calculated
Data on replacement compact fluorescent lamps (screw in type, electronic ballast)		
<i>Number of lamps per fixture</i>	1	observed
<i>Power consumption per compact fluorescent lamp</i>	15	observed
<i>Number of fixtures (basis for savings)</i>	6	observed
<i>Electricity cost (\$/kWh)</i>	\$0.056	avg. from electric bills
Calculations		
Estimate total hours of operation (hr/d)*(d/wk)*(wk/yr)=	5,200	annual hours
Estimate energy consumption for incandescent bulbs (# watts/fixture)*(# fixtures)*(1 kW/1,000 watts)*(facility op. hours)=	2,808	kWh per year
Estimate energy consumption for compact fluorescent fixtures (watts/fixture)*(# fixtures)*(1 kW/1,000 watts)*(facility op. hours)=	468	kWh per year
Estimate the energy savings (energy consumed by incandescent bulbs-energy consumed by CFs)=	2,340	kWh per year
Estimate the energy cost savings (energy savings)*(\$/kWh)=	\$131	\$ per year

8.0 Continue LED Exit Light Retrofit

Assumptions	Comments
Exit sign operating hours	
<i>Hours per day</i>	24 typical
<i>days per week</i>	7 typical
<i>weeks per year</i>	52 typical
Data on existing incandescent exit sign	
<i>Number of lamps per sign</i>	2 observed
<i>Watts per lamp</i>	20 estimated
<i>Power consumption per sign (watts)</i>	40 calculated
<i>Number of fixtures (basis for savings)</i>	4 arbitrary
Data on LED exit sign	
<i>Number of lamps per sign</i>	2 observed
<i>Watts per lamp</i>	2.8 estimated
<i>Power consumption per sign (watts)</i>	5.6 calculated
<i>Number of fixtures (basis for savings)</i>	4 arbitrary
Estimated cost of electricity (\$/kWh)	\$0.056 2000 Bills
Calculations	
Estimate total hours of operation (hr/d)*(d/wk)*(wk/yr)=	8,736 hours
Estimate energy consumption for exit signs with incandescent bulbs (# watts/exit sign)*(# exit signs)*(1 kW/1,000 watts)*(operating hours)=	1,398 kWh/yr
Estimate energy consumption for LED operated exit signs (# watts/exit sign)*(# exit signs)*(1 kW/1,000 watts)*(operating hours)=	196 kWh/yr
Estimate energy savings (incandescent bulb consumption-LED consumption)=	1,202 kWh/yr
Estimate the energy cost savings (energy savings)*(electrical \$/kWh)=	\$67 dollar savings per year

9.0 Replace Older 15 hp Motor with High Efficiency 15 hp Motor example

Assumptions		Comments
Facility operating hours		
<i>hours per day</i>	18	provided
<i>days per week</i>	5	provided
<i>weeks per year</i>	52	provided
Data on existing 15 hp motor		
<i>Number of motors to be replaced (basis for study)</i>	1	assumed
<i>Motor horsepower</i>	15	observed
<i>Motor efficiency (%)</i>	89	arbitrary
<i>Operating time as a percent of facility operating hours (%)</i>	100	assumed
Data on replacement high efficiency motors		
<i>Number of replcement motors (basis for study)</i>	1	assumed
<i>Motor horsepower</i>	15	observed
<i>Motor efficiency (%)</i>	93	estimated
Electricity cost (\$/kWh)	\$0.056	est. from electric bills
Calculations		
Estimate total hours of operation (hr/d)*(d/wk)*(wk/yr)=	2,340	hours
Estimate energy consumption for the existing motor (# motors)*(motor hp)*(0.746 kW/hp)*(1/(motor effc)/100)*(% operation/100)*(facility hours)=	29,421	kWh/yr
Estimate energy consumption for the high efficiency motor (# motors)*(motor hp)*(0.746 kW/hp)*(1/(motor effc)/100)*(% operation/100)*(facility hours)=	28,155	kWh/yr
Estimate energy savings (existing motor consumption-high efficiency motor consumption)=	1,265	kWh/yr
Estimate the energy cost savings (energy savings)*(\$/kWh)=	\$71	dollar savings per year

10.0 Consider Use of Weekend Night Setback Controls For Electric Entry Heaters

Assumptions		Comments
Weekend & night setback hours possible		
<i>hours per day</i>	16	typical
<i>days per week</i>	7	typical
<i>weeks per year</i>	26	assuming 6-month winter
Winter conditions		
<i>Entry way daytime temperature setting (degrees F)</i>	68	observed
<i>Setback temperature (degrees F)</i>	55	assumed
<i>Average temperature outside (degrees F)</i>	35	estimated
<i>Night & Weekend Setback Hours</i>	84	assumed
Worst Case Electric Heating Cost For Entryway Heaters		
	\$500	assumed
Calculations		
Estimate the percent of time setback can be used $((\text{weekend setback hours per week}) * (\text{wk/yr})) / ((\text{winter hr/d}) * (\text{d/wk} * \text{wk/yr})) * 100 =$	75	percent
Estimate temperature difference 1 $(\text{present building temperature} - \text{average outside temperature}) =$	33	degrees F
Estimate temperature difference 2 $(\text{setback building temperature} - \text{average outside temperature}) =$	20	degrees F
Estimate energy savings using setback	4,053	kWh
Estimate energy cost savings using setback $(\text{winter heating bill}) * (\% \text{ time setback can be used} / 100) * ((\text{temperature difference 2}) / (\text{temperature difference 1})) =$	\$227	dollar savings per year

* Allows 4 hours for building to cool to setback temperature.

11.0 PROGRAMMABLE THERMOSTAT FOR LOADING DOCK AREA

This measure estimates the heating energy and related cost savings realized by temperature within the loading dock.

Assumptions:

500 therms, estimated annual therm consumption for space heating
 10 °F, average temperature drop during setback period
 212 days, duration of heating season
 8,900 HDD, degree days per heating season
 \$0.45 per therm, average cost of natural gas

ESTIMATED SAVINGS:

$$\left(\frac{10 \text{ } ^\circ\text{F} \times 212 \text{ days}}{8,900 \text{ HDD}} \right) \times 500 \text{ therms} = 119 \text{ therms saved}$$

$$119 \text{ therms} \times \$0.45 \text{ per therm} = \$54 \text{ Cost savings}$$

ESTIMATED COST:

One programmable thermostat \$50

SIMPLE PAYBACK:

$$\frac{\$50}{\$54} = \boxed{0.9 \text{ Years}}$$

12.0 PROGRAMMABLE THERMOSTATS FOR MANUFACTURING AREA

This measure estimates the energy and related cost savings realized by controlling temperature within the manufacturing area.

WINTER HEATINGAssumptions:

11,000 therms, Estimated annual natural gas consumption (space heating)
 4 °F, Average temperature drop during setback period
 212 days, Duration of average heating season
 8,900 HDD, Degree days per heating season
 \$0.45 per therm, Cost of natural gas
 65 degree, balance point

ESTIMATED SAVINGS:

$$\left(\frac{4 \text{ } ^\circ\text{F} \times 212 \text{ days}}{8,900} \right) \times 11,000 \text{ therms} = 1,048 \text{ therms}$$

$$1,048 \text{ therms} \times \$0.45 \text{ per therm} = \$472$$

SUMMER COOLINGAssumptions:

601,317 kWh, Estimated annual consumption for space cooling (~22% of load for commercial)*
 4 °F, Average temperature rise during setback period
 122 days, Duration of average cooling season
 998 CDD, Degree days per cooling season
 \$0.056 per kWh, Cost of electricity

*Note, for industrial application load was increased to 30% for cooling

ESTIMATED SAVINGS:

$$\left(\frac{4 \text{ } ^\circ\text{F} \times 122 \text{ days}}{998} \right) \times 601,317 \text{ kWh} = 294,031 \text{ kWh}$$

$$294,031 \text{ kWh} \times \$0.056 \text{ per kWh} = \$16,466$$

TOTAL ENERGY COST SAVINGS:

$$\$472 + \$16,466 = \$16,937$$

ESTIMATED IMPLEMENTATION COST:

One (1) programmable PLC	\$3,000
Wiring and installation	<u>\$1,000</u>
TOTAL:	\$4,000

SIMPLE PAYBACK:

$$\frac{\$4,000}{\$16,937} = \boxed{0.2 \text{ Years}}$$

13.0 Seal Air Leaks Around Overhead Doors in Dock Area

Assumptions	Comments
Miscellaneous data	
<i>Cost of heat loss through cracks or worn weather seals (\$/yr/sq in)</i>	\$1.00 estimated at \$5.00/MMBTU; 5 mph wind
<i>Leak thickness (inches)</i>	1/8 measured
<i>Average leak length (feet)</i>	50 measured
Unit heater efficiency (%)	80 typical
Natural gas cost (\$/MMBTU)	\$4.50 est. from gas bill summary
Calculations	
Estimate the average total area of leaks (leak thickness)*(leak length)*(12 in/1 ft)=	75 square inches
Estimate the energy cost savings (cost of heat loss through leaks)*(avg. total leaks area)/(heater effic/100) *(gas \$/MMBTU)/(\$5.00/MMBTU)=	14.00 \$84 total savings per year
Estimate the heat energy savings (energy cost savings)/(natural gas \$/MMBTU)=	188 therms/yr

15.0 ELECTRIC WATER HEATER REPLACEMENT

This measure estimates the energy and related cost savings realized by replacing the existing electric water heaters with new natural gas fired units. *Tankless for small 12 gallon and standard for 40 gallon

Assumptions:

4,875 annual kWh for large unit
 1462 annual kWh for small unit
 270 annual therms for large unit
 81 annual therms for small unit

ESTIMATED SAVINGS:

6337 kWh at \$0.056 compared to 351 therms at \$0.45

\$355 for electric option
\$140 for natural gas option

Total **\$215**

SIMPLE PAYBACK: Tankless heater plus a standard heater total cost \$750

$$\frac{\$750}{\$215} = 3.5 \text{ Years}$$

XYZ Company
Anytown, USA

Rooftop Air Conditioning Operating Cost

This measure estimates the energy and related costs incurred by operating the rooftop air conditioning system at XYZ facility.

Assumptions:

9.5 EER, Energy efficiency of rooftop unit (BTU/hr per Watt)
 15.0 tons, Nominal cooling capacity of unit
 800 hr, Annual local cooling hours (Equivalent full-load hours) from ARI Directory
 12,000 BTU/hr per ton, Cooling energy conversion factor
 1,000 Watts/kW, Electrical power conversion factor
 1, Number of units installed
 \$0.074 per kWh, Average cost of electricity

CALCULATIONS:

Power Requirement of Rooftop System (per unit):

$$\frac{12,000 \text{ BTU/hr/ton} \times 15.0 \text{ tons}}{9.5 \text{ EER} \times 1,000 \text{ Watts/kW}} = 18.95 \text{ kW}$$

Estimated Annual Energy Use of Rooftop Unit:

$$18.95 \text{ kW} \times 800 \text{ hours} \times 1 \text{ unit(s)} = \boxed{15,158 \text{ kWh}}$$

ESTIMATED OPERATING COST:

$$15,158 \text{ kWh} \times \$0.074 / \text{kWh} = \mathbf{\$1,122 \text{ Annual Cost for Air Conditioning}}$$

Chapter 5

Conclusion and Recommendations

The energy audit has provided detailed calculations of XYZ company's current energy consumption. The audit covers two specific aspects of XYZ energy consumption which are:

- Analyze various areas with significant energy consumption at the XYZ facility.
- Provide specific areas in which XYZ can reduce their energy consumption.

The next step would be to group the various items into different facets of the building such as HVAC, lighting, operations. The items can then be budgeted and scheduled for implementation. In the future XYZ Company should perform an energy audit and evaluate the energy bills on an annual basis.

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