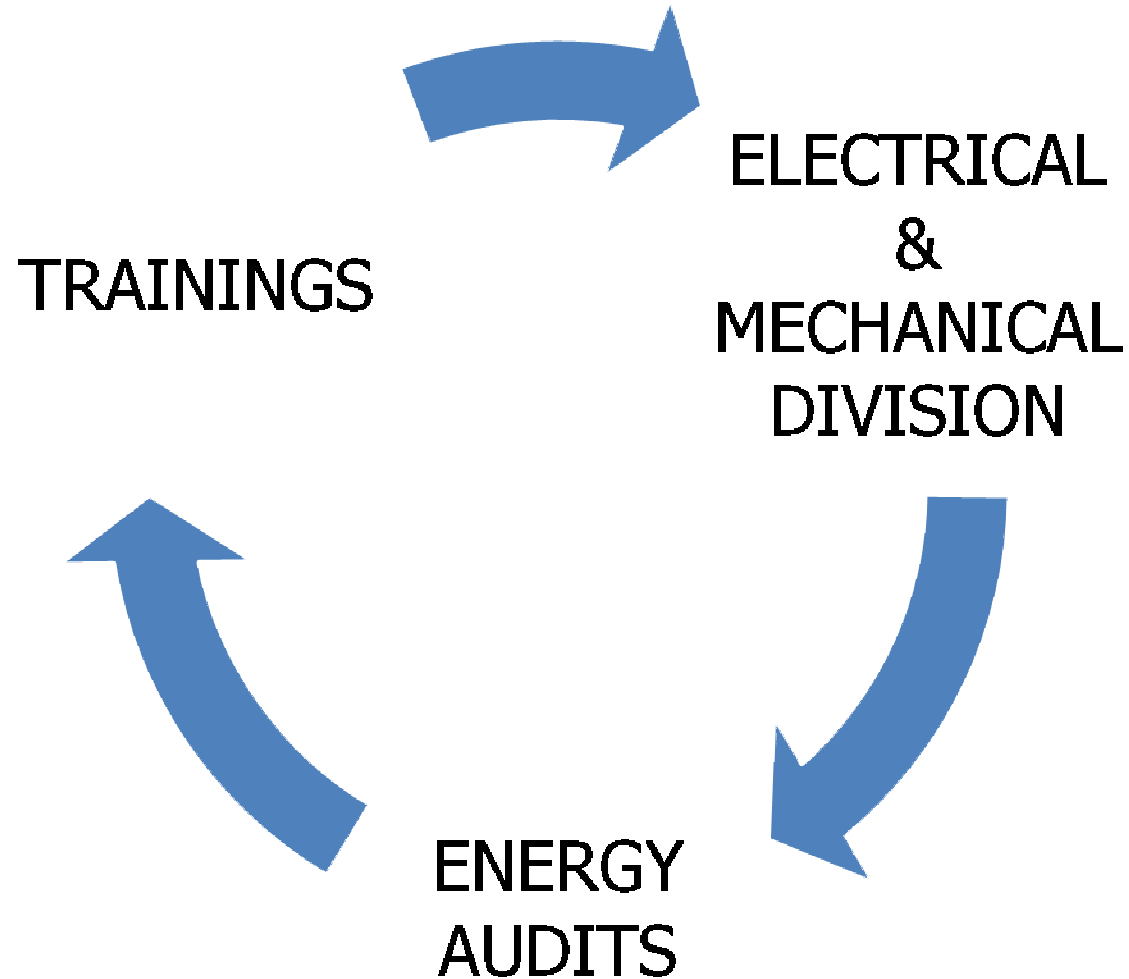


# ENERGY CONSERVATION PRESENTATION

BY :

PCG CORPORATION

# ENGINEERING SERVICES:



## Clients References Energy Projects

Bristol Myers Barceloneta	"Electric Bill Analysis"	
Lilly Guayama	"Electric Bill Analysis"	
Bristol Myers Manatí	"Electric Bill Analysis"	
INXX	"Electric Bill Analysis"	\$ 35k credit
Thermoking	"Electric Bill Analysis"	\$ 817k credit
Autoridad de Puertos	"Electric Bill Analysis"	\$ 70k credit
Municipio Vega Baja	"Electric Bill Analysis"	
Bristol-Myers	"Energy Audit" (Las cuatro plantas en P.R.)	
Marriott Hotel	"Energy Audit"	
General Electric	"Energy Audit"	
Valeant Pharmaceutical	"Energy Audit"	
Rexnord	"Energy Audit"	
Pfizer	"Energy Audit"	
Ryder Hospital	"Energy Audit"	
San Lucas Hospital	"Energy Audit"	
IPR Pharmaceutical	"Energy Audit"	
AAA	"Energy Audit"	
Baxter/ Maricao	"Steam System Audit"	
McNeil Consumer	"Steam System Audit"	
Bristol Barceloneta	"Steam System Audit"	
BBVA	"Power Factor Correction"	
Pueblo Xtra	"Power Factor Correction"	
Biovail Laboratory	"Power Factor Correction"	
Hospitales San Lucas	"Power Factor Correction"	
Citibank	"Power Factor Correction"	
Hotel Conquistador	"Power Factor Correction"	
Supermercados Grande	"Power Factor Correction"	
Becton Dickinson	"Power Factor Correction"	
Plaza Del Norte	"Power Factor Correction"	
Citibank	"Re-lamping" – 17 Citifinancials	

**PERFORMING AN  
ENERGY AUDIT FROM  
AN OPERATIONAL  
POINT OF VIEW**

# What Is Energy Management?

The use of Engineering and  
Economic principles to

CONTROL

the cost of energy to provide  
needed services in buildings  
and industries.

# NEED FOR ENERGY MANAGEMENT

## IMPORTANT REASONS:

1. ENVIRONMENTAL QUALITY
2. ECONOMIC COMPETITIVENESS
- 3. REDUCE COSTS** AND CREATE JOBS
4. ENERGY SECURITY
5. CORPORATE REQUIREMENT

# **DRIVING FACTORS IN MAJOR INVESTMENTS FOR BUSINESS AND INDUSTRY**

1. ENVIRONMENTAL REGULATIONS
2. PRODUCT QUALITY
3. PRODUCTIVITY IMPROVEMENT
4. ENERGY AWARENESS

# **DEFINITIONS**

**ECO's**

**Energy Conservation  
Opportunities**

# DEFINITIONS

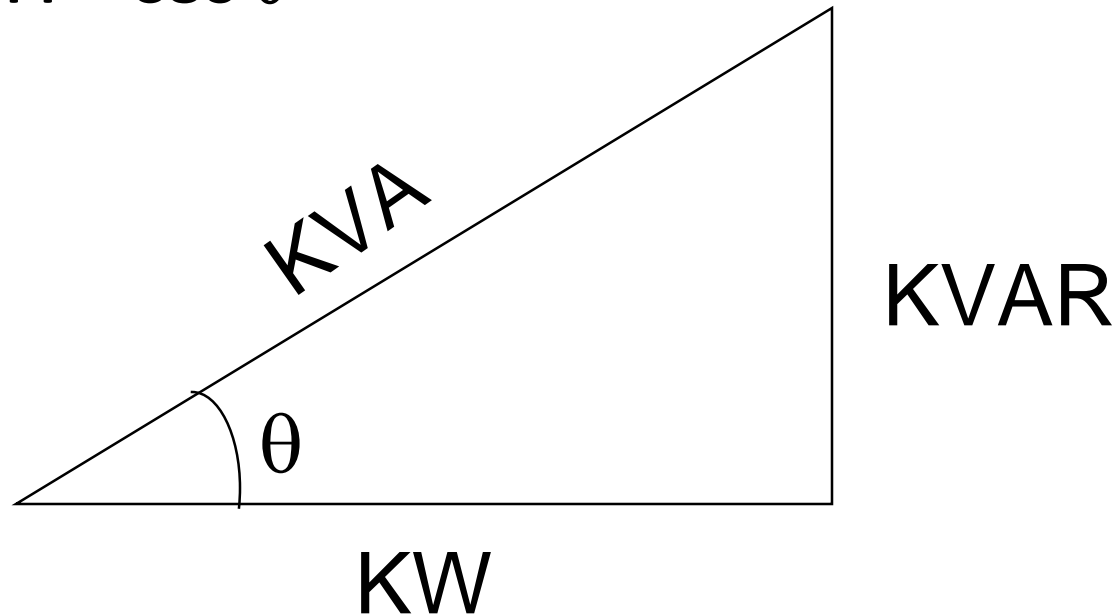
- **ENERGY:** the capacity of doing work
  - Thermal, Electromagnetic, Nuclear, Mechanical, Chemical, etc.
- **ENERGY CONSERVATION LAW**
  - Energy is transformed from one form to another and the total amount of energy remains the same.

## CONT.

- **EFFICIENCY** – is the ratio of the output of a system in relation with its input.
- **MOTORS** – a device that converts electrical energy into mechanical energy.
- **GENERATOR** – converts mechanical energy into electrical energy.
- **TRANSFORMER** - Is a device that converts AC electric energy at one voltage level to an AC electric energy at another voltage level. They are classified as “step-up” or “step-down” transformers depending of the function they are being used for.

CONT.

- **POWER FACTOR** : is the ratio of the total power produced between the power used.
  - $PF = \cos \theta$



## CONT.

- **COGENERATION** – is the sequential production of thermal and electric energy from a single fuel source.

Heat, that would normally be lost, is recovered in the production of one form of energy. The heat is then used to generate the second form of energy.

# **HOW & WHY ENERGY CONSERVATION**

# HOW AND WHY?

- HOW?: In addition to PdM
  - Energy Audits
  - Fuel Switching
  - Electric Rate Structures
  - Electrical System Utilization
    - PF Correction
  - Lighting Improvements
  - Motors And Applications
  - Insulation
  - HVAC Improvements
  - Waste Heat Recovery; Cogeneration, ETC.

# HOW AND WHY?

- WHY?:
  - Most energy savings cost will come from improvements in energy efficiency.
  - **Some savings will come from changing the patterns of energy use.**
  - Energy leaders will guide others to follow.
  - Our life style depends on it.

# **ENERGY AUDITS**

# **ENERGY AUDITS**

An Energy Audit (or Energy Survey) is a study of how energy is used in a facility and an analysis of what alternatives could be used to reduce energy costs.

# **ENERGY AUDITS**

This process starts by collecting information of the facility's operation and about its past record of utility bills. This data is then analyzed to get a picture of how the facility uses ( and possibly wastes) energy, and identify ECO's.

# Types of Energy Audits

There is a direct relationship to the cost of the audit (amount of data collected and analyzed) and the number of energy conservation opportunities (ECO's) to be found.

**Walk-through** - is the least costly and identify preliminary energy savings. A visual inspection of the facility is made to determine maintenance and operation energy saving opportunities plus data collection of information to determine the need for a more detailed analysis.

**Mini-Audit** - this type of audit requires tests and measurements to quantify energy uses and losses and determine the economics for changes.

**Maxi-Audit** - this type of audit goes one step further than the mini-audit. It contains an evaluation of how much energy is used for each function such as lighting, process, etc.

# Nine Major Systems To Consider

- Building Envelope
- HVAC System
- **Electrical Supply System**
- **Lighting**
- **Boilers and Steam System**
- Hot Water System
- **Compressed Air System**
- **Electric Motors**
- Special Purpose Equipment

## What to Look for

- **Lighting** - making a detailed inventory of all lighting is important. Type of light fixtures and lamps, wattage of lamps and hours of operation. Take notes of the tasks performed in each area. This will help the auditor select alternative lighting technologies that might be more energy efficient.
- **HVAC Equipment** - all heating, air conditioning and ventilation equipment should be inventoried. Size, model numbers, electrical specifications and estimated hours of operation. Inspections to determine the condition of the evaporator and condenser coils, the air filters and the insulation on the refrigerant lines.
- **Water Heaters** - Size, age, type, model number, electrical characteristics. What the hot water is used for, how much is used and what time it is used. Also, the temperature of the hot water should be measured.

## What to Look for

- **Electric Motors** - an inventory of all electric motors over 1 hp should be taken. Motor size, use, age, model, estimated hours of operation, electrical characteristics, and possibly the operating power factor. Measures of voltage, current and the use of the motor.
- **Waste Heat Sources** - Possible opportunities of waste heat recovery to be used as the substantial or total source needed of hot water. Waste heat sources are: air conditioners, air compressors, boilers, process cooling systems, etc.
- **Steam / Compressed Air Systems** - an inspection of the steam pipe lines should be done in order to find leaks. Analysis of the areas required pressure provide a good saving opportunity.

## What to Look for

- **Peak Equipment Load** - look for any piece of electrically powered equipment that is used infrequently or whose use could be controlled or shifted to off-peak times.
- **Electric Rate Analysis** - verify the electric rate that your company actually have to look for opportunities in scheduling process.

**PROBLEM ?**

# **PROBLEMS**

- One of the problems for an energy managers is to trying to reduce cost for a facility when these costs are accounted for as part of general overhead.

# **SOLUTION**

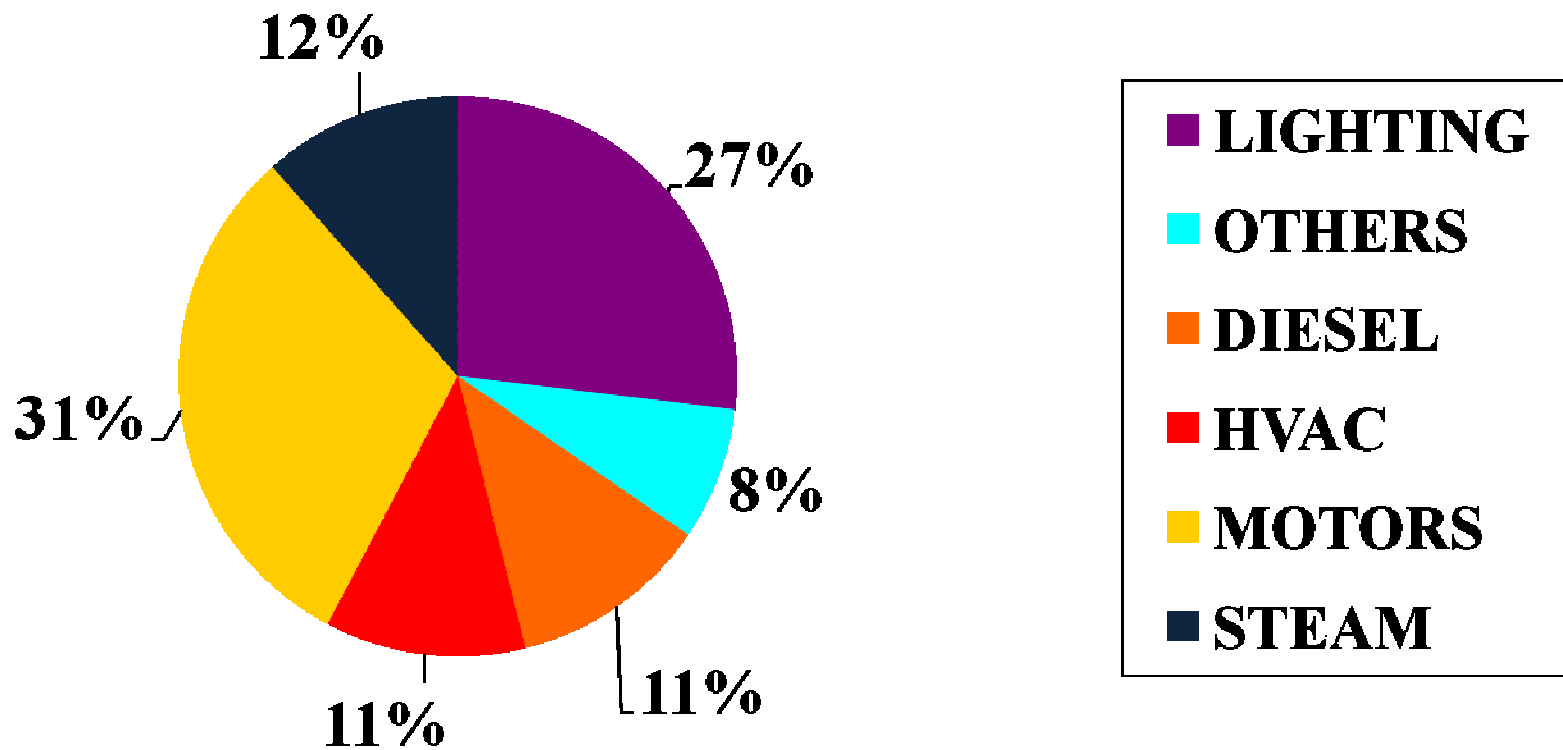
- Allocate energy costs down to “cost centers” in the company or the facility.
- Sub-metering – readily available and cost effective

**SECRET !!!!!**

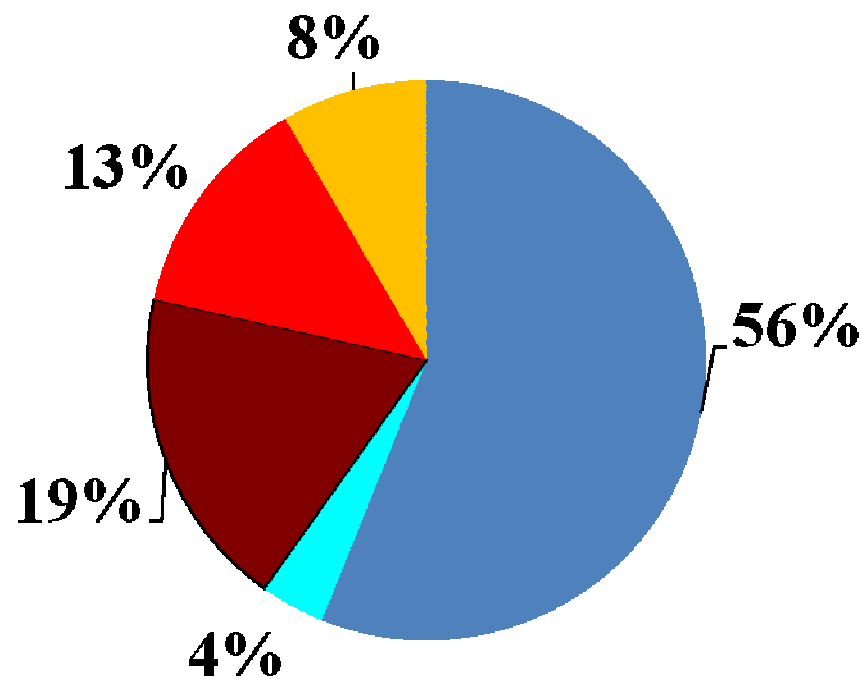
**10 % Theory**

90 % Common Sense

# ENERGY DISTRIBUTION PROFILE



# STEAM DISTRIBUTION PROFILE



■ **PROCESS**

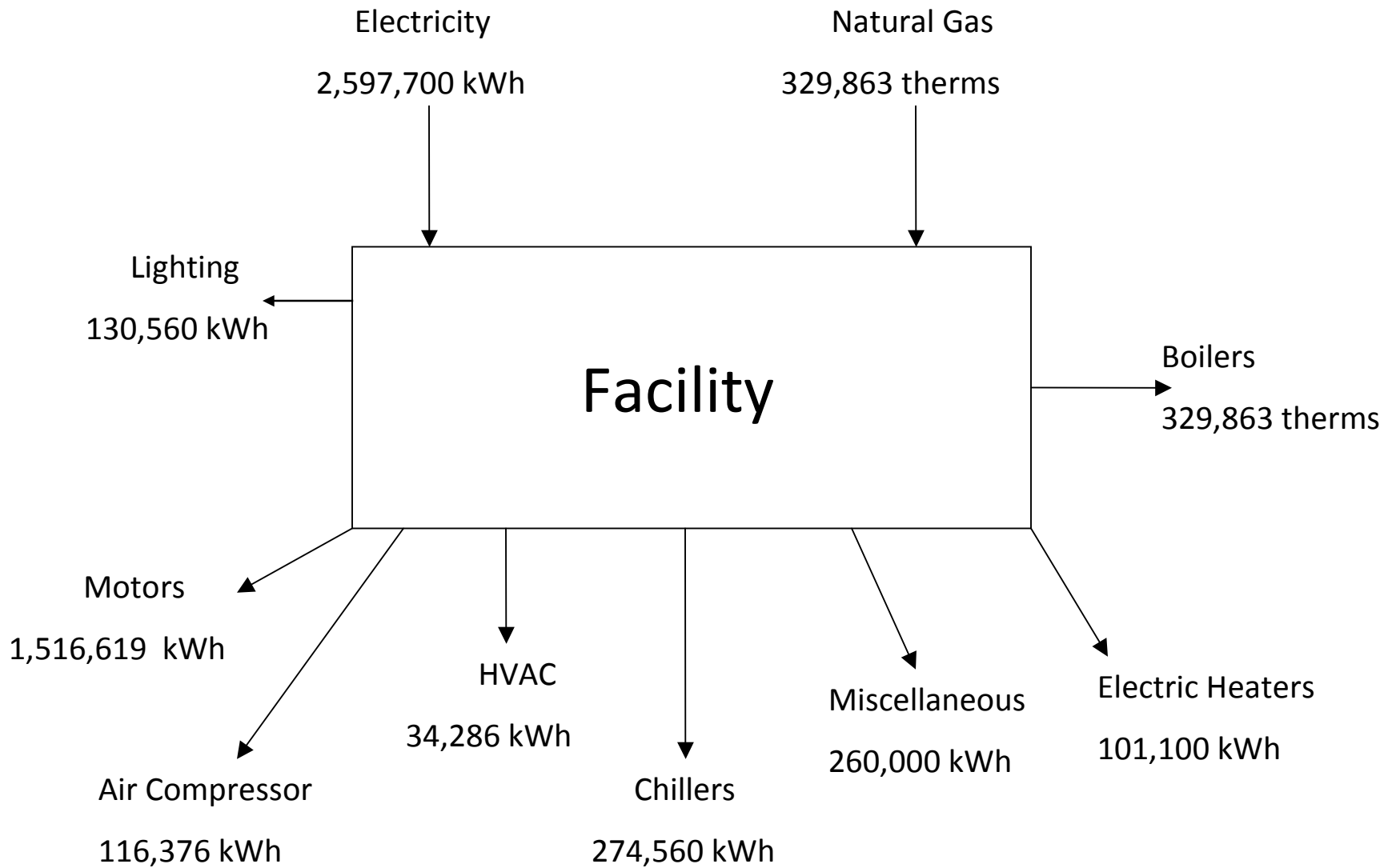
■ **HOT WATER**

■ **BOILER  
FEEDWATER**

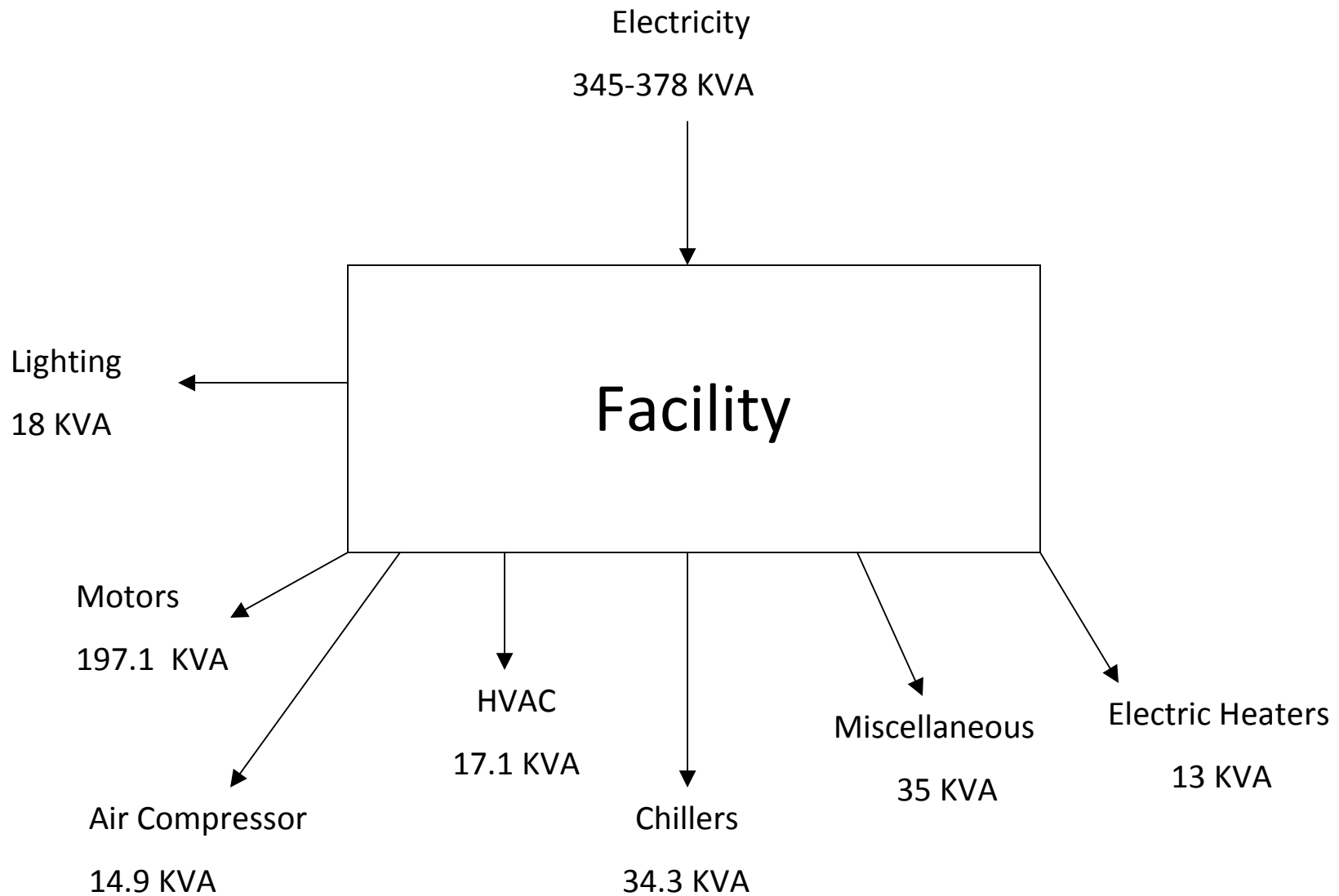
■ **LEAKS**

■ **OTHER**

# Energy Balance for a Facility



# Demand Balance for a Facility



# ENERGY USE INDEX (EUI)

- BASIC MEASURE OF A FACILITY'S ENERGY PERFORMANCE
- A STATEMENT OF THE NUMBER OF BTU'S OF ENERGY USED ANNUALLY PER SQUARE FOOT OF CONDITIONED SPACE.
- THE EUI IS THE RATIO OF THE TOTAL BTU'S TO THE TOTAL NUMBER OF SQUARE FEET OF CONDITIONED SPACE

# **ENERGY COST INDEX (ECI)**

The ECI adds up all cost of energy and divides result by total square feet of conditioned space.

# EXAMPLE.

- A facility has 100,000 square feet of conditioned floor space and uses 1.76 million KWh and 6.5 million cubic feet of natural gas in one year.

# ENERGY COST INDEX (ECI)

- The ECI adds up all cost of energy and divides result by total square feet of conditioned space.

EXAMPLE: 1.76 Million KWh x \$ 0.17

= \$ 299,200 / yr

6.5 Million ft<sup>3</sup> natural gas @ \$7.00/1000 ft<sup>3</sup>

= \$ 45,500 / yr

ECI = (\$ 299,200 + \$ 45,500) / 100,000 ft<sup>2</sup>

= \$ 3.45/ ft<sup>2</sup> /year

# **INDIVIDUAL SYSTEMS CONSIDERATIONS**

# **ECONOMICAL**

# **ANALYSIS**

# **INVESTMENTS**

THE BASIC CRITERIA FOR EVALUATING ANY INVESTMENT DECISION IS THAT THE SAVINGS GENERATED BY THE INVESTMENT MUST BE GREATER THAN THE COST INCURRED.

# Simple Payback

Simple Payback (SPB) is the number of years before the savings “Payback” the investment.

$$\text{SPB} = \text{INVESTMENT} / \text{NET ANNUAL SAVINGS}$$

**Example: A project has an investment of \$ 100,000. Savings per year are \$ 22,000 but added maintenance because of the project is \$ 2,000. What is the SPB?**

$$\text{Net savings } \$ 22,000 - \$ 2,000 = \$ 20,000$$

$$\text{SPB} = (\$ 100,000 / \$ 20,000) = 5 \text{ YEARS}$$

## NOTE:

SPB does not consider interest and ignores what happens after the payback period. Thus, SPB is not an accurate decision criterion; but everyone understands it (or think they do) and we will likely always have it around. Used in the proper fashion, SPB is not a bad “first cut” tool.

# **ELECTRICAL SYSTEM**

# **ELECTRICAL SYSTEM**

The majority of electrical energy in the United States is used to run electric motor driven systems. More than 50%.

## **Most Frequent Opportunities of Electrical Management Are:**

1. Peak Load Reduction
2. Electrical System Utilization
3. Power Quality
4. Harmonics
5. Power Factor Improvement

## **To Improve System Efficiency:**

1. Maintain Voltage Levels
2. Minimize Phase Imbalance
3. Maintain Power Factor
4. Maintain Good Power Quality
5. Select Efficient Transformers
6. Chose Replacements Before a Motor Fails
7. Choose Energy Efficient Motors
8. Match Motor Operation Speeds
9. Size Motors for Efficiency
10. Perform Periodic Checks
11. Control Temperatures
12. Lubricate Correctly
13. Maintain Motor Records

# **Power Factor Improvements**

## **Benefits**

- Increased plant capacity.
- Reduced power factor “penalty” charges for the electrical utility.
- Improvement of voltage supply.
- Less power in feeders, transformers and distribution equipment.

# **LIGHTING**

**20% OF THE TOTAL POWER  
GENERATED IN THE UNITED  
STATES IS USED IN LIGHTING**

# LIGHTING

## PRINCIPLES OF EFFICIENT LIGHTING DESIGNS

- Meet target light levels
- Efficiently produce light
- Efficiently deliver light
- Automatically control lighting operation

# LIGHTING ENERGY MANAGEMENT

## STEPS

1. Identify necessary light quantity and quality to perform visual task.
2. Increase light source efficiency if occupancy is frequent.
3. Optimize lighting controls if occupancy is infrequent.
4. Create a lighting maintenance program.

# **ELECTRIC MOTORS**

**50% OF THE TOTAL  
ELECTRICAL POWER IN  
UNITED STATES IS USED FOR  
ELECTRICAL MOTORS  
MORE THAN 70% IN MANY  
INDUSTRY**

# MOTORS

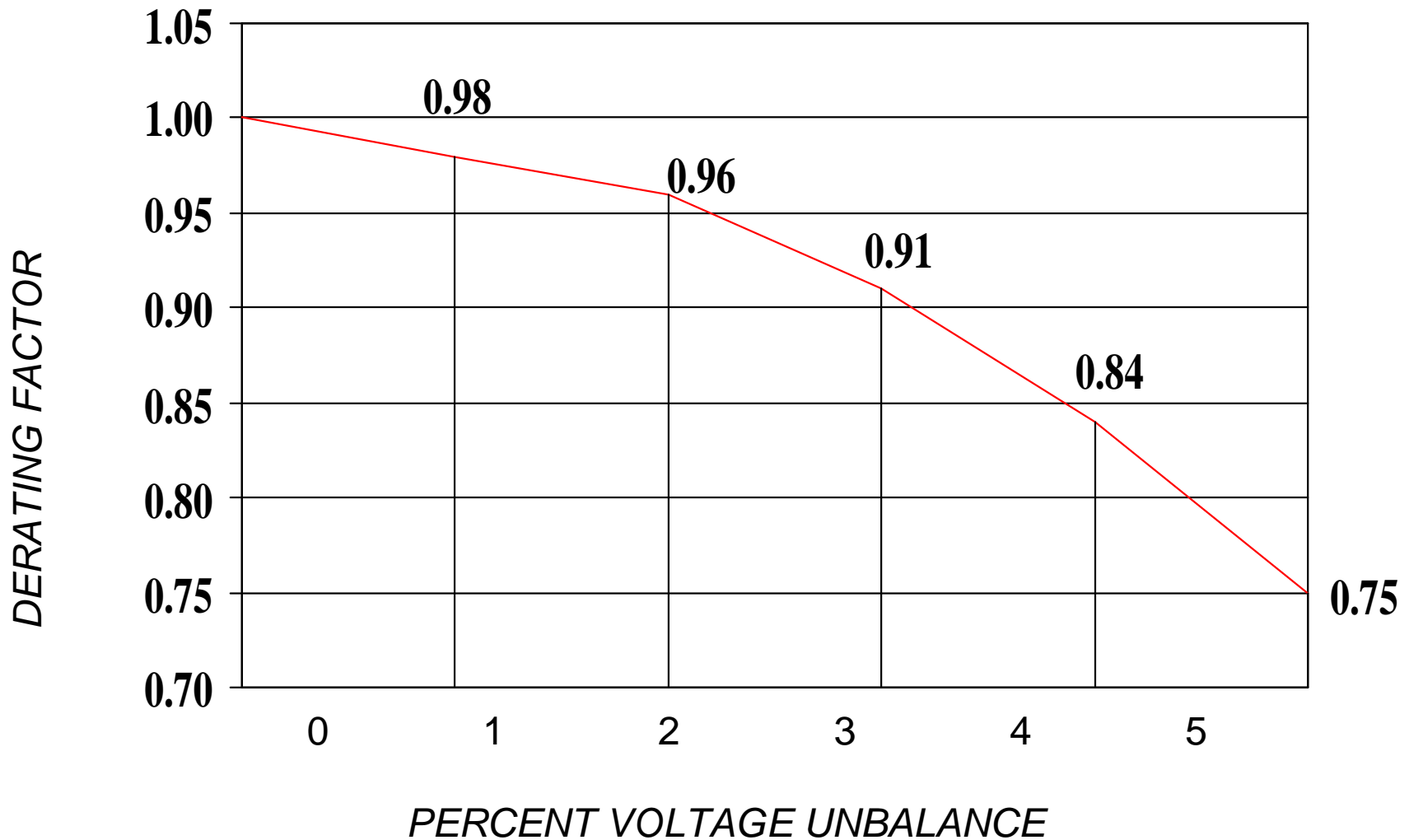
The purpose of an electric motor is to convert electrical energy into mechanical energy.

Generally, electric motors are efficient at converting electrical energy into mechanical energy. 30% more expensive.

Motors efficiency tell us how much of the electrical energy produce by the motor is converted into mechanical energy.

The portion used by the motor is the difference between the electrical energy input to the mechanical energy output.

# Induction Motors Derating Factor due to Unbalance Voltage



# **Air & Water Heat Flow** **Problems**

## AIR – Sensible Heat Only

$$Q = \text{CFM} \times 1.08 \times \Delta T \quad [\text{Btu/h}]$$

## WATER – Sensible Heat Only

$$Q = \text{GPM} \times 500 \times \Delta T \quad [\text{Btu/h}]$$

## EXAMPLE – DUCT LOSS

10,000 CFM of air leaves an air handler at 50 °F. It is delivered to a room at 65 °F.  
How much energy was lost in the ductwork?

$$q = \text{CFM} \times 1.08 \times \Delta T$$

$$= 10,000 \text{ CFM} \times 1.08 \times (65-50) \text{ °F}$$

$$= 162,000 \text{ Btu/h (13.5 ton)}$$

# **COMPRESSED AIR SYSTEM**

# COMPRESSORS

## BASIC DEFINITION:

Mechanical device taking in Ambient Air and Increasing its Pressure

# COMPRESSED AIR SYSTEM

- It is one of the most expensive utilities created by a plant or facility.
- Usually more than \$ 50,000 are needed to operate a 100 Hp air compressor.
- Large cost reduction potential (20-50%)
- Management (Supply Side -Demand Size)

# WHY BOTHER?

Example:

100 Hp Compressor

70% Load

8000 hrs/yr

\$92 /KVA/yr

Electricity @ \$.17/Kwh

$$(100\text{hp}) \left( \frac{.746\text{kw}}{\text{hp}} \right) (.7) \left[ \frac{\$ 92}{\text{KVA/yr}} + \frac{(8000\text{hrs}) (\$.17)}{\text{yr Kwh}} \right]$$

$$= 52.22 [\$92 + \$1360] = \mathbf{\$ 75,823}$$

# SYSTEM ECO's

Match Supply to Demand

- Pressure Regulators

Electric Motors

- Efficient Ones

Leaks

- 20 to 30%

Controls

Air Distribution

- Length, Diameter, Loop, Slope

# SYSTEM ECO's

## **Watch Pressure Drops**

- 2 psi Increase (decrease) in Pressure Increase (decrease) Energy use by 1%
- Excess Pressure Increases Wear on Equipment (Maintenance)
- Insufficient pressure can dramatically impact productivity.
- Undersized lines or hoses
- Filters, Disconnects, Regulators

## ENERGY HINT:

A good system should have  
Pressure Drop of Less than  
10% of compressor discharge  
from Receiver Tank Output to  
Point Of Use.

# **BOILERS**

# COMBUSTION EFFICIENCY

- In any closed combustion system such as a boiler, we can measure precisely what occurred at the burner by carefully measuring the exhaust.
- The goal is to be able to carefully control the fuel and airflow to ensure the complete and efficient combustion.
- We will see why excess air is important and why too much excess air is expensive.

# % SAVINGS IN FUEL

- $\% \text{ Savings} = \frac{\text{New Eff.} - \text{Old Eff.}}{\text{New Eff.}}$

$$\text{Savings} = (\% \text{ Savings})(\text{Fuel Consumption})$$

# Example 1

- Last year a  $20 \times 10^6$  BTU/HR boiler consumed 19000 MCF of natural gas at \$4.00/MCF. The boiler operates at 6% O<sub>2</sub> and 700 °F STR.

What is the saving to correcting that to  
3% O<sub>2</sub> ?

Eff 1. = 74.5%

Eff. 2 = 77%

$$\% \text{ Savings} = \frac{77 - 74.5}{77} = 3.2 \%$$

$$\begin{aligned} \$ \text{ Savings} &= (3.2\%) \left[ 19,000 \frac{\text{MCF}}{\text{YR}} \right] \left[ \frac{\$ 4.00}{\text{MCF}} \right] \\ &= \$ 2,500 / \text{YR} \end{aligned}$$

## Example 2

- Now you can install an economizer that will reduce the stack temperature rise to 400 °F.

What is the % Fuel Saving for that change?

$$\text{Eff. 1} = 77 \%$$

$$\text{Eff. 2} = 83 \%$$

$$\% \text{ Savings} = \frac{83-77}{83} = 7.2 \%$$

# PROPER % BLOW DOWN

- $\text{PROPER \%} = \frac{A}{B-A}$

A = Feed Water Impurities

B = Boiler Impurities Allowed

# **STEAM TRAPS**

# **STEAM TRAPS**

THE BASIC FUNCTION OF A STEAM TRAP IS TO ALLOW CONDENSATE FORMED IN THE HEATING PROCESS TO BE DRAINED FROM THE EQUIPMENT.

# **BAD STEAM TRAPS**

- If condensate is allowed to back up in the steam chamber, it cools below the steam temperature as it gives up sensible heat to the process and reduces the effective potential for heat transfer.
- Avoidance of “water hammer” in steam systems.

# **INSULATION**

# FUNDAMENTALS

- The basic function of thermal insulation is to retard the flow of unwanted heat energy either to or from a specific location.
- The efficiency of an insulation is measured by an overall property called **Thermal Conductivity**.

**THERMAL CONDUCTIVITY,  $k$  value** - is a measure of the amount of heat that passes through 1 square foot of 1 inch thick material in 1 hour when there is a temperature difference of 1 °F across the insulation thickness.

The units are: Btu-in / hr Ft<sup>2</sup> °F

The lower the  **$k$  value**, the more efficient the insulation.

The American Society of Testing Materials (ASTM) has developed sophisticated test methods that are the standards in the industry.

# Energy Calculations

- STEP 1: Calculate present heat losses
- STEP 2: Determine Insulation thickness
- STEP 3: Calculate heat losses with insulation
- STEP 4: Determine heat losses savings
- STEP 5: Estimate fuel cost savings

## Energy Action Plan

- Establish an Annual Goal - 3 to 5 % for the first year.
- Get Management Support
- Design an Energy Conservation Program
  - Select a team (just 3 or 4)
  - Train your team
  - Buy some equipment
  - Make a Walk-through Audit to find ECO's
  - Show results in company boards - that way you get support to continue with other projects, and other people will start to give you ideas for other ECO's.

# **Energy Audit Toolbox**

# **EDUCATION**

# Tools

- Light meter
- Thermometers
- Voltmeter
- Combustion Analyzer
- Airflow Measurements Devices
- Power Factor Meter
- Ultrasound Equipment
- Infrared Camera
- Vibration Analyzer
- Tachometer

# The Energy Audit Report

- The energy audit report details the final results of the energy analyses and provides energy cost savings recommendations.
- The length and detail of this report will vary depending on the type of the facility audited.
- An industrial audit should have a detailed explanation of the EMO's (Energy Management Opportunities) and benefit-cost analyses.

# **Successful Cases**