ENERGY CONSERVATION
PRESENTATION

BY :
PCG CORPORATION
ENGINEERING SERVICES:

- TRAININGS
- ELECTRICAL & MECHANICAL DIVISION
- ENERGY AUDITS
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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.
• **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.
• **POWER FACTOR**: is the ratio of the total power produced between the power used.
  
  • \( PF = \cos \theta \)
• **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
STEAM DISTRIBUTION PROFILE

- PROCESS: 56%
- HOT WATER: 8%
- BOILER FEEDWATER: 19%
- LEAKS: 4%
- OTHER: 13%
Energy Balance for a Facility

Facility

Electricity
- 2,597,700 kWh

Natural Gas
- 329,863 therms

Boilers
- 329,863 therms

Electric Heaters
- 101,100 kWh

Miscellaneous
- 260,000 kWh

Chillers
- 274,560 kWh

HVAC
- 34,286 kWh

Motors
- 1,516,619 kWh

Air Compressor
- 116,376 kWh

Lighting
- 130,560 kWh
Demand Balance for a Facility

Electricity
345-378 KVA

Facility

Lighting
18 KVA

Motors
197.1 KVA

Air Compressor
14.9 KVA

HVAC
17.1 KVA

Chillers
34.3 KVA

Miscellaneous
35 KVA

Electric Heaters
13 KVA
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 ft³ natural gas @ $7.00/1000 ft³ = $45,500 / yr

ECI = ($299,200 + $45,500) / 100,000 ft² = $3.45/ ft² /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.

\[ SPB = \frac{\text{INVESTMENT}}{\text{NET ANNUAL SAVINGS}} \]

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?

Net savings $22,000 - $2,000 = $20,000

\[ SPB = \frac{\$100,000}{\$20,000} = 5 \text{ YEARS} \]
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. Choose 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

PERCENT VOLTAGE UNBALANCE

DERATING FACTOR
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 ºF. It is delivered to a room at 65 ºF. How much energy was lost in the ductwork?

\[ q = \text{CFM} \times 1.08 \times \Delta T \]

\[ = 10,000 \, \text{CFM} \times 1.08 \times (65-50) \, ^\circ\text{F} \]

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

\[
\begin{align*}
(100\text{hp})(0.746\text{kw})(0.7)[\ & \$ \ 92 \ \ + \ (8000\text{hrs}) \ (\$ \ 0.17)] \\
\text{hp} & \quad \text{KVA/yr} & \quad \text{yr} & \quad \text{Kwh}
\end{align*}
\]

= 52.22 \ [\$92 \ + \ $1360] = \$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

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

Savings = (% Savings)(Fuel Consumption)
Example 1

• Last year a 20 x 10^6 BTU/HR boiler consumed 19000 MCF of natural gas at $4.00/MCF. The boiler operates at 6% O_2 and 700 ºF STR.

What is the saving to correcting that to 3% O_2?
Eff 1. = 74.5%  

Eff. 2 = 77%  

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

\[
\$ \text{ Savings} = (3.2\%) \times \left[ 19,000 \ \text{MCF} \times \$ 4.00 \right] \text{YR MCF}
\]

\[
= \$ 2,500 / \text{YR}
\]
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?

Eff. 1 = 77 %  
Eff. 2 = 83 %

% Savings = \( \frac{83-77}{83} \) = 7.2 %
PROPER % BLOW DOWN

• 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\(^2\) °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