# Energy conservation and auditing

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# Course outlines

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# Course outlines: (**Not for Now**)

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# Textbook

- Steve Doty, Wayne C. Turner. ***Energy Management Handbook***. 8$^{th}$ edition. 2013.

# Chapter 1
# Introduction

# Professional Associations That Have Reacted to Energy

- Most primary engineering associations now have an energy sub-organization or have integrated energy into their missions. Examples are:
  - The Association of Energy Engineers (AEE)
  - The American Institute of Architects (AIA)
  - The American Society of Mechanical Engineers (ASME)
  - The Association of Heating Refrigeration and Air Conditioning Engineers (ASHRAE)
  - The Illumination Engineers Society of North America (IESNA)
  - The Institute of Electrical and Electronic Engineers (IEEE)

# Professional Associations That Have Reacted to Energy

- Product and trade groups that include a focus on energy include:
  - National Electrical Manufacturers Association (NEMA)
  - Air-Conditioning, Heating, and Refrigeration Institute (AHRI, formed when ARI and GAMA merged)
  - American Gas Association (AGA)
  - Edison Electric Institute (EEI)
  - Electric Power Research Institute (EPRI)
  - North American Insulation Manufacturers Association (NAIMA)

# Professional Associations That Have Reacted to Energy

- Associations related to energy policy, energy supply, energy conservation, renewable energy, energy financing, include:
  - American Wind Energy Association (AWEA)
  - International District Energy Association (IDEA)
  - American Solar Energy Society (ASES)
  - Association of Energy Service Professionals (AESP)
  - Geothermal Heat Pump Consortium (GHPC)
  - International Ground Source Heat Pump Association (IGSHPA)
  - National Association of State Energy Officials (NASEO)
  - World Alliance for Decentralized Energy (WADE)
  - US Combined Heat and Power Association (USCHPA)
  - Alliance to Save Energy (ASE)
  - American Council for an Energy Efficient Economy (ACEEE)
  - Council of American Building Officials (CABO)
  - Building Owners and Managers Association (BOMA)
  - Biomass Energy Research Association (BERA)
  - Green Building Council (USGBC)

# THE VALUE OF ENERGY MANAGEMENT

- Business, industry and government organizations are under tremendous economic and environmental pressures.
- Energy management has been an important tool to help organizations.

- The problems that organizations face:
  1. Meeting more stringent environmental quality standards, primarily related to reducing global warming and reducing acid rain.
  2. Becoming—or continuing to be—economically competitive in the global marketplace

# THE VALUE OF ENERGY MANAGEMENT

- Most facilities (manufacturing plants, schools, hospitals, office buildings, etc.) can save according to the profile shown in **Figure 1-1**.

√ Low cost activities first year or two: 5 to 15%

√ Moderate cost, significant effort, three to five years: 15 to 30%

√ Long-term potential, higher cost, more engineering: 30 to 50%

**Figure 1-1. Typical Savings through Energy Management**

- Energy management can make the difference between profit and loss and can establish real competitive enhancements for most companies.

# THE VALUE OF ENERGY MANAGEMENT

- **Figure 1-2**. A facility with energy cost at 8% of total operating cost and operating on a 5% net profit margin will experience a profit increase from 5% to 6.7% with a 20% reduction in energy use—*a 34% profit increase.*

20% Energy Savings
Table shows revised profit value

| Original Profit Margin | Energy Cost % of Total Operating Cost | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1% | 2% | 3% | 4% | 5% | 6% | 7% | 8% | 9% | 10% |
| 1% | 1.2% | 1.4% | 1.6% | 1.8% | 2.0% | 2.2% | 2.4% | 2.6% | 2.9% | 3.1% |
| 2% | 2.2% | 2.4% | 2.6% | 2.8% | 3.0% | 32% | 3.4% | 3.7% | 3.9% | 4.1% |
| 3% | 3.2% | 3.4% | 3.6% | 3.8% | 4.0% | 4.3% | 4.5% | 4.7% | 4.9% | 5.1% |
| 5% | 5.2% | 5.4% | 5.6% | 5.8% | 6.1% | 6.3% | 6.5% | 6.7% | 6.9% | 7.1% |
| 10% | 10.2% | 10.4% | 10.7% | 10.9% | 11.1% | 11.3% | 11.6% | 11.8% | 12.0% | 12.2% |
| 20% | 20.2% | 20.5% | 20.7% | 21.0% | 21.2% | 21.5% | 21.7% | 22.0% | 22.2% | 22.4% |
| 30% | 30.3% | 30.5% | 30.8% | 31.0% | 31.3% | 31.6% | 31.8% | 32.1% | 32.4% | 32.7% |

**Figure 1-2. Energy Savings Effect on Profit (14)**

# Seeing the big picture

- The golden rule for energy conservation measures is to *begin by using less*.
- Energy conservation is effective at offsetting the need for increased generation capacity, including renewable energy use.
- It is almost always true that it is more cost effective to reduce the load through conservation measures than to increase the size of the generator, PV panel, etc.
- The term "negawatts" was coined and introduced by Amory Lovins, in a 1989 speech, and is effective at describing the symbiotic effects of energy conservation.
- A useful principle (and paradigm shift for many customers) is to control energy functions as a direct controllable cost rather than an overhead cost.

# Seeing the big picture

- Often, the energy savings is not the main driving factor when companies decide to purchase new equipment, use new processes, or use new high-tech materials.
- The combination of increased productivity, increased quality, reduced environmental emissions, and reduced energy costs provides a powerful incentive for companies and organizations to implement these new technologies.

# Seeing the big picture

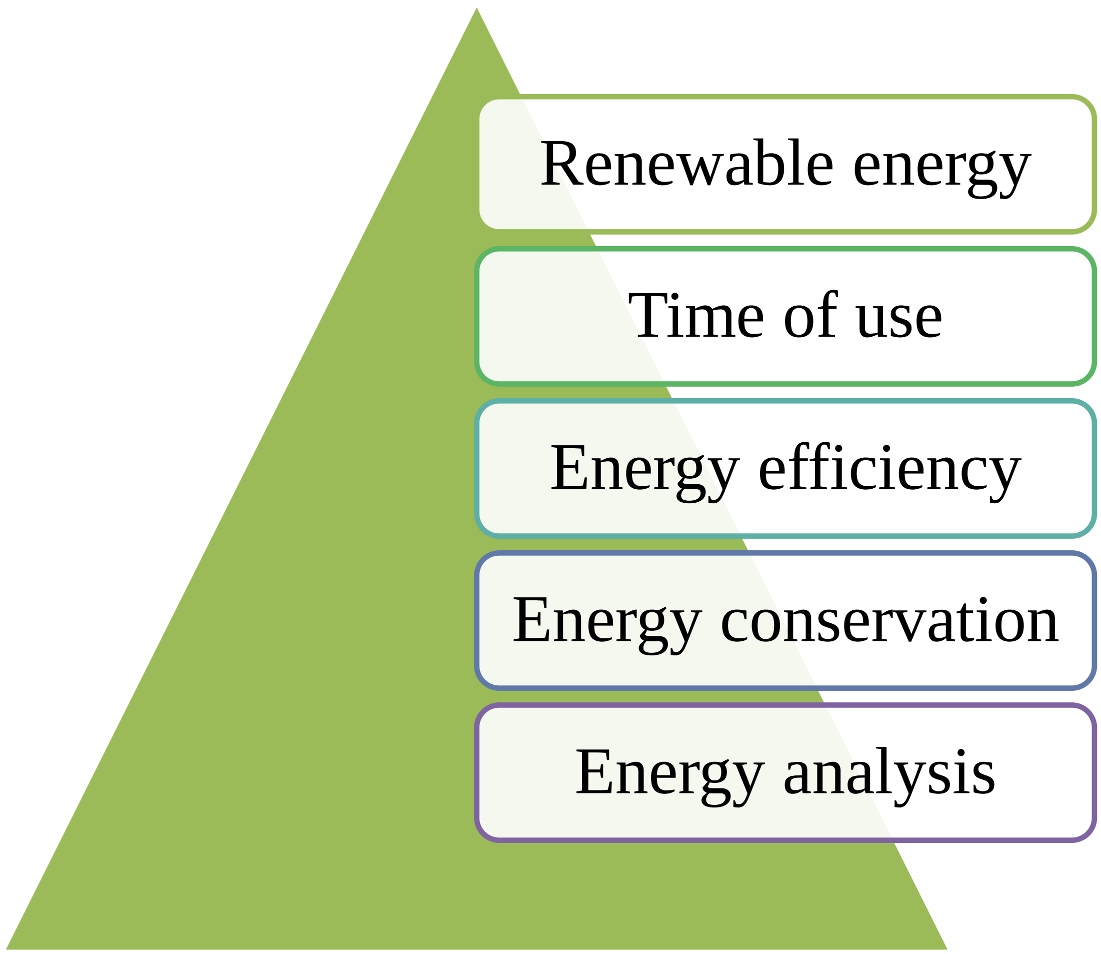
- Total quality management (TQM) is another emphasis that many businesses and other organizations have developed.
- TQM is an integrated approach to operating a facility, and energy cost control should be included in the overall TQM program.
- TQM is based on the principle that front-line employees should have the authority to make changes and other decisions at the lowest operating levels of a facility.
- If employees have energy management training, they can make informed decisions and recommendations about energy operating costs.

# Seeing the big picture

- Energy management can help in national concerns:

1. Maintaining energy supplies that are:
   - Available without significant interruption, and
   - Available at costs that do not fluctuate too rapidly.
2. Helping solve other national concerns which include:
   - Need to create new jobs
   - Need to improve the trade balance by reducing costs of imported energy
   - Need to minimize the effects of a potential limited energy supply interruption

# Seeing the big picture



# THE ENERGY MANAGEMENT PROFESSION

- For some of these people, energy management will be their primary duty, and they will need to acquire in-depth skills in energy analysis, as well as knowledge about existing and new energy using equipment and technologies.
- For others, such as maintenance managers, energy management skills are simply one more area to cover in an already full plate of duties and expectations. The authors are writing this *Energy Management Handbook* for both of these groups of readers and users.

- Plant Energy Manager
- Utility Energy Auditor
- State Agency Energy Analyst
- Consulting Energy Manager
- DSM Auditor / Manager
- Building / Facility Energy Manager
- Utility Energy Analyst
- Federal Energy Analyst
- Consulting Energy Engineer

**Figure 1-3. Typical Energy Management Job Titles**

# THE ENERGY MANAGEMENT PROFESSION

- In the 1980s, few university faculty members would have stated their primary interest was energy management, yet today there are numerous faculty who prominently list energy management as their principal specialty.
- In 2006, there were 26 universities throughout the country listed by DOE as industrial assessment centers (IAC).
- Other universities offer coursework and/or do research in energy management but do not have one of the above centers. Finally, several professional journals and magazines now publish exclusively for energy managers.

# THE ENERGY MANAGEMENT PROFESSION

**Table 1-3. Industrial Energy Functions by Expenditure and Btu, 1978**

*Source:* Technical Appendix, *The Least-Cost Energy Strategy,* Carnegie-Mellon University Press, Pittsburgh, Pa., 1979, Tables 1.2.1 and 11.3.2.

| *Function* | *Dollar Expenditure (billions)* | *Percent of Expenditure* | *Percent of Total Btu* |
|---|---|---|---|
| Machine drive | 19 | 35 | 12 |
| Feedstocks | 16 | 29 | 35 |
| Process steam | 7 | 13 | 23 |
| Direct heat | 4 | 7 | 13 |
| Indirect heat | 4 | 7 | 13 |
| Electrolytic | 4 | 7 | 3 |
| Space conditioning and lighting | 1 | 1 | 1 |
| Total | 55 | 100 | 100 |

# THE ENERGY MANAGEMENT PROFESSION

- The future for energy management is extremely promising.
- It is cost effective, it improves environmental quality, it helps reduce the trade deficit, and it helps reduce dependence on foreign fuel supplies.
- Energy management will continue to grow in size and importance.

# SOME SUGGESTED PRINCIPLES OF ENERGY MANAGEMENT

- ***EDITOR'S NOTE:*** *The material in this section is repeated from the first editions of this handbook published in 1982.*
- *It was unchanged for the second edition.*
- *Some of the numbers quoted may now be a little old, but the principles are still sound.*
- *Amazing, but what was right then for energy management is still right today! The game has changed, the playing field has moved; but the principles stay the same.*

# SOME SUGGESTED PRINCIPLES OF ENERGY MANAGEMENT

- ***(Principle #1):*** *Dollars are the bottom line for businesses, which is as it should be; fuel switching alternatives are a prime example of this. However, some energy management tasks are better done with Btus. Some examples:*
  - *Building efficiency metrics and certifications are usually in units of kBtu/SF-yr; as are industry benchmarks*
  - *Energy calculations may be viable for several years after an audit, but costs change each time the utility changes rates*
  - *Some buildings use electric resistance heating. Comparing such a building to one that uses gas heating might show the Btus per SF to be 'normal,' while comparing dollars per SF might suggest something is terribly wrong.*

# SOME SUGGESTED PRINCIPLES OF ENERGY MANAGEMENT

- *One of the most desirable and least reliable skills for an energy manager is to predict the future cost of energy.*
- *To the extent that energy costs escalate in price beyond the rate of general inflation, investment paybacks will be shortened, but of course the reverse is also true.*
- ***Figure 1-4** shows the pattern of energy prices over time. Even the popular conception that energy prices always go up is shown to be false when normalized to constant dollars. This volatility in energy pricing may account for some business decisions that appear overly conservative in establishing rate of return or payback period hurdles.*

# SOME SUGGESTED PRINCIPLES OF ENERGY MANAGEMENT

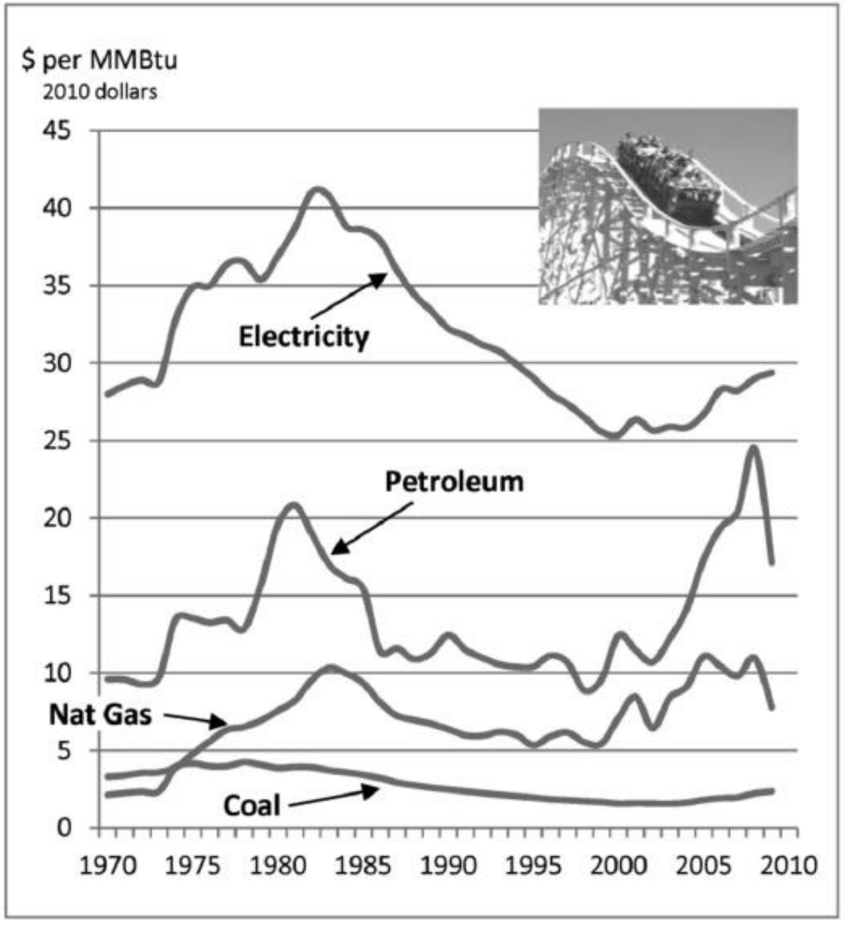



**Figure 1-4. Historical Energy Cost**

Source: Annual Energy Review 2010, Table 3.3 Consumer Price Estimates for Energy by Source, 1970-2009, EIA, October 2011. Values adjusted to constant 2009 dollars, using U.S. BLS CPI figures.

# SOME SUGGESTED PRINCIPLES OF ENERGY MANAGEMENT

- ***(Principle #3):*** *Capturing the 80% meter is a good strategy when aiming directly at savings and tracking the results.*
- *Obviously, when comparing to a benchmark value expressed in kBtu/SF-yr, the comparison is only valid when all energy and all SF are incorporated. This can be especially challenging in campus properties with multiple buildings and a history of add-ons; the power from one building may serve two others and the steam supply may serve other, different buildings. The energy use per SF metric is also important for any facility that reports carbon emissions.*

# SOME SUGGESTED PRINCIPLES OF ENERGY MANAGEMENT

- ***(Principle #4):*** *It is very common and natural for habits to be lax without accountability. "If it's free, I don't care" may be blunt, but underscores the point.*
- *So the concept of 'controls' in this principle include accountability so that energy use and cost are on the operating radar screen. This gives rise to things such as:*
  - *Being sure the utility usage and bills are shared with operations staff*
  - *Tracking energy use and cost in each building of a fleet*
  - *Sub metering of tenant usage*
  - *Sub metering of discrete functions on a property, such as the main boiler house, kitchen, laundry, or data center*

# SOME SUGGESTED PRINCIPLES OF ENERGY MANAGEMENT

- The ***first principle*** is to *control the costs of the energy function or service provided, but not the Btu of energy.*
- The ***second principle*** of energy management is to *control energy functions as a product cost, not as a part of manufacturing or general overhead.*
- The ***third principle*** is to *control and meter only the main energy functions*—the roughly 20% that make up 80% of the costs. As Peter Drucker pointed out some time ago, a few functions usually account for a majority of the costs.
- The ***fourth principle*** is to put *the major effort of an energy management program into installing controls and achieving results*.

# Chapter 2
# Effective Energy Management

# Introduction

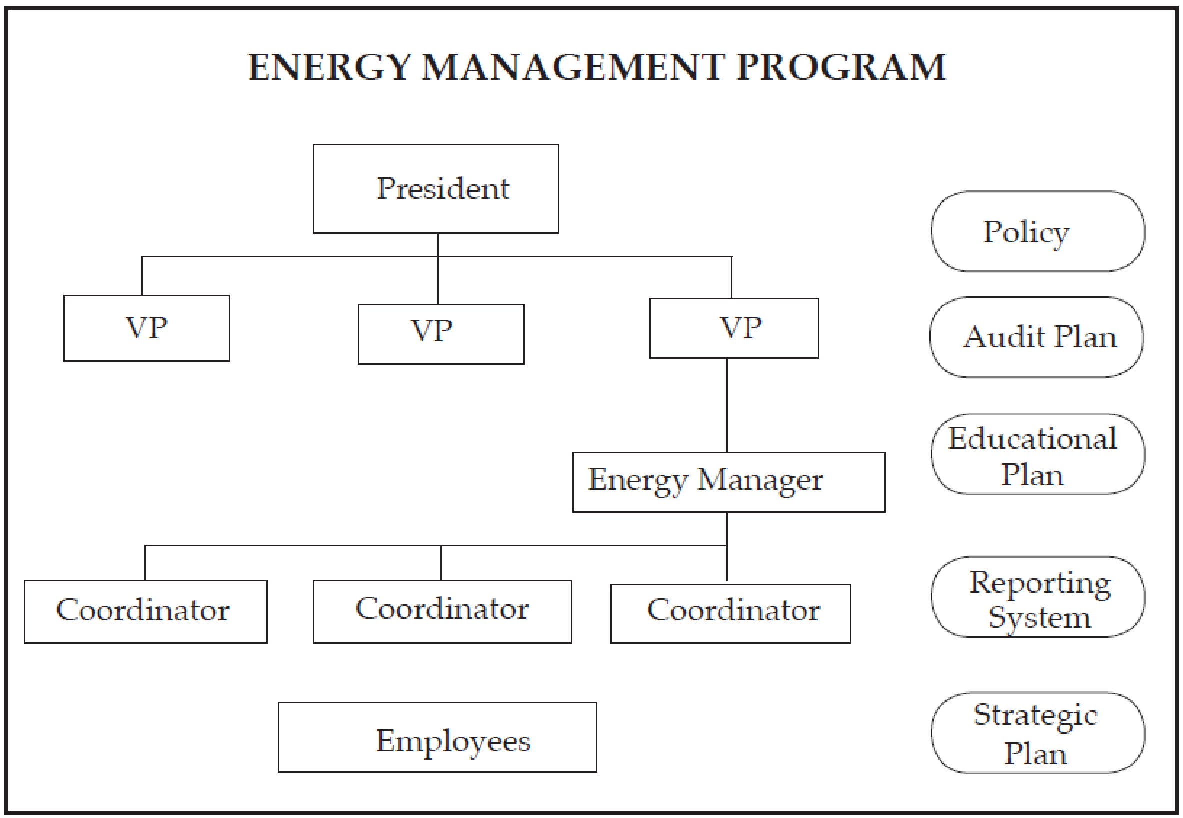
- *Managing energy is not a just technical challenge, but one of how to best implement those technical changes within economic limits, and with a minimum of disruption.*

# Introduction

- Unlike other management fads that have come and gone, such as value analysis and quality circles, the need to manage energy will be permanent within our society.
- There are several reasons for this:
  1. There is a direct economic return.
  2. Most manufacturing companies are looking for a competitive edge.
  3. Energy technology is changing so rapidly that state-of-the-art techniques have a half life of ten years at the most.
  4. Energy security is a part of energy management.
  5. Future price shocks will occur. When world energy markets swing wildly with only a five percent decrease in supply, as they did in 1979, it is reasonable to expect that such occurrences will happen again.

# ENERGY MANAGEMENT PROGRAM

- Program components



# ORGANIZATIONAL STRUCTURE

- **Energy Manager**

- This position should be high enough in the organizational structure to have access to key players in management, and to have a knowledge of current events within the company.

- **Developing a working organizational structure may be the most important thing an energy manager can do**.

# ORGANIZATIONAL STRUCTURE

- In her book titled *Performance Contracting: Expanded Horizons*, Shirley Hansen gives the following requirements for an energy management:
  - Create and maintain an energy management plan
  - Establish energy records
  - Identify outside assistance
  - Assess future energy needs
  - Identify financing sources
  - Make energy recommendations
  - Implement recommendations
  - Provide liaison for the energy committee
  - Plan communication strategies
  - Evaluate program effectiveness

# Chapter 3
# Energy Auditing

*“You can’t manage what you can’t measure”*

# Introduction

- No-cost or very low-cost operational changes can often save a customer or an industry 10-20% on utility bills; capital cost programs with payback times of two years or less can often save an additional 20-30%.

- In many cases these energy cost control programs will also result in both reduced energy consumption and reduced emissions of environmental pollutants.

# Introduction

- An energy audit consists of a detailed examination of how a facility uses energy, what the facility pays for that energy, and finally, a recommended program for changes in operating practices or energy-consuming equipment that will cost-effectively save dollars on energy bills.

- Sometimes called an energy survey or an energy analysis.

- The term "audit" should be avoided if it clearly produces a negative image in the mind of a particular business or individual.

# ENERGY AUDITING SERVICES

- Energy audits are performed by several different groups.
- Electric and gas utilities throughout the country (USA) offer free residential energy audits.
- Some utilities also perform audits for their industrial and commercial customers.

# ENERGY AUDITING SERVICES

- Large commercial or industrial customers may hire an engineering consulting firm to perform a complete energy audit.
- Other companies may elect to hire an energy manager or set up an energy management team whose job is to conduct periodic audits and to keep up with the available energy efficiency technology.
- The U.S. Department of Energy (U.S. DOE) funds a program where universities around the country operate industrial assessment centers which perform free energy audits for small and medium sized manufacturing companies.

# BASIC COMPONENTS OF AN ENERGY AUDIT

- Not all of the procedures described in this section are required for every type of audit.

- The audit process starts by collecting information about a facility's operation and past record of utility bills.
- Data are then analyzed to get a picture of how the facility uses—and possibly wastes—energy, as well as to help the auditor learn what areas to examine to reduce energy costs.
- Specific changes—called energy conservation opportunities (ECOs)—are identified and evaluated to determine their benefits and their cost-effectiveness.
- These ECOs are assessed in terms of their costs and benefits, and an economic comparison is made to rank the various ECOs. Finally, an action plan is created where certain ECOs are selected for implementation, and the actual process of saving energy and saving money begins.

# BASIC COMPONENTS OF AN ENERGY AUDIT

- **The Auditor’s Toolbox**
- **Tape Measures**
- **Lightmeter**
- **Thermometers (& humidity sensors)**
- **Infrared Cameras**
  - can be used to find overheated electrical wires, connections, neutrals, circuit breakers, transformers, motors and other pieces of electrical equipment. They can also be used to find wet insulation, missing insulation, roof leaks, and cold spots. Thus, infrared cameras are excellent tools for both safety related diagnostics and energy savings diagnostics. A good rule of thumb is that if one safety hazard is found during an infrared scan of a facility, then that has paid for the cost of the scan for the entire facility.
- **Voltmeter**
- **Clamp-on Ammeter**
- **Wattmeter/Power Factor Meter**
- **Combustion Analyzer**
- **Airflow Measurement Devices**
  - Measuring air flow from heating, air conditioning, or ventilating ducts, or from other sources of air flow, is one of the energy auditor’s tasks. Airflow measurement devices can be used to identify problems with air flows, such as whether the combustion air flow into a gas heater is correct. Typical airflow measuring devices include a velometer, an anemometer, or an airflow hood.

# BASIC COMPONENTS OF AN ENERGY AUDIT

- **Blower Door Attachment**
  - Building or structure tightness can be measured with a blower door attachment.
- **Smoke Generator**
  - A simple smoke generator can also be used in residences, offices, and other buildings to find air infiltration and leakage around doors, windows, ducts, and other structural features.
- **Safety Equipment**
  - The use of safety equipment is a vital precaution for any energy auditor. A good pair of safety glasses is an absolute necessity for almost any manufacturing facility audit visit. Hearing protectors may also be required on audit visits to noisy plants or areas with high horsepower motors driving fans and pumps. Electrical insulated gloves should be used if electrical measurements will be taken, and thermally insulated gloves should be used for working around boilers and heaters. Breathing masks may also be needed when hazardous fumes are present from processes or materials used. Steel-toe and steel-shank safety shoes may be needed on audits of plants where heavy materials, hot or sharp materials, or hazardous materials are being used.

# BASIC COMPONENTS OF AN ENERGY AUDIT

- **Miniature Data Loggers**
  - Miniature ("mini") data loggers have appeared in low cost models in the last five years. These are often devices that can be held in the palm of the hand and are electronic instruments that record measurements of temperature, relative humidity, light intensity, light on/off, and motor on/off. If they have an external sensor input jack, these little boxes are actually general purpose data loggers. With external sensors they can record measurements of current, voltage, apparent power (kVA), pressure, and $CO_2$.
  - These data loggers have a microcomputer control chip and a memory chip, so they can be initialized and then record data for periods of time from days to weeks.

# BASIC COMPONENTS OF AN ENERGY AUDIT

- **Vibration Analysis Gear**
  - The correlation between machine condition (bearings, pulley alignment, etc.) and energy consumption is related, and this equipment monitors such machine health.
  - This equipment comes in various levels of sophistication and price.
  - At the lower end of the spectrum are vibration pens (or probes) that simply give real-time amplitude readings of vibrating equipment in in/sec or mm/sec. This type of equipment can cost under $1,000. The engineer compares the measured vibration amplitude to a list of vibration levels (ISO2372) and is able to determine if the vibration is excessive for that particular piece of equipment.

# BASIC COMPONENTS OF AN ENERGY AUDIT

- **Preparing for the Audit Visit**
    - Some preliminary work must be done before the auditor makes the actual energy audit visit to a facility.
  - **Energy Use Data**
    - The energy auditor should start by collecting data on energy use, power demand, and cost for at least the previous 12 months
  - **Rate Structures**
    - Energy charges: For electrical use, this is in terms of kWh and is often different for on- and off-peak use. For fuel, this is in terms of gallons of oil, therms of gas, etc. and usually does not differentiate by time of use, although there may be seasonal adjustments (e.g. higher in winter).
    - Electrical Demand Charges: The demand charge is based on a reading of the maximum power in kW that a customer demands in one month. Power is the rate at which energy is used, and it varies quite rapidly for many facilities.
    - Demand charges are often different for on- and off-peak times.
    - Ratchet Clauses: Some utilities have a ratchet clause in their rate structure which stipulates that the minimum power demand charge will be the highest demand recorded in the last billing period or some percentage (i.e., typically 70-75%) of the highest power demand recorded in the last year. The ratchet clause can increase utility charges for facilities during periods of low activity or where power demand is tied to extreme weather.
    - Discounts/Penalties: Utilities generally provide discounts on their energy and power rates for customers who accept power at high voltage and provide transformers on site. They also commonly assess penalties when a customer has a power factor less than 0.9-0.95. Inductive loads (e.g., lightly loaded electric motors, old fluorescent lighting ballasts, etc.) reduce the power factor.
    - Water and wastewater charges.

# BASIC COMPONENTS OF AN ENERGY AUDIT

**Figure 3-1. Sample Summary of Energy Usage and Costs**

| *Month* | *kWh Used (kWh)* | *kWh Cost ($)* | *Demand (kW)* | *Demand Cost ($)* | *Total Cost ($)* |
|---|---|---|---|---|---|
| Mar | 44960 | 1581 | 213 | 1495 | 3076 |
| Apr | 47920 | 1859 | 213 | 1495 | 3354 |
| May | 56000 | 2318 | 231 | 1621 | 3939 |
| Jun | 56320 | 2423 | 222 | 1558 | 3981 |
| Jul | 45120 | 1908 | 222 | 1558 | 3466 |
| Aug | 54240 | 2410 | 231 | 1621 | 4032 |
| Sept | 50720 | 2260 | 222 | 1558 | 3819 |
| Oct | 52080 | 2312 | 231 | 1621 | 3933 |
| Nov | 44480 | 1954 | 213 | 1495 | 3449 |
| Dec | 38640 | 1715 | 213 | 1495 | 3210 |
| Jan | 36000 | 1591 | 204 | 1432 | 3023 |
| Feb | 42880 | 1908 | 204 | 1432 | 3340 |
| Totals | 569,360 | 24,243 | 2,619 | 18,385 | 42,628 |
| Monthly Averages | 47,447 | 2,020 | 218 | 1,532 | 3,552 |

This example is simplified for the sake of illustration. Most rate structures that include demand charges also include time of use charges for on/off peak, and power factor charges.

# BASIC COMPONENTS OF AN ENERGY AUDIT

- **Example:** A company that fabricates metal products gets electricity from its electric utility at the following general service demand rate structure.
- Rate structure:
  - Customer cost = $21.00 per month
  - Energy cost = $0.051 per kWh
  - Demand cost = $6.50 per kW per month
  - Taxes = Total of 8%
  - Fuel adjustment = A variable amount per kWh each month
- Find the energy used cost for this company. Use previous table data.

### Table 3-1. Typical Metrics to Extract From Customer Utility Bills (1)

| Metric | How to Calculate | How Used |
|---|---|---|
| Overall $/kWh | Total electric cost / Total kWh used | Measures defined in terms of kWh savings are converted to $ savings with this factor.<br><br>When high compared to other facilities in the region, this prompts the question "why?" |
| Overall $/therm for gas | Total gas cost / Total therms used | Measures defined in terms of therm savings are converted to $ savings with this factor. |
| Energy Use Index (EUI) in kBtu/SF-yr | Convert electric energy use to kBtu with kWh * 3.413<br><br>Convert gas energy use to kBtu with Therms/100<br><br>Total Gas and Elec kBtu and divide by building SF | EUI values are benchmarked for common building uses.<br><br>Similar strategy for manufacturing, where the EUI is in terms of Btu/lb of milk, Btu per ton of concrete, Btu/gallon of beer, etc.<br><br>Where benchmarks are available, this simple comparison of the customer to their peers establishes whether existing energy use, in general, is high, low, or average and suggests reasonable targets for improvement |
| Overall $/1000 gallons for water and waste | Total water+waste cost / total water gallons used (thousands) | Measures defined in terms of water savings are converted to $ savings with this factor.<br><br>These costs also subtract from measures that use water to save energy such as cooling towers and evaporative cooling. |
| Differential between on-off peak kWh charges | | The higher the differential, the greater the incentive to shift loads to off peak.<br><br>This is a key parameter for economic viability of Thermal Energy Storage (TES) systems. |
| Differential between on-off peak demand charges | | The higher the differential, the greater the incentive to shift loads to off peak.<br><br>This is a key parameter for economic viability of Thermal Energy Storage (TES) systems. |

| | | |
|---|---|---|
| Load factor | Avg. demand / max demand<br>Or<br>(Total kWh per month / days per month / 24hours) / max demand | Customers with low load factors will almost always have high overall $/kWh, since demand charges are a greater portion of the total costs.<br><br>Low load factors are a prompt to suggest ways to level the load – spacing out equipment use to avoid setting peaks. |
| Overall $/therm for electric heating, compared to gas | $/therm electric heating =<br>$/kWh * (100,000/3413)<br><br>$/therm for gas, from above, divide by firing efficiency (e.g. 0.80). | Provides relative benefit of fuel switching options.<br><br>For <u>example</u>, if gas heating cost per therm is 40% less than electric heating, then an electric boiler conversion to gas fired will save 40% in dollars by fuel switching. |
| Fraction of electric bill that is demand | Demand charges / total electric charges | Establishes relative importance of demand charges.<br><br>For <u>example</u>, if demand charges are two thirds of the bill, demand will get more focus than if it is 25% of the bill. |
| Magnitude of power factor charges | Usually denoted on the bill. | Establishes a budget for power factor correction measures.<br><br>For <u>example</u>, with a 3 year payback hurdle, power factor charges of $10,000 per year mean that up to $30,000 in corrective measures would constitute a viable alternative for the customer. |

# BASIC COMPONENTS OF AN ENERGY AUDIT

- **Physical and Operational Data for the Facility**
  - Geographic Location/Weather Data
  - Facility Layout
  - Operating Hours
  - Equipment List: review it before conducting the audit.

# BASIC COMPONENTS OF AN ENERGY AUDIT

- **Energy Audit Safety Considerations**
  - The auditor should be careful when examining any operating piece of equipment, especially those with open drive shafts, belts or gears, or any form of rotating machinery.
  - If necessary, the auditor may need to come back when the machine or device is idle in order to safely get the data.
  - The auditor should never approach a piece of equipment and inspect it without the operator or supervisor being notified first.

# BASIC COMPONENTS OF AN ENERGY AUDIT

- **Safety Checklist**
- General:
  a) Decline any task that does not appear safe. Safety is more important than savings.
  b) Do not enter confined spaces or areas where a respiratory breathing hazard exists, without being properly trained and equipped to do so.
  c) Use two hands on ladders; use shoulder straps to carry tools and note pads when climbing.
  d) Conduct the field work with a helper or with the customer rather than alone.
  e) Do not operate switches, disconnects, valves, or open equipment panels; let the customer do this for you.

# BASIC COMPONENTS OF AN ENERGY AUDIT

- Electrical:
  a) Avoid working on live circuits, if possible.
  b) Securely lock off circuits and switches before working on a piece of equipment.
  c) Always keep one hand in your pocket while making measurements on live circuits to help prevent cardiac arrest.

# BASIC COMPONENTS OF AN ENERGY AUDIT

- Hearing:
  - Use foam insert plugs while working around loud machinery to reduce sound levels up to 30 decibels.
- Clothing:
  a) Avoid loose clothing, especially neck ties.
  b) Remove rings, bracelets, watches, etc. if working near exposed electrical connections.
  c) Wear steel toed shoes in mechanical and machinery areas.

# BASIC COMPONENTS OF AN ENERGY AUDIT

- **Conducting the Audit Visit**
- **Introductory Meeting**
- **Audit Interviews**
- **Walk-through Tour**
- **Getting Detailed Data**
- **Energy Audits: What to Look for**
  - HVAC Equipment
  - Electric Motors
  - Water Heaters
  - Waste Heat Sources
  - Peak Equipment Loads
  - Other Energy-Consuming Equipment:

# BASIC COMPONENTS OF AN ENERGY AUDIT

- **Preliminary Identification of ECOs**
- **Post-Audit Analysis**
- **The Energy Audit Report**

**Energy Audit Report Format**

Executive Summary

- A brief summary of the recommendations showing costs and savings, with a table of ECOs ranked by simple payback.

Table of Contents

Introduction

- Purpose of the energy audit
- Need for a continuing energy cost control program

Facility Description

- Product or service, and materials flow
- Size, construction, facility layout, and hours of operation
- Equipment list, with specifications

Energy Bill Analysis

- Utility rate structures
- Tables and graphs of energy consumptions and costs
- Discussion of energy costs and energy bills

Energy Conservation Opportunities

- Listing of potential ECOs
- Cost and savings analysis
- Economic evaluation

Action Plan

- Recommended ECOs and an implementation schedule
- Designation of an energy monitor and ongoing program

Conclusion

- Additional comments not otherwise covered

# BASIC COMPONENTS OF AN ENERGY AUDIT

- **The Energy Action Plan**
  - The last step in the energy audit process is to recommend an action plan for the facility.
  - The energy action plan lists the ECOs which should be implemented first, and suggests an overall implementation schedule.