Energy Audits

Good energy management begins with an energy audit

Effective management of energy-consuming systems can lead to significant cost and energy savings as well as increased comfort, lower maintenance costs, and extended equipment life. A successful energy management program begins with a thorough energy audit.

The energy audit evaluates the efficiency of all building and process systems that use energy. The energy auditor starts at the utility meters, locating all energy sources coming into a facility. The auditor then identifies energy streams for each fuel, quantifies those energy streams into discrete functions, evaluates the efficiency of each of those functions, and identifies energy and cost savings opportunities.

Audit activities, in general order, include:

- Identify all energy systems
- Evaluate the condition of the systems
- Analyze the impact of improvements to those systems
- Write up an energy audit report

The report documents the use and occupancy of the building and the condition of the building and building systems equipment. The report also recommends ways to improve efficiency through improvements in operation and maintenance items (O&M), and through installation of energy conservation measures (ECM).

Degrees of Thoroughness

Audit levels, in order of increasing complexity are:

Level 1-The walk-through audit. The walk-through audit is a tour of the facility to visually inspect each system. The walk-through includes an evaluation of energy consumption data to analyze energy use quantities and patterns, as well as to provide comparisons with industry averages, or benchmarks, for similar facilities. This is the least costly audit, but a level 1 audit can yield a preliminary estimate of savings potential and a list of low-cost savings opportunities through improvements in operational and maintenance practices. The level 1 audit information may be used for a more detailed audit later if the preliminary savings potential appears to warrant further auditing activity.

Level 2-Standard audit. The standard audit quantifies energy use and losses through a more detailed review and analysis of equipment, systems, operational characteristics, and on-site measurements and testing. Standard energy engineering calculations are used to analyze efficiencies and calculate energy and cost savings based on improvements and changes to each system. The standard audit will also include an economic analysis of recommended ECMs.

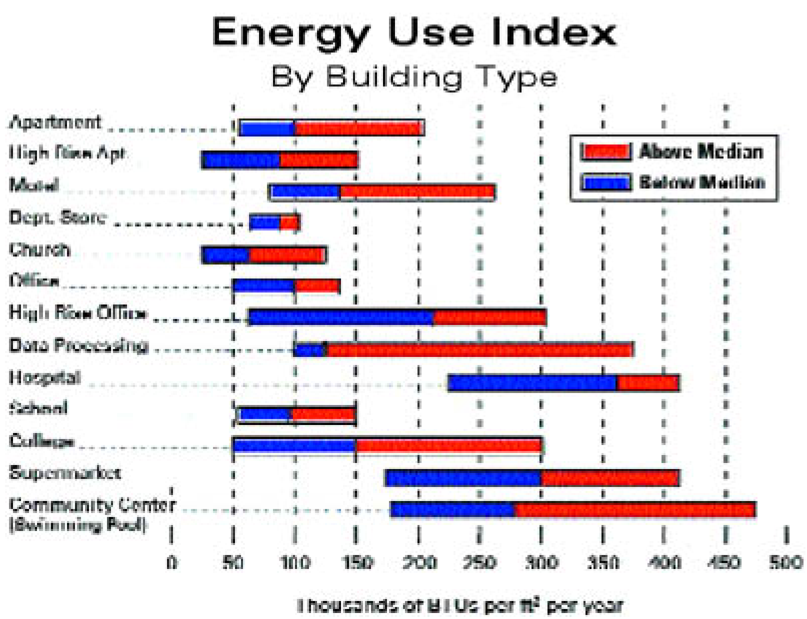
Level 3-Computer simulation. The level 3 audit is the most expensive level of energy audit and is most often warranted for complex facilities or systems. The audit includes more detailed energy use by function and a more comprehensive evaluation of energy use patterns. Computer simulation software is used to predict building system performance and accounts for changes in weather and other conditions. The goal is to build a base for comparison that is consistent with the actual energy use of the facility. The auditor will then make changes to improve the efficiency of various systems and measure the effects compared to the baseline. This method also accounts for interactions between systems to help prevent overestimation of savings.

The Audit Process

The first step is to determine which audit is appropriate for a facility, given the complexity of its systems and buildings. Then, information may be collected on the structural and mechanical components that affect building energy use and the operational characteristics of the facility. Much of this information can be collected prior to the site visit. Evaluating energy use and systems before going on-site helps identify potential savings and makes best use of time spent on-site.

The audit consists of three distinct steps: *preliminary data collection and evaluation, site visit, and analysis and reporting.* An estimate of the time for each step can be made. Allocating time for each step leads to a more comprehensive and useful audit report. The following sections describe the tasks associated with each step of the audit process.

Preliminary Data Collection



A pre-site review of building systems and their operation should generate a list of specific questions and issues to be discussed during the actual visit to the facility.

This preparation will help ensure the most effective use of your on-site time and minimize disruptions to building personnel. A thorough pre-site review will also reduce the time required to complete the on-site portion of the audit.

The first task is to collect and review two years worth of utility energy data for all fuels, including electricity, natural gas, fuel oil, and any other delivered fuels. This information is used to analyze operational characteristics, calculate energy benchmarks for comparison to industry averages, estimate savings potential, set an energy reduction target, and establish a baseline to monitor the effectiveness of implemented measures.

Several steps must be taken to ensure you have all the information required to do a thorough and accurate evaluation of energy consumption data.

- Make sure you receive copies of all monthly utility bills (for all meters) and delivered fuel invoices.
- Sort utility bills by building or by meter and organize them into 12-month blocks using the meter-read dates.

- Locate all meters and sub-meters. If numerous meters are used, label them on a site plan.
- Determine which building or space is served by which meter.
- Calculate the conditioned area (in square feet) for each building.

Use a computer spreadsheet to enter, sum, and calculate benchmarks and to graph utility information. Record energy units (kWh, therms, gallons, etc.), electric demand (kW), and cost for each fuel type. Units of production (number of units, occupied rooms, students, persons served, etc.) should also be included when energy use depends on production. Relationships between energy use and those factors that drive energy use can be determined by analyzing the data. Some of these factors include occupancy, sales volume, floor area, and outdoor temperatures.

The Energy Use Index

The Energy Use Index (EUI) is expressed in British Thermal Units/square foot/year ($BTU/ft^2/yr$) and can be used to compare energy consumption to similar building types or to track consumption from year to year in the same building. The EUI is calculated by converting annual consumption of all fuels to BTUs, then dividing by the area (gross square footage) of the building. EUI is a good indicator of the relative potential for energy savings. A comparatively low EUI indicates less potential for large energy savings.

By tracking the EUI using a rolling 12-month block, building performance can be evaluated based on increasing or decreasing energy use trends. This method requires a minimum of two years of energy consumption data to establish the trend line.

To calculate BTUs and cost per square foot, the heated (or cooled) area to be calculated must be determined for each building. Blueprints can be used to obtain the dimensions of each floor, or the outside of the building (gross area) can be measured. The total building area is found by multiplying this area by the number of floors. Basement areas and mechanical rooms are not usually included as conditioned areas.

Load Factor

Evaluating use (kilowatt-hours [kWh]), power (kilowatts [kW]), and power factor charges separately can be useful in evaluating the impact of demand and power factor penalties on the monthly electric bill. Rescheduling or alternating run times of larger equipment can lower demand costs. Power factor correction devices can have paybacks of less than two years. Although demand and power factor correction measures save little energy, the significant cost savings and relatively short payback periods make them attractive in the audit analysis.

There is a difference between billing and actual demand on the utility bill. Actual demand is the value registered on the meter and should be used to evaluate power requirements and load factor for the facility. Billing demand is the amount of demand for which the facility is billed. Rate schedules that include a ratchet clause, power factor adjustment, or first block of kW at no charge can cause billing and actual demand to differ.

Load factor (LF) is the relationship between electric use (kWh) and demand (kW). LF is commonly calculated by dividing the monthly electric use by the demand by the number of hours in the billing period. This gives a ratio of average demand to peak demand and is a good indicator of the cost savings potential of shifting some electric loads to off-peak hours to reduce overall demand.

The theoretical maximum load factor for a facility that consumes electricity at a steady rate at the highest demand registered on the demand meter is 1 (one). An LF of 1 indicates that there is no variation in consumption or time of day peaks in demand. Most facilities don't operate 24 hours a day, so load factors will normally be considerably lower than the theoretical maximum. For facilities with high load factors, the only way to reduce demand is by installing more efficient electrical equipment. A low load factor is a good indication that a facility has demand peaks at some time in the billing period. The causes of these demand peaks need to be identified and controlled.

Operation of nonessential equipment can be restricted during peak demand periods and rescheduled for operation during off peak hours. Many energy management control systems (EMCS) have demand limiting and load shedding capabilities that can help maintain acceptable load factors. The important thing is to monitor the load factor and establish what is normal for each facility, noting any significant changes in the electric use consumption and load factor.

Analyzing Energy Data

Graphs and consumption data must be analyzed to understand how energy is used at the facility and which factors influence consumption the most. This is done by identifying how each energy using system in the building operates during the year. Annual energy use is allocated to either base or seasonal loads, and equipment is matched to each category.

Energy data should be organized into a presentation that includes graphs, tables, and pie charts, which make it easier to see consumption trends and understand how each building uses energy. Presented visually, the information is more appealing and easier to understand than text-only format.

Looking at Loads

Base loads consist of energy-using systems that consume a continuous amount of energy throughout the year. The base load can be established by drawing a horizontal line across a graph of energy consumption or cost at the average point of lowest consumption for each energy type. The base load is that portion of consumption or cost below the line. Base loads include lighting, office equipment, appliances, domestic hot water, and ventilation. High base loads indicate that energy management efforts should be focused in these areas.

Seasonal loads, such as heating and air conditioning, are identified as the portion of consumption or cost located above the line used to establish base loads on the graph. Seasonal loads can be the result of changes in weather or operation of the building.

High seasonal loads may reveal opportunities to reduce consumption by making improvements to the heating and air conditioning equipment, temperature controls, the building envelope, or to other systems which are affected by seasonal operation.

After utility use has been allocated to seasonal or base loads, the auditor should prepare a list of the major energy-using systems in the building and estimate the time when each system is in operation throughout the year. The list will help identify how each system uses energy and potential savings.

Those building systems with the greatest savings potential are easier to discover when the seasonal and base loads are understood. Building systems such as heating, cooling, lighting, and hot water can then be targeted for more detailed data collection.

One of the easiest ways to evaluate energy data is to watch for the trends in use, demand, or costs over time. Either graphing two or more years of monthly data on one graph or graphing only the annual totals for several years can help.

Another useful method for evaluating monthly data is a rolling summary where a new 12-

month total is calculated each month by dropping the oldest month and adding the newest.

This curve will remain relatively flat if there are no significant changes in energy use. Even though each monthly figure is an annual total, any sudden change is the result of that month's operation. This is a good graph to see the overall consumption trends of the facility. A gradual increase, for example, may indicate that occupancy or production has increased, or that system efficiency is slowly degrading.

Another useful method for evaluating monthly data is a rolling summary where a new 12-month total is calculated each month by dropping the oldest month and adding the newest.

Building Profile

Obtaining mechanical, architectural, and electrical drawings and specifications for the original building as well as for any additions or remodeling work that may have been done is the first step to creating a building profile. Any past energy audits or studies should be reviewed.

The auditor can use this information to develop a building profile narrative that includes age, occupancy, description, and existing conditions of architectural, mechanical, and electrical systems. The profile should note the major energy-consuming equipment or systems and identify systems and components that are inherently inefficient.

Having several copies of a simple floor plan of the building will be useful for notes during the site visit. A separate copy should be made for noting information on locations of HVAC equipment and controls, heating zones, light levels, and other energy-related systems. If architectural drawings are not available, emergency fire exit plans are usually posted on each floor; these plans are a good alternative for a basic floor plan.

A site sketch of the building or complex should also be made. The sketch should show the relative location and outline of each building; name and building number of each building; year of construction of each building and additions; dimensions of each building and additions; location, fuel type and identification numbers of utility meters; central plants; and orientation of the complex.

While completing the pre-site review, the auditor should note areas of particular interest and write down any questions about the lighting systems and controls, HVAC zone controls, or setback operation. Other questions may regard equipment maintenance practices. At this point the auditor should discuss preliminary observations with the building manager or operator by phone. The building manager or operator should be asked about their interest in particular conservation projects or planned changes to the building or its systems. The audit should be scheduled when key systems are in operation and when the building operator can take part.

Potential ECM and O&M procedures can be developed during this preliminary research phase. These can be discussed with the building operator or manager at the time of the site visit.

The Site Visit

The site visit will be spent inspecting actual systems and answering specific questions from the preliminary review. A full day should be allocated on-site for each building. The amount of time required will vary depending on the completeness of the preliminary information collected, the complexity of the building and systems, and the need for testing equipment.

Prior to touring the facility, the auditor and building manager should review the auditor's energy consumption profiles. The building manager can provide occupancy schedules, O&M

practices, and plans that may have an impact on energy consumption. This kind of information can help identify times when building systems such as lighting, recirculating pumps, or outside air ventilation can be turned off and temperatures set back.

Analysis and Reporting

Post-site work is a necessary and important step to ensure the audit will be useful. The auditor needs to evaluate the information gathered during the site visit, research possible conservation opportunities, organize the audit into a comprehensive report, and make recommendations on mechanical, structural, operational and maintenance improvements.

Immediately after the audit, the auditor should review and clarify notes from the site visit and complete information obtained during the audit so it isn't forgotten. More copies of the floor plan can be used to clean up notes for permanent records. Photos should be labeled, identified, and matched to a floor plan.

Proposed ECM and O&M lists should be reviewed. Measures lacking potential should be eliminated and an explanation provided. Preliminary research on potential conservation measures should be developed along with energy savings calculations and cost estimates.

After the retrofit options are analyzed, the cost effectiveness of each ECM needs to be determined. A number of methods have been developed to provide a uniform method of comparison.

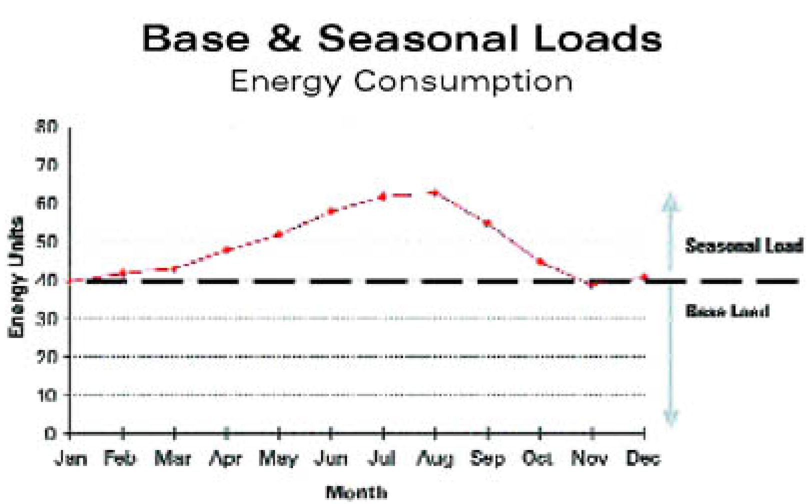
The least complicated of these methods is referred to as simple payback (SPB). SPB is calculated by dividing the cost of the retrofit by the energy cost savings. The result is the number of years after which the investment will have paid for itself. Those projects with the shortest paybacks are assumed to be the most cost effective.

Simple Payback = First Cost/Energy Savings

SPB is the easiest method to use and does not require any consideration of future value factors such as discount rates, inflation and other annual costs during the life of the measure.

Other more sophisticated types of payback analyses involve consideration of changes in operating costs, return rates on money invested, fuel cost escalations, and life cycle costing. The two other most common economic evaluation methods used in energy audit reports include net present value and life cycle cost.

The Audit Report



The audit report should be prepared keeping in mind the various audiences that will be using each section. Each section should be customized to most effectively reach that audience.

Audiences for audit reports may include:

- Administrator/superintendent
- Facilities and plant managers
- Comptroller
- Plant engineer
- O&M

The following outlines the basic components of a well-organized audit report:

1. Executive Summary

The executive summary should be a simple, straightforward, and to the point explanation of the current situation and recommended improvements, outlining the advantages of those improvements. The executive summary should include a brief introduction to the facility and describe the purpose of the audit and overall conclusions. An executive may read no further than this one- or two-page introduction, so a list of recommended actions is essential.

2. Building Information

This section provides a general background of the facility, the mechanical systems, and operational profile. A description of the building envelope, age and construction history, operating schedules, number of employees, occupancy patterns, and a discussion of the operation and maintenance program should be included.

The building information section should also contain a floor plan, selected photos of the facility and mechanical systems, a description of energy types used in the plant, and a description of the primary mechanical systems and controls.

3. Utility Summary

The utility summary provides energy accounting information for the last two years as well as selected charts and graphs. The charts and graphs should be easy to understand and demonstrate the overall consumption patterns of the facility.

Actual monthly consumption by fuel type may be of more interest to the engineering and maintenance staff while annual costs or dollar-savings information may be more appropriate for administrative personnel. Pie charts of energy use and cost by fuel type can offer compelling documentation of overall energy uses and expenses. The utility summary also includes reports of overall facility benchmarks, energy use indices, and comparisons with industry averages. A copy of the utility rate schedules and any discussion or evaluation of rate alternatives for which the facility may qualify can be part of this section.

4. ECMs

The ECM section summarizes the energy conservation measures that meet the financial criteria established by the facility owner or manager. The report should provide the estimated cost, estimated savings, and simple payback for each measure in a summary chart. A one- or two-page description of each energy conservation measure and support calculations should follow this summary chart. The description should describe each ECM and include energy use and savings calculations, as well as economic analysis and provide any assumptions that were made regarding operation or equipment efficiency. ECMs that were considered but did not meet financial criteria should also be identified.

5. O&M measures

Observations include items that will reduce energy consumption and costs, address existing problems, or improve practices that will help prolong equipment life of systems not being retrofit. Cost and savings estimates of each O&M recommendation are listed.

6. Appendices

Information in this section may include floor plans and site notes; photos; audit data forms; motor, equipment, and lighting inventories; and equipment cut sheets of existing or recommended systems.

Followup

The building manager should review the audit report with the auditor to become familiar with ECMs and methods of funding the ECMs. The building manager must also understand how to provide training for building operators and occupants to improve the operating efficiency of the building.

Energy audits provide the information that energy managers need to identify energy consumption patterns and components of a facility and document existing conditions, Energy conservation opportunities can be identified and prioritized. By taking an open-minded and methodical approach to the audit process, it is possible to identify and avoid unnecessary expenditures in most facilities while improving building operation and comfort. Occupants will welcome the improvements and management will appreciate the reduced energy costs.

Reference:
http://www.energyusernews.com