B.Sc. Mechanical Engineering

ME 415: Energy Management and Planning 3(2,1)

Lectures

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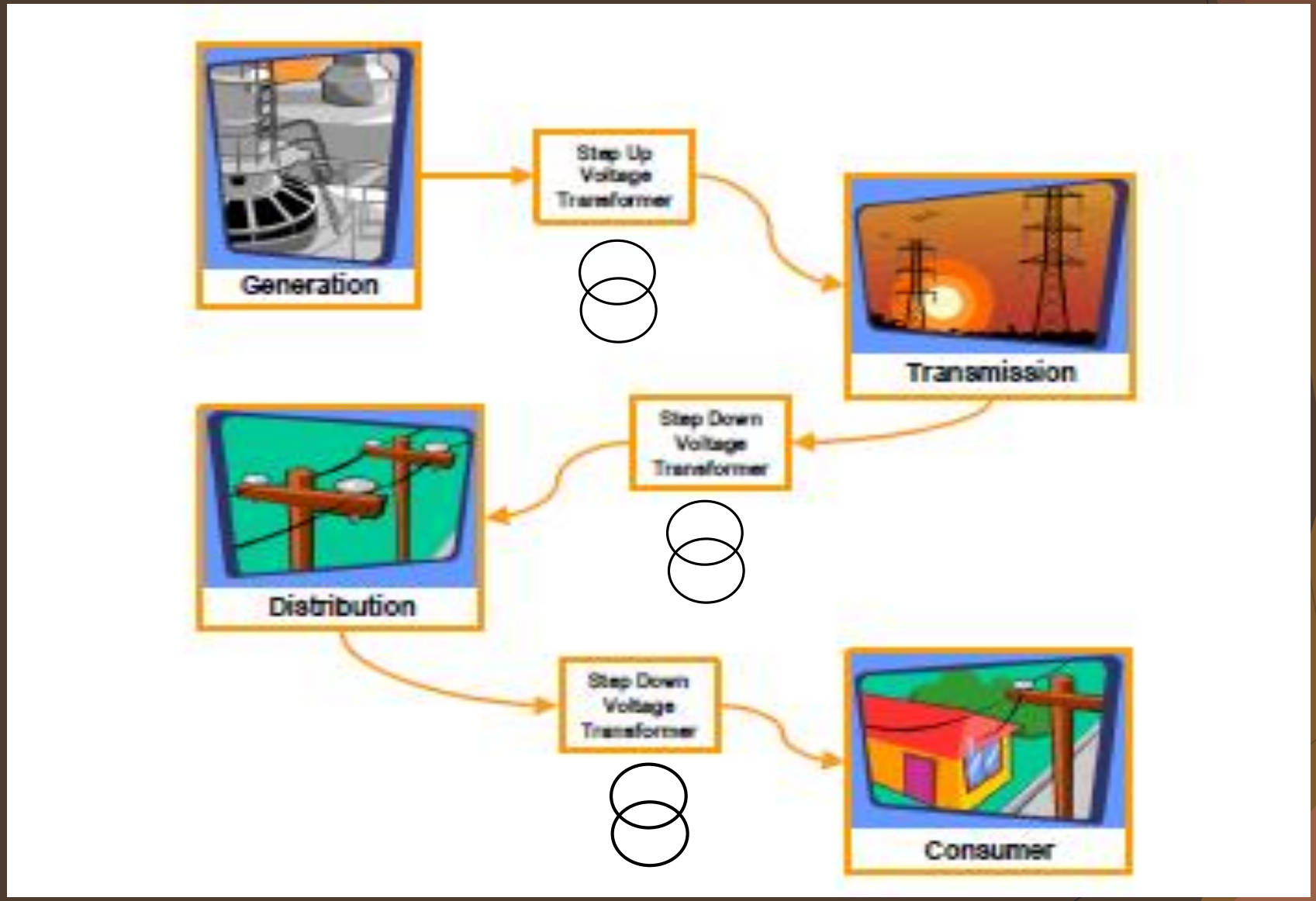
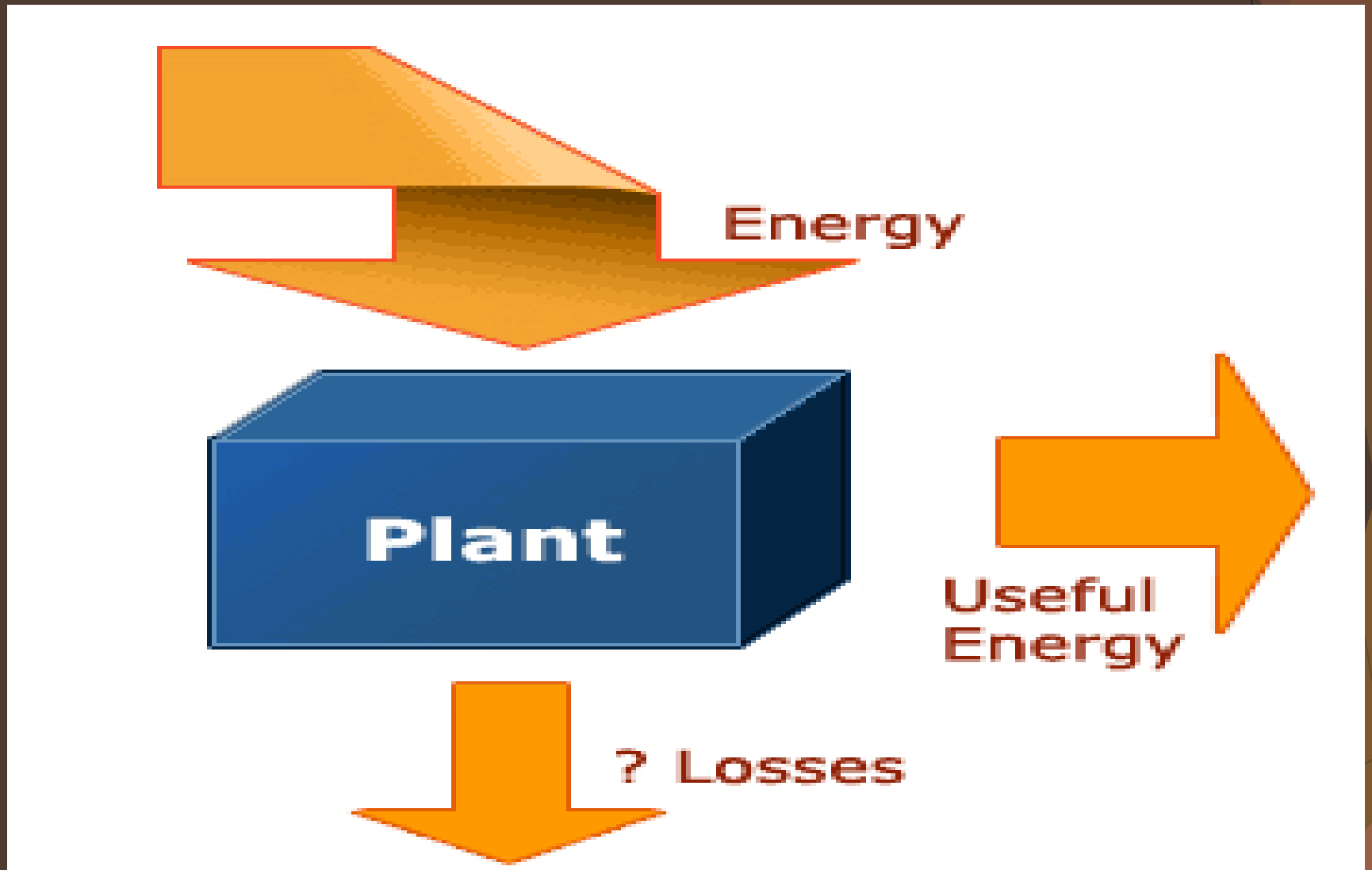
ENERGY AUDIT


Generation
Step Up Voltage Transformer
Transmission
Step Down Voltage Transformer
Distribution
Step Down Voltage Transformer
Consumer


Energy
Plant
Useful
Energy
? Losses

Energy Loss

Where and how do most of the losses occur, how much energy is actually lost and are they controllable or recoverable? The answers to these questions remain well concealed in a black box where once energy is input, we do not know what really happens to it inside and how much the losses are. It is only when we look into the black box and extract these details that we are able to ascertain the performance of the overall or process levels and respond more effectively to the weaknesses in energy management.

Energy audit:

Energy audit is a systematic study or survey to identify how energy is being used in a building or plant, and identifies energy savings opportunities. Using proper audit methods and equipment, an energy audit provides the energy manager with essential information on how much, where and how energy is used within an organization (factory or building).

Contents:

- Phases of Energy Audit:

Phase 1….Preparing for Energy Audit

Phase 2….The Facility Inspection

Phase 3….Implementations

Phase 1

Preparing for Energy Audit

The energy audit process starts with an examination of the historical and descriptive energy data for the facility. Specific data that should be gathered in this preliminary phase contains:

- Gathering Data on Facility
- Tools for the Audit
- Safety Considerations.

Gathering Data on Facility

- Gathering Data on Facility includes:

  - Analysis of Bills
  - Geographic Location / Weather Data
  - Facility Layout
  - Operating Hours
  - Equipment List

Analysis of Bills

The audit must begin with a detailed analysis of the energy bills for the previous twelve months. This is important for several reasons: the bills show the proportionate use of each different energy source when compared to the total energy bill; an examination of where energy is used can point out previously unknown energy wastes.

Sample of Energy Bill Form

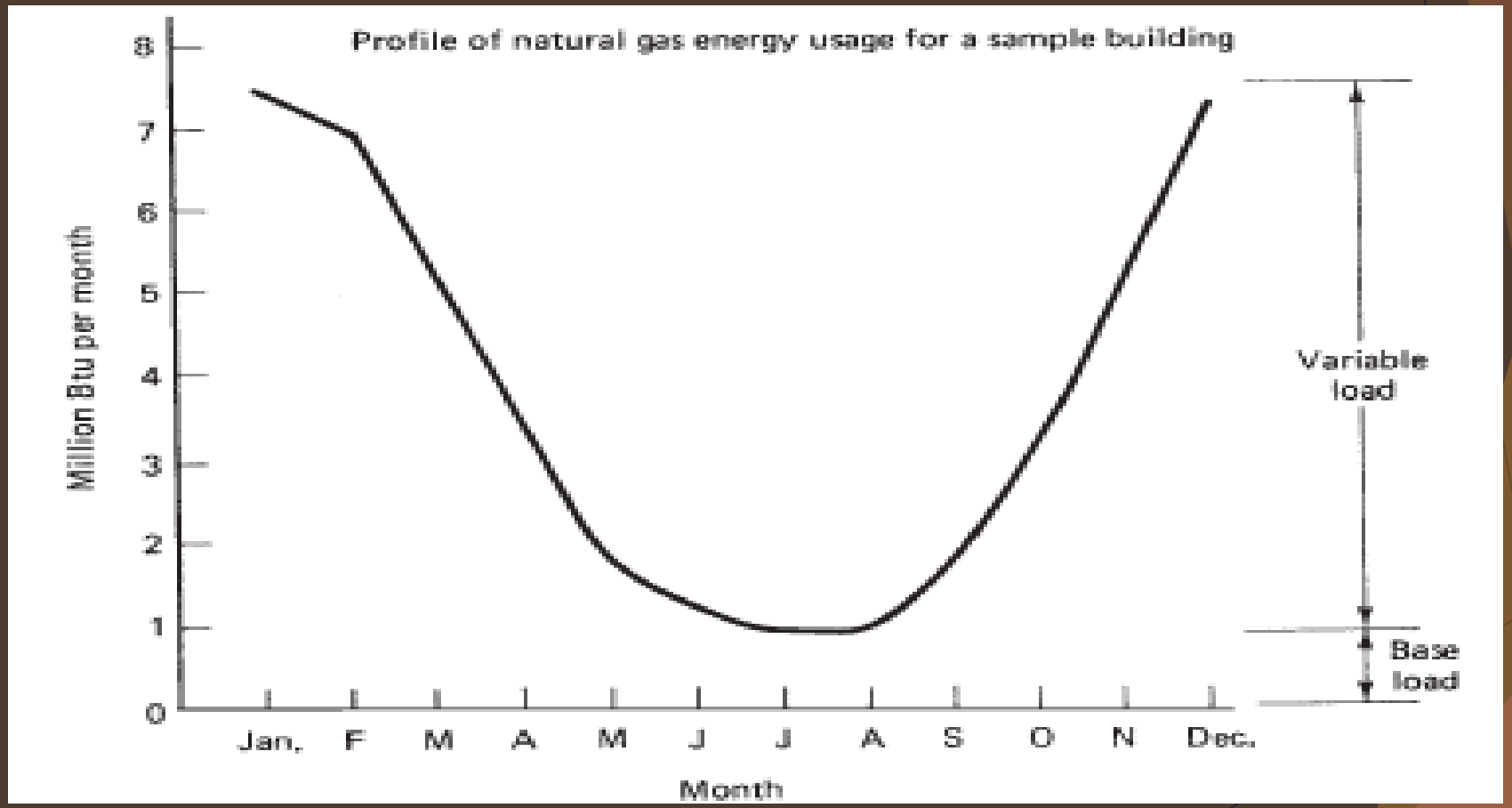
Location/Meter #_____

From _____ to _____
(Mo./Yr.) (Mo./Yr.)

	Electrical use			Gas use			Fuel oil	
Month	Peak kW	Usage: kWh	Cost	MMCF[a]	Dth[b]	Cost	Gallons	Cost

[a] 1 MMCF = 10^6 ft^3
[b] 1Dth = 10 therms = 10^6 Btu

Graph of Energy Consumption



Geographic Location / Weather Data

The geographic location of the facility should be noted, together with the weather data for that location. The state energy office can provide the average degree days for heating and cooling for that location for the past twelve months. This degree-day data will be very useful in analyzing the energy needed for heating or cooling the facility. *Heating degree days* (HDD) are specific to a particular geographic location. The degree day concept assumes that the average building has a desired indoor temperature of 70°F,

Geographic Location / Weather Data

and that 5°F of this is supplied by internal heat sources such as lights, appliances, equipment, and people. Thus, the base for computing HDD is 65°F. If there were a period of three days when the outside temperature averaged 50°F each day, then the number of HDD for this three day period would be:

HDD = (65° – 50°) × 3 days = 45 degree days.

Facility Layout

Next the facility layout or plan should be obtained, and reviewed to determine the facility size, floor plan, and construction features such as wall and roof material and insulation levels, as well as door and Window sizes and construction. A set of building plans could supply this information in sufficient detail.

Operating Hours

Operating hours for the facility should also be obtained. How many shifts does the facility run? Is there only a single shift? Are there two? Three? Knowing the operating hours in advance allows some determination as to whether any loads could be shifted to off-peak times. Adding a second shift can often reduce energy bills because the energy costs during second and third shifts are usually substantially cheaper. In Chapter Three for an explanation of on-peak and off-peak electric rates.

Equipment List

Finally, the auditor should get an equipment list for the facility and review it before conducting the audit. All large pieces of energy Consuming equipment such as heaters, boilers, air conditioners, chillers, water heaters, and specific process-related equipment should be identified. This list, together with data on operational uses of the equipment allows the auditor to gain a good understanding of the major energy-consuming tasks or equipment at the facility.

Tools for the Audit

To obtain the best information for a successful energy cost control program, the auditor must make some measurements during the audit visit. The amount of equipment needed depends on the type of energy consuming equipment used at the facility. For example, if waste heat recovery is being considered, then the auditor must take substantial temperature measurement data from potential heat sources. Tools commonly needed for energy audits include the following:

Tools for the Audit

- **Tape Measures**
- **Light meter**
- **Thermometer**
- **Voltmeter**
- **Wattmeter / power factor meter**
- **Combustion Analyzer**
- **Ultrasonic leak Detector**
- **Air flow measurement Devises**
- **Safety Equipment.**

Safety Considerations

Safety is a critical part of any energy audit. The auditor and the audit team should have a basic knowledge of safety equipment and procedures. Before starting the facility tour, the auditor or audit team should be thoroughly briefed on any specialized safety equipment and procedures for the facility. They should never place themselves in a position Where they could injure themselves or other people at the facility.

Safety Checklist

Electrical:

- Avoid working on live circuits, if possible.
- Securely lock circuits and switches in the off position before working on a piece of equipment.
- Always keep one hand in your pocket while making measurements on live circuits to help prevent accidental electrical shocks.

Respiratory:

- When necessary, wear a full face respirator mask with adequate filtration particle size.

Safety Checklist

- Use activated carbon cartridges in the mask when working around low concentrations of noxious gases.
- Use a self-contained breathing apparatus for work in toxic environments.

Hearing:

- Use foam insert plugs while working around loud machinery to reduce sound levels by nearly 30 decibels.

Phase 2

The Facility Inspection

Facility Inspection

The facility inspection is an important part of the overall audit process. Data gathered on this tour, together with an extensive analysis of this data will result in an audit report that includes a complete description of the time-varying energy consumption patterns of the facility, a list of each piece of equipment that affects the energy consumption together with an assessment of its condition, a chronology of normal operating and maintenance practices, and a list of recommended energy management ideas for possible implementation.

Steps in completing 2nd phase

Introductory Meeting

The audit leader should start the audit by meeting with the facility manager and the maintenance supervisor. He should briefly explain the purpose of the audit and indicate the kind of information the team needs to obtain during the facility tour. If possible, a facility employee who is in a position to authorize expenditures or make operating policy decisions should be at this initial meeting.

Audit Interviews

Getting the correct information on facility equipment and operation is important if the audit is going to be most successful in identifying ways to save money on energy bills. The company philosophy towards investments, the impetus behind requesting the audit, and the expectations from the audit can be determined by interviewing the general manager, chief operating officer, or other executives. The facility manager or plant manager should have access to much of the operational data on the facility, and a file of data on facility equipment. The finance officer can provide any necessary financial records, such as utility bills for electric, gas, oil, other fuels, water and wastewater, expenditures for maintenance and repair, etc.

Audit Interviews (cont..)

The auditor must also interview the floor supervisors and equipment operators to understand the building and process problems. Line or area supervisors usually have the best information on the times their equipment is used. The maintenance supervisor is often the primary person to talk to about types of lighting and lamps, sizes of motors, sizes of air conditioners and space heaters, and electrical loads of specialized process equipment. Finally, the maintenance staff must be interviewed to find the equipment and performance problems.

Initial Walk-through Tour

An initial facility/plant tour should be conducted by the facility/ plant manager, and should allow the auditor or audit team to see the major operational and equipment features of the facility. The main purpose of the initial tour is to obtain general information, and to obtain a general understanding of the facility's operation. More specific information should be obtained from the maintenance and operational people during a second, and more detailed data collection tour.

Gathering Detail Data

Following the initial facility or plant tour, the auditor or audit team should acquire the detailed data on facility equipment and operation that will lead to identifying the significant Energy Management Opportunities (EMOs) that may be appropriate for this facility. This data is gathered by examining the nine major energy-using systems in the facility.

As each of these systems are examined, the following questions should be asked:

Gathering Detail Data

1. What function(s) does this system serve?
2. How does this system serve its function(s)?
3. What is the energy consumption of this system?
4. What are the indications that this system is probably working?
5. If this system is not working, how can it be restored to good working
   condition?
6. How can the energy cost of this system be reduced?
7. How should this system be maintained?
8. Who has direct responsibility for maintaining and improving the operation and energy efficiency of this system?

Examination of Different Systems

- The building envelope
- The boiler and steam distribution system
- The heating, ventilating, and air conditioning system
- The electrical supply system.
- Lights, windows, and reflective surfaces
- The hot water distribution system
- Air compressors and the air distribution system.
- Motors
- Manufacturing processes

System: Envelope

Component	Location	Maintenance condition	Est. air gap (total)
Door	North side	Poor	0.2 ft^2
	South	OK	0.05 ft^2
	Gymnasium	Good	None
Windows	North	Some broken	2.2 ft^2
	East	OK	None
Roof	Main building	No insulation	

Completed inspection form for building envelope.

Lightening System

Area	Type of lighting (e.g., HPS)	Watts per fixture	Number of fixtures	Total kW	Operating hours	Operating days	kWh/month
Interior							
____	_____	_____	_____	_____	_____	_____	_____
____	_____	_____	_____	_____	_____	_____	_____
____	_____	_____	_____	_____	_____	_____	_____
____	_____	_____	_____	_____	_____	_____	_____
____	_____	_____	_____	_____	_____	_____	_____
____	_____	_____	_____	_____	_____	_____	_____
Exterior							
____	_____	_____	_____	_____	_____	_____	_____
____	_____	_____	_____	_____	_____	_____	_____
____	_____	_____	_____	_____	_____	_____	_____
____	_____	_____	_____	_____	_____	_____	_____
____	_____	_____	_____	_____	_____	_____	_____
____	_____	_____	_____	_____	_____	_____	_____

Data collection form for lighting system.

Preliminary Identification of Energy Management Opportunities

As the audit is being conducted, the auditor should take notes on potential EMOs that are evident. As a general rule, the greatest effort should be devoted to analyzing and implementing the EMOs which show the greatest savings, and the least effort to those with the smallest savings potential. Therefore, the largest energy and cost activities should be examined carefully to see where savings could be achieved.

Preliminary Identification of Energy Management Opportunities

Identifying EMOs requires a good knowledge of the available energy efficiency technologies that can accomplish the same job with less energy and less cost. For example, over-lighting indicates a potential lamp removal or lamp change EMO, and inefficient lamps indicate a potential lamp technology change. Motors with high use times are potential EMOs for high efficiency replacements. Notes on waste heat sources should indicate what other heating sources they might replace, and how far away they are from the end use point. Identifying any potential EMOs during the walk-through will make it easier later on to analyze the data and to determine the final EMO recommendations

The Energy Audit Report

The next step in the energy audit process is to prepare a report which details the final results of the energy analyses and provides energy cost saving recommendations. The length and detail of this report will vary depending on the type of facility audited. A residential audit may result in a computer printout from the utility. An industrial audit is more likely to have a detailed explanation of the EMOs and benefit-cost analyses.

Energy Audit Report Format

- Executive Summary

A brief summary of the recommendations and cost savings

- 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 Audit Report Format

- Energy Bill Analysis

Utility rate structures

Tables and graphs of energy consumptions and costs

Discussion of energy costs and energy bills

- Energy Management Opportunities

Listing of potential EMOs

Cost and savings analysis

Economic evaluation

Energy Audit Report Format

- Energy Action Plan

Recommended EMOs and an implementation schedule

Designation of an energy monitor and ongoing program

- Conclusion

Additional comments not otherwise covered

The Energy Action Plan

An important part of the energy audit report is the recommended action plan for the facility. Some companies will have an energy audit conducted by their electric utility or by an independent consulting firm, and will then make changes to reduce their energy bills. They may not spend any further effort in the energy cost control area until several years in the future when another energy audit is conducted. In contrast to this is the company which establishes a permanent energy cost control program, and assigns one person—or a team of people—to continually monitor and improve the energy efficiency and energy productivity of the company.

Phase 3

Implementation

IMPLEMENTING THE AUDIT RECOMMENDATIONS

The Energy Action Team:

Now that the preliminary audits have uncovered some energy management measures that can save significant amounts of money or can substantially improve production, funding for the changes and employee support are two additional critical ingredients for success. These can best be obtained with the help of a committee, preferably called something like the energy action team.

Functions of the Energy Action Committee

1. Create support within the company for energy management.
2. Generate new ideas.
3. Evaluate suggestions
4. Set goals.
5. Implement the most promising ideas.

Monitoring

Energy management is not complete without monitoring and its associated feedback, and neither is the energy audit process. In an energy audit, monitoring discloses what measures contributed toward the company goals, what measures were counterproductive, and whether the goals themselves were too low or too high.