TUTORIAL - 3

Energy Audit and Energy Information System

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1. What is an Energy Audit? Write Difference between Preliminary & Detailed Energy Audits.

- Energy Audit is the key to a systematic approach for decision-making in the area of energy management. It attempts to balance the total energy inputs with its use, and serves to identify all the energy streams in a facility. It quantifies energy usage according to its discrete functions. Industrial energy audit is an effective tool in defining and pursuing comprehensive energy management programme.

- As per the Energy Conservation Act, 2001, Energy Audit is defined as "the verification, monitoring and analysis of use of energy including submission of technical report containing recommendations for improving energy efficiency with cost benefit analysis and an action plan to reduce energy consumption".

➢ Two types of energy audit

1) Preliminary Energy Audit
2) Detailed Energy Audit

➢ **<u>Difference between Preliminary Energy Audit and Detailed Energy Audit</u>**

1. **Preliminary energy audit** is a relatively quick exercise to:

   - Establish energy consumption in the organization
   - Estimate the scope for saving
   - Identify the most likely (and the easiest areas for attention)
   - Identify immediate (especially no-/low-cost) improvements/ savings
   - Set a 'reference point'
   - Identify areas for more detailed study/measurement
   - Preliminary energy audit uses existing, or easily obtained data

2. **Detailed energy audit**
   - Provides a detailed energy project implementation plan for a facility, since it evaluates all major energy using systems.
   - Offers the most accurate estimate of energy savings and cost.
   - Considers the interactive effects of all projects, accounts for the energy use of all major equipment.
   - Includes detailed energy cost saving calculations and project cost.
   - Energy balance based on an inventory of energy using systems, assumptions of current operating conditions and calculations of energy use. This estimated use is then compared to utility bill charges.

2. What is the importance of Energy Audit?

- The identification and implementation of recommendations for energy efficiency improvements arising from an Energy Audit can deliver different inter-related benefits to site operators like

  - Setting of energy efficiency targets
  - Financial benefits in terms of reduced costs or increased profits
  - Operational benefits including improved productivity, comfort and safety, and
  - security of energy supply
  - Environmental benefits such as sustainability, conservation of resources and
  - Emissions savings including greenhouse gas reductions.

- Environmental benefits are often realized through compliance with environmental legislation or regulatory requirements for instance:

  - The proposed introduction of an energy tax by late 2004 should provide additional motivation to improve energy efficiency.

- Electricity market deregulation and the increased deployment of renewable energy conversion systems have improved accessibility to sustainable energy supplies.

3. Explain steps in Energy Audit OR discuss various steps of energy audit.

Energy Audit:

Energy Audit is defined as "the verification, monitoring and analysis of use of energy including submission of technical report containing recommendations for improving energy efficiency with cost benefit analysis and an action plan to reduce energy consumption".

Type of Energy Audit:

Energy Audit can be classified into the following two types.

I. Preliminary Audit
II. Detailed Audit

➢ **Ten Steps Methodology for Detailed Energy Audit**

Step No	PLAN OF ACTION	PURPOSE / RESULTS
Phase I –Pre Audit Phase		
1	• Plan and organize • Walk through Audit • Informal Interview with Energy Manager, Production / Plant Manager	• Resource planning, Establish/organize an Energy audit team • Organize Instruments & time frame • Macro Data collection (suitable to type of industry.) • Familiarization of process/plant activities

		• First hand observation & Assessment of current level operation and practices
2	• Conduct of brief meeting / awareness programmed with all divisional heads and persons concerned (2-3 hrs.)	• Building up cooperation • Issue questionnaire for each department • Orientation, awareness creation
Phase II –Audit Phase		
3	• Primary data gathering, Process Flow Diagram, & Energy Utility Diagram	• Historic data analysis, Baseline data collection • Prepare process flow charts • All service utilities system diagram (Example: Single line power distribution diagram, water, compressed air & steam distribution. • Design, operating data and schedule of operation • Annual Energy Bill and energy consumption pattern (Refer manual, log sheet, name plate, interview)
4	• Conduct survey and monitoring	• Measurements : Motor survey, Insulation, and Lighting survey with portable instruments for collection of more and accurate data. Confirm and compare operating data with design data.
5	• Conduct of detailed trials /experiments for selected energy guzzlers	• Trials/Experiments: - 24 hours power monitoring (MD, PF, kWh etc.). - Load variations trends in pumps, fan compressors etc. - Boiler/Efficiency trials for (4 – 8 hours) - Furnace Efficiency trials Equipments Performance experiments etc.
6	• Analysis of energy use	• Energy and Material balance & energy loss/waste analysis

7	• Identification and development of Energy Conservation (ENCON) opportunities	• Identification & Consolidation ENCON measures • Conceive, develop, and refine ideas • Review the previous ideas suggested by unit personal • Review the previous ideas suggested by energy audit if any • Use brainstorming and value analysis techniques • Contact vendors for new/efficient technology
8	• Cost benefit analysis	• Assess technical feasibility, economic viability and prioritization of ENCON options for implementation • Select the most promising projects • Priorities by low, medium, long term measures
9	• Reporting & Presentation to the Top Management	• Documentation, Report Presentation to the top Management.
Phase III –Post Audit phase		
10	• Implementation and Follow-up	• Assist and Implement ENCON recommendation measures and Monitor the performance • Action plan, Schedule for implementation • Follow-up and periodic review

4. Layout general procedure in Energy Audit.

Answer:

- Energy Audit is the key to a systematic approach for decision-making in the area of energy management.
- It attempts to balance the total energy inputs with its use, and serves to identify all the energy streams in a facility.
- It quantifies energy usage according to its discrete functions. Industrial energy audit is an effective tool in defining and pursuing comprehensive energy management programmed.
- Energy Audit will help to understand more about the ways energy and fuel are used in any industry, and help in identifying the areas where waste can occur and where scope for improvement exists.

- The Energy Audit would give a positive orientation to the energy cost reduction, preventive maintenance and quality control programmers which are vital for production and utility activities.
- Energy Audit is the translation of conservation ideas into realities, by lending technically feasible solutions with economic and other organizational considerations within a specified time frame.
- The primary objective of Energy Audit is to determine ways to reduce energy consumption per unit of product output or to lower operating costs. Energy Audit provides a "bench-mark" (Reference point) for managing energy in the organization and also provides the basis for planning a more effective use of energy throughout the organization.

The type of Energy Audit to be performed depends on:

- ❖ Function and type of industry.
- ❖ Depth to which final audit is needed.
- ❖ Potential and magnitude of cost reduction desired.

Thus Energy Audit can be classified into the following two types:-

1. Preliminary Audit
2. Detailed Audit

1. Preliminary Energy Audit:-

- Preliminary energy audit is a relatively quick exercise to:
- Establish energy consumption in the organization.
- Estimate the scope for saving
- Identify the most likely (and the easiest areas for attention
- Identify immediate (especially no-/low-cost) improvements/ savings
- Set a 'reference point'
- Identify areas for more detailed study/measurement
- Preliminary energy audit uses existing, or easily obtained data

2. Detailed Energy Audit Methodology:-

- A comprehensive audit provides a detailed energy project implementation plan for a facility, since it evaluates all major energy using systems.
- This type of audit offers the most accurate estimate of energy savings and cost. It considers the interactive effects of all projects, accounts for the energy use of all major equipment, and includes detailed energy cost saving calculations and project cost.
- In a comprehensive audit, one of the key elements is the energy balance. This is based on an inventory of energy using systems, assumptions of current operating conditions and calculations of energy use. This estimated use is then compared to utility bill charges.
- Detailed energy auditing is carried out in three phases: Phase I, II and III.
  - ➢ Phase I - Pre Audit Phase :
  - Plan and organize.
  - Walk through Audit
  - Informal Interview with Energy Manager, Production / Plant Manager
  - ➢ Phase II - Audit Phase :
  - Primary data gathering, Process Flow Diagram, & Energy Utility Diagram
  - ➢ Phase III - Post Audit Phase
  - Implementation and Follow-up.

5. Why energy audit is requiring?

Answer:

- Energy Audit will help to understand more about the ways energy and fuel are used in any industry, and help in identifying the areas where waste can occur and where scope for improvement exists.
- The Energy Audit would give a positive orientation to the energy cost reduction, preventive maintenance and quality control programmes which are vital for production and utility activities. Such an audit programme will help to keep focus on variations which occur in the energy costs, availability and reliability of supply of energy, decide on appropriate energy mix, identify energy conservation technologies, retrofit for energy conservation equipment etc.
- In general, Energy Audit is the translation of conservation ideas into realities, by lending technically feasible solutions with economic and other organizational considerations within a specified time frame.
- The primary objective of Energy Audit is to determine ways to reduce energy consumption per unit of product output or to lower operating costs. Energy Audit provides a "bench-mark" (Reference point) for managing energy in the organization and also provides the basis for planning a more effective use of energy throughout the organization.

6. Why instruments are required for Energy Audit? Please give brief details of six Energy Audit instruments.

The requirement for an energy audit such as identification and quantification of energy necessitates measurements; these measurements require the use of instruments. These instruments must be portable, durable, easy to operate and relatively inexpensive. The parameters generally monitored during energy audit may include the following:

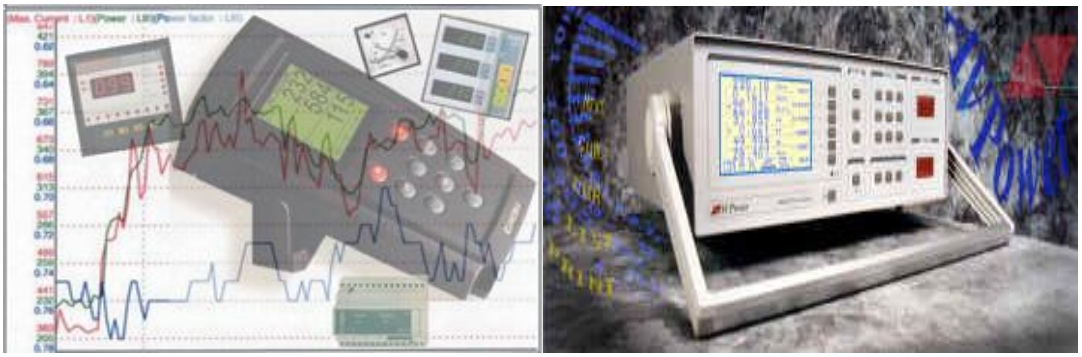
Basic Electrical Parameters in AC &DC systems – Voltage (V), Current (I), Power factor, Active power (kW), apparent power (demand) (kVA), Reactive power (kVAr), Energy consumption (kWh), Frequency (Hz), Harmonics, etc.

Parameters of importance other than electrical such as temperature & heat flow, radiation, air and gas flow, liquid flow, revolutions per minute (RPM), air velocity, noise and vibration, dust concentration, Total Dissolved Solids (TDS), pH, moisture content, relative humidity, flue gas analysis – CO_2, O_2, CO, SO_x, NO_x, combustion efficiency etc.

Key instruments for energy audit are listed below.
The operating instructions for all instruments must be understood and staff should familiarize themselves with the instruments and their operation prior to actual audit use.

1. **Electrical Measuring Instruments:**
   These are instruments for measuring major electrical parameters such as kVA, kW, PF, Hertz, kVAr, Amps and Volts. In addition some of these instruments also measure harmonics.

   These instruments are applied on-line i.e. on running motors without any need to stop the motor. Instant measurements can be taken with hand-held meters, while more advanced ones facilitates cumulative readings with print outs at specified intervals.



2. Pitot Tube and manometer:

Air velocity in ducts can be measured using a pitot tube and inclined manometer for further calculation of flows.

3. Fyrite:

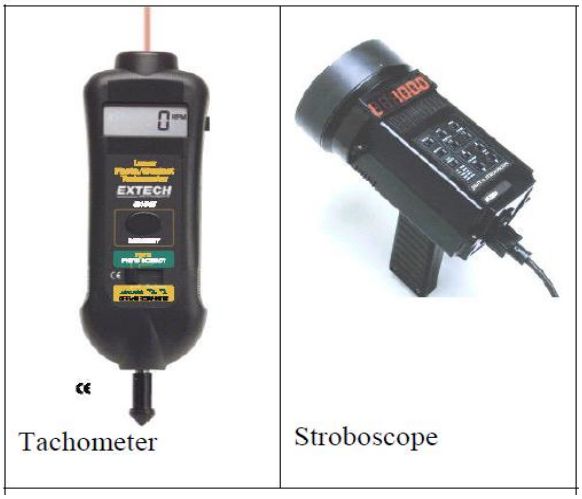
A hand bellow pump draws the flue gas sample into the solution inside the fyrite. A chemical reaction changes the liquid volume revealing the amount of gas. A separate fyrite can be used for O_2 and CO_2

4. Fuel Efficiency Monitor:

This measures oxygen and temperature of the flue gas. Calorific values of common fuels are fed into the microprocessor which calculates the combustion efficiency.

5. Speed Measurements:

In any audit exercise speed measurements are critical as they may change with frequency, belt slip and loading. A simple tachometer is a contact type instrument which can be used where direct access is possible. More sophisticated and safer ones are non-contact instruments such as stroboscopes.



Tachometer

Stroboscope

6. Lux meters:

Illumination levels are measured with a lux meter. It consists of a photo cell which senses the light output, converts to electrical impulses which are calibrated as lux.

7. Contact thermometer:

These are thermocouples which measures for example flue gas, hot air, hot water temperatures by insertion of probe into the stream.

For surface temperature, a leaf type probe is used with the same instrument.

8. Infrared Thermometer:

This is a non-contact type measurement which when directed at a heat source directly gives the temperature read out. This instrument is useful for measuring hot spots in furnaces, surface temperatures etc.

9. Water flow meter:

This non-contact flow measuring device using Doppler Effect / Ultra sonic principle. There is a transmitter and receiver which are positioned on opposite sides of the pipe. The meter directly gives the flow. Water and other fluid flows can be easily measured with this meter.

10. Combustion analyzer:

This instrument has in-built chemical cells which measure various gases such as O_2, CO, NO_X and SO_X.

11. Leak Detectors:

Ultrasonic instruments are available which can be used to detect leaks of compressed air and other gases which are normally not possible to detect with human abilities**.**

7. Indicate where the retrofit can play a role in an industrial facility & how?

Modifyingexisting equipment or structures withadditionalorew components or members.Principally retrofitting describes the measures taken in the manufacturing industry to allow new or updated parts to be fitted to old or outdated assemblies (like blades to wind turbines).

The production of retrofit parts is necessary in manufacture when the design of a large assembly is changed or revised. If, after the changes have been implemented, a customer (with an old version of the product) wishes to purchase a replacement part then retrofit parts and assembling techniques will have to be used so that the revised parts will fit suitably onto the older assembly. Another example of this is car customizing, where older vehicles are fitted with new technologies: power windows, cruise control, remote keyless systems, electric fuel pumps, etc.

- **Retrofit helpful in industry**

In the past, the conventional, manual surveying of industrial sites for retrofits or facility expansion often required hundreds of hours, sometimes over months, and sometimes involved potentially hazardous locations. When as-built infrastructures were hidden or not precisely detailed in original plans, the resulting survey errors usually led to expensive re-work or change orders for retrofit or expansion projects.

Today, high-definition survey technology (HDS) makes it possible for data to be collected from hundreds survey points, with densities and accuracies of 1/8 inch, in a matter or hours instead of days or weeks. HDS technology is based on an imaging laser that collects up to 50,000 survey shots per second, making it far easier to provide data that can be used for 2D line work or 3D models. An HDS system also features an external camera that collects photographic images in a 360-degree, RGB color values. These image files are later fused to the data points that are assembled as "point clouds," which can then be utilized for site mapping, project planning, and civil, structural and MEP design as data is extracted into formats such as AutoCAD, Revit, and Micro Station. Provided by professional specialists, HDS can be used to survey a plethora of industrial projects such as processing plants, refineries, and mining operations and other facilities that plan to make modifications, retrofit, expand, or upgrade key equipment.

- **Efficiencies that lead to savings**

This service captured all of the information about the building in a very quick and efficient manner, enabling us to plan around the existing structure with very accurate information." McNeil Engineering is a multi-faceted firm that performs HDS scanning for the past 5 years, as well as other survey-related services, civil engineering, structural engineering, consulting and landscape architecture.

- **Eliminating errors**

Many design and engineering firms turn to HDS technology because the scans it provides are so accurate that it virtually removes the need to work from records that could be somewhat inaccurate, thereby eliminates the need for re-work.

- **An added measure of safety**

Because all scanning is performed from ground level, HDS scanning technology is unobtrusive, making it unnecessary to interrupt production processes. This convenience also adds a measure of safety, as pointed out by Brian Akers, Piping Lead at Job Industrial Services, Inc. (Salt Lake City). Job Industrial Services handles retrofit and expansion projects with refineries, mining, and power & gas transmission facilities in Utah and throughout the U.S. Naturally, safety is a priority of the firm.

"HDS technology improves on the safety of our personnel because we spend significantly less field time in potentially dangerous environments," Akers explains. "This is the case particularly in the refinery industry, where you may have thousands of miles of infrastructure. If we're doing a retrofit, we can have a service provide laser scans, and with the point cloud information we can do a model a lot more accurately than we can do with conventional field measurements."

- **New Construction vs. Retrofit**

The major difference between a new construction and retrofit window is the way the new window frame is attached to the house.

To install a new construction window the installer will have to chip away the original stucco, cut away some interior drywall, remove the window, remove the paper backing behind the stucco, and then once the new window is in ensure the window is properly flashed and re-wrapped properly to ensure everything is watertight. After that, they will patch the stucco which was removed to perform the window install.

In a retrofit install, the windows include a Z-bar or Flush fin which allows the installer to cut down and reuse the existing window frame to mount the retrofit window frame to. The flush fin (Z-bar) covers the gap between the inside of the existing frame and the exterior of the replacement window and allows you to simply install the window from outside rather than tearing out the exterior stucco and interior drywall.

If you're original windows were installed correctly and aren't leaking the retrofit windows would be the way to go in my opinion. You will lose a tiny bit of window viewing area using the retrofits, but the install time will be much faster (and of course much less expensive) and there's no worry about tearing up the inside and outside of your house. I've never seen patched stucco that looks totally right either. The energy savings will be there regardless of the installation method you choose.

8. Briefly explain the importance of "energy information systems" in energy action planning.

Accurate, actionable data is critical to the success of every energy management program. If the integrity of your data is in question, your entire program is in jeopardy.

Unfortunately, many energy information systems were designed to meet the needs of Accounting, leaving Energy Managers without the tools required to effectively manage energy. The flow diagram below illustrates the components and reporting capabilities of a comprehensive energy information system.

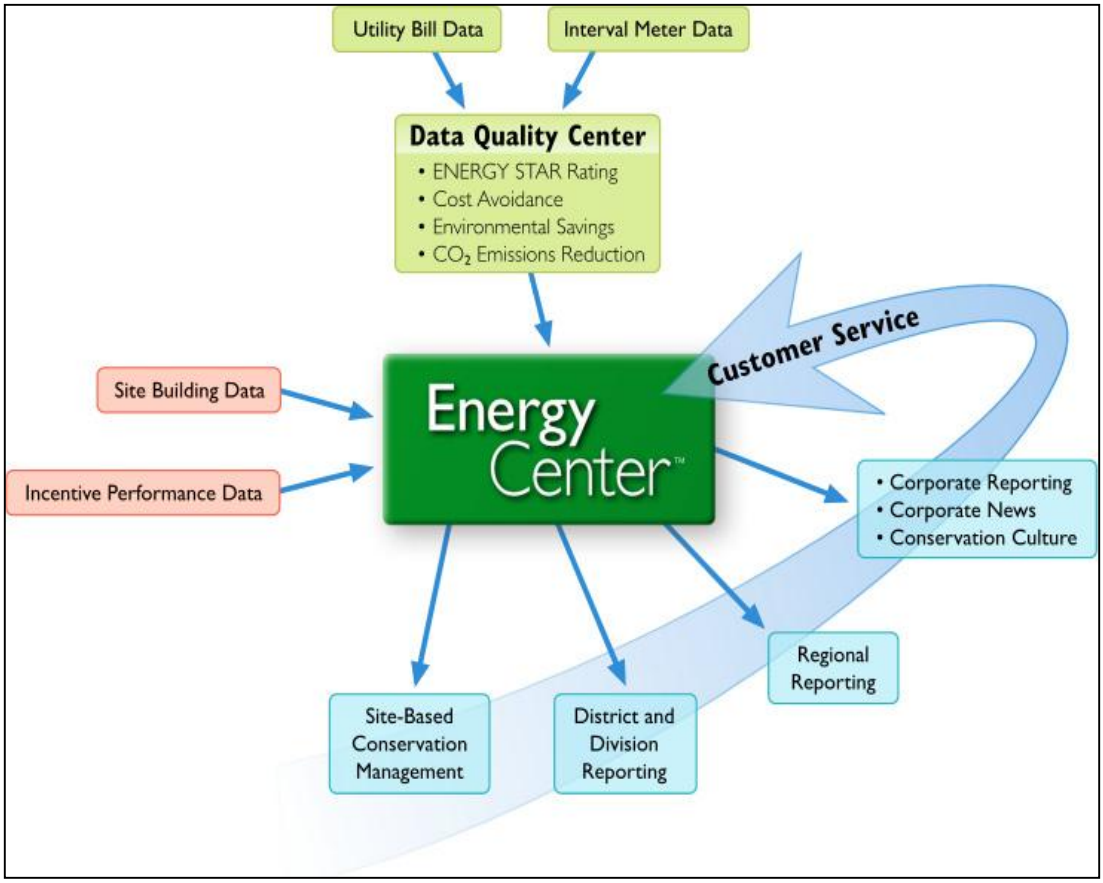


Figure: Engineer Information System

NET can meet your energy information needs through a web-based application or a system that resides behind your firewall. We are software neutral — so whether you use Energy CAP, Metrix, Utility Manager, or any other program, we can deliver the quality data you need.

The **Energy Information System** provides *cost efficient* energy information in order to reduce consumption advance the knowledge of products and services required to save energy and improve and the environment.

- **Automatic Data Collection**

Automated data import from Utility Companies, Energy Management Systems, Ac Qui suite Sub-metering Devices and more. The import process includes Data analysis, Quality Control and Weather data integration.

- **Multi-Level Reporting**

Report consumption and calculated values for multiple levels (meter, account, building, etc.) and across time (year, month, day, hour). Create an unlimited number of *interactive* custom reports.

- **Simple, User-Friendly Design**

A simple point and click interface guides you through your report design. Saving a report is as easy as saving a Favorite in your browser. Simply select a link to generate colorful charts of your data.

- **Scalable and Flexible**

Allows you to start small and add up to thousands of meters and hundreds of buildings.

- **Integration**

Automatically upload consumption and cost data to your account on Energy Star's Portfolio Manager and automatically download the ratings. Export reports to EXCEL, PDF, csv or copy and paste reports directly into your documents. Automatically email reports to subscribers.

9. Explain the role of Energy information system.

In recent years, there has been rapid advancement in access to interval meter data for commercial buildings as utilities upgrade their metering infrastructure. While this represents an exciting step forward, the next phase of this evolution involves being able to effectively utilize this information, improving the way businesses across the country use energy every day. An Energy Information System (EIS) plays the role of turning data into information that's useful for motivating energy-saving improvements.

- **Why do we need EIS in programs?**
  - Reducing the cost of finding measures
  - Reducing the cost of verifying savings
  - Increasing savings depth by using a platform for engaging customers in continuous improvement, with the ability to account for O&M and behavioral savings
  - Utilizing a whole building approach to savings instead of measures in isolation
  - Helping ensure persistence of savings

- **An Energy Management Information System (EMIS)** is an important element of a comprehensive energy management program. It provides relevant information to key individuals and departments that enables them to improve energy performance.

An EMIS can be characterized by its deliverables, features, elements and support. Deliverables include the early detection of poor performance, support for decision making and effective energy reporting. Features of an EMIS include the storage of data in a usable format, the calculation of effective targets for energy use, and comparison of actual consumption with these targets. Elements include sensors, energy meters, hardware and software (these may already exist as process and business performance monitoring systems). Essential support includes management commitment, the allocation of responsibility, procedures, training, resources and regular audits.

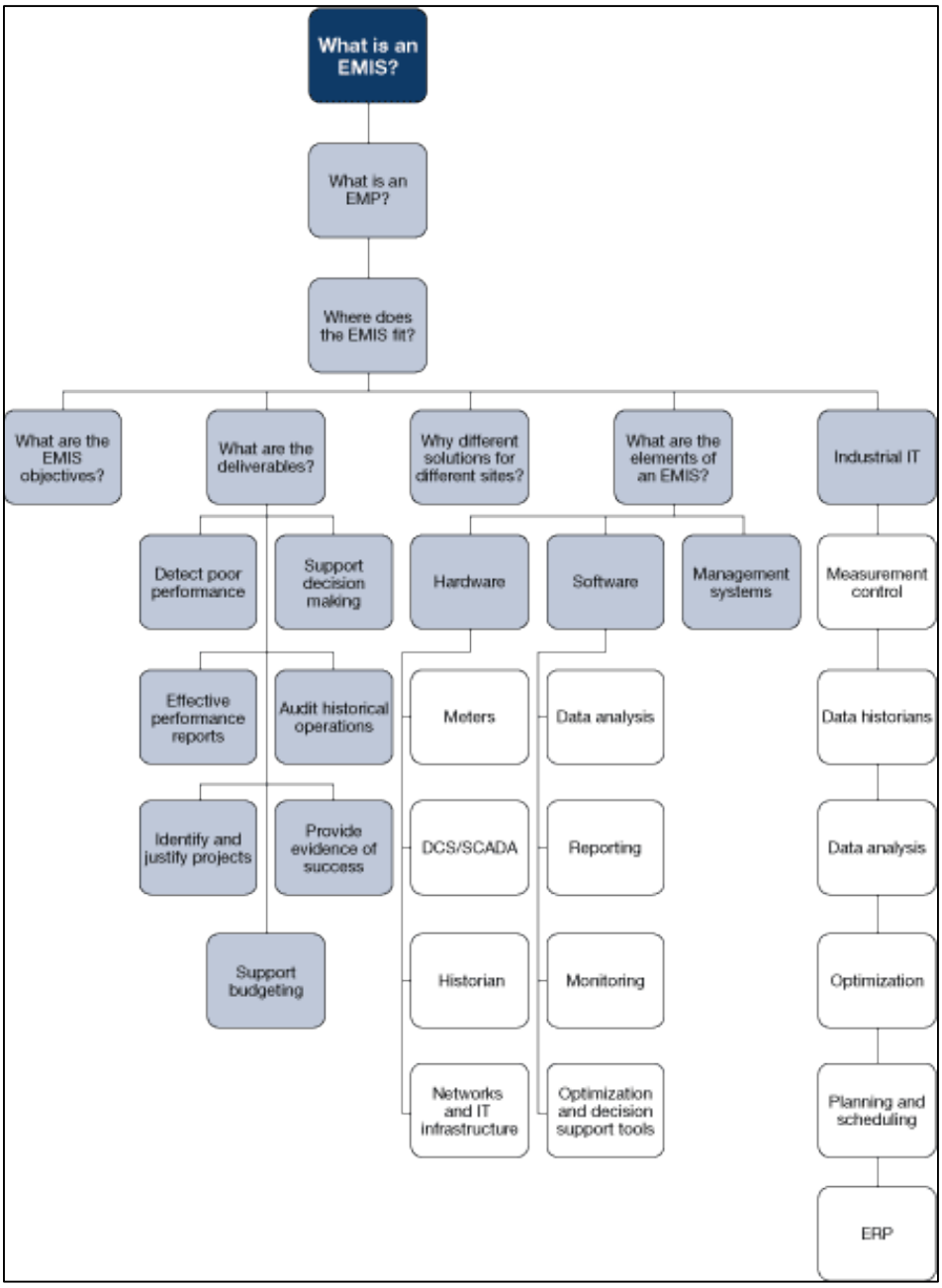


Figure: Basics of an EMIS

- **What Is an EMIS?**

An EMIS provides information to appropriate personnel within an organization to help them manage energy use and costs. The exact nature of the EMIS will depend on

- the particular site
- the processes and plant involved
- the cost of energy (in relation to other costs)
- existing meters and instruments
- monitoring and control systems
- the data historian
- data analysis and reporting systems
- existing management systems

- **Energy Management Programs and the EMIS**

An Energy Management Information System (EMIS) is only one element of a comprehensive energy management program (EMP), albeit an important one without which full benefits will not be achieved and sustained. A good EMIS should reduce energy use (and cost) by at least 5 percent.

Actions that generally need to be taken in order to address energy use in an EMP may include one or more of the following:

- Developing and approving an energy policy and strategy
- Training and actions to raise knowledge and awareness
- Energy audits to identify and evaluate opportunities
- Developing and implementing improvement opportunities
- Implementing performance management systems, including the EMIS.

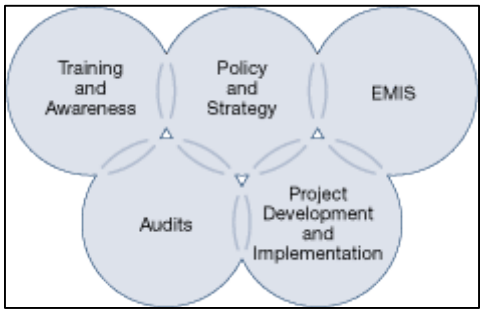


Figure: Elements of an energy management program (EMP)

An EMIS is the key element of performance management; it also provides essential support to the energy auditing process. A modern EMIS will be a software solution that is tightly integrated into an organization's systems for process monitoring and control and IT systems. Furthermore, the EMIS will often be part of a larger system used to manage process (and business) performance more generally.

It is important to recognize that an EMIS does not stand alone. It needs management commitment, procedures, organization, training and appropriate technical expertise.

10. Discuss computer control energy management.

Energy Management Systems (EMS) are an automated, computer-controlled method of controlling and managing the energy uses in a building to reduce and optimize energy expenses while at the same time maintaining a comfortable environment.

Stones River Electric is one of the nation’s largest Energy Management System providers. We install a variety of systems and equipment all designed to control and to conserve your facility’s energy consumption. From small box retail to large scale multi-store, multi-state rollouts, we can accommodate any EMS installation requirement. We can control your interior and exterior lighting, signage, HVAC, coolers and freezers with a variety of customer preferred options that can be programmed, monitored and modified from your own computer system or from the Stones River Electric “Consider It Done” Department.

Let Stones River Electric design an Energy Management System that best meets your facilities energy needs.

We install a variety of systems and equipment all designed to control and to conserve your facility's energy consumption

11. List all the requirements of energy action planning?

The areas requiring attention for energy action planning.

- **Personal involvement**

  Individuals must be educated as on need for energy conservation, and then personally involved in some way in the conservation programme.

- **Competition**

  Competition can be employed to good effect as a motivating factor in energy conservation. With energy monitoring in place, similar production lines can compete with each other on energy efficiency with rewards of financial bonuses or sometimes-just simple honour. Equally the use of energy management competitions can lead to competition between different companies - for example for 'Energy Manager of the Year' again with some prize involved together with the honour of winning.

- **Budgets**

  Budgets for energy use within each activity centre in an organisation should be treated separately like labour or raw material budgets and accounted for in similar fashion.

- **Assessing managerial performance**

  As part of overall policy, energy management can be included in the performance assessment of a manager.

- **Energy coordination**

  In certain energy intensive industries, it might be corporate policy to assign an engineer to each manufacturing facility with primary responsibility for energy management and conservation.

- **Capital and human resources**

  Having made each division of an organisation responsible for its energy use, the senior management should ensure that the requisite personnel and capital funds are made available to undertake the energy programme.

- **Cost Centre accountability**

Each discrete activity would be accountable for its energy use separately and the individual manager answerable for the same. This entails detailed sub-metering of energy use to each such

- **Energy representative**

  Each department would assign responsibility to an individual (preferably an engineer) to act as delegate to the plant energy management committee activity.

- **Training**

  Sufficient training for the energy representative and engineers involved in energy conservation activities should be carried out.

- **Metering**

  Metering is one of the management tools for energy conservation. At the individual's level, there is a psychological impact involved with metering - Just having meters installed and monitored is in itself an inducement to reduce unnecessary energy consumption.

- **Publicity**

One of the best ways of promoting an energy conservation programme is a publicity programme aimed at the worker on the job. Among the ways of publicizing such a programme are:

• Signs and posters displayed in the factory or office

• Progress charts showing targets and achievements

• Energy conservation stickers on light switches and thermostats

• Information on bulletin boards

• Articles in in-house magazines

In conclusion, involving people in energy conservation means changing habits. Senior managers must be willing participant in all programmes and lead by example. All employees must learn to practice energy conservation in all areas of their daily routines.