ENERGY CONSERVATION AND EFFICIENCY

Energy Audit

- The fundamental goal of energy management is to produce goods and provide services with the least cost and least environmental effect.
- The term energy management means many things to many people. One definition of energy management is:
- *The judicious and effective use of energy to maximize profits (minimize costs) and enhance competitive positions".*
- "*The strategy of adjusting and optimizing energy, using systems and procedures so as to reduce energy requirements per unit of output while holding constant or reducing total costs of producing the output from these systems*".
- 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".**
- The objective of Energy Management is to achieve and maintain optimum energy procurement and utilization, throughout the organization and:
- To minimize energy costs / waste without affecting production & quality
- To minimise environmental effects.

Need for Energy Audit

- In any industry, the three top operating expenses are often found to be energy (both electrical and thermal), labour and materials.
- 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 programs 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, rétrofit 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

Type of Energy Audit

- The type of Energy Audit to be performed depends on:
  - **Function and type of industry**
  - **Depth to which final audit is needed, and**
  - **Potential and magnitude of cost reduction desired**
- Thus, Energy Audit can be classified into the following two types.
- Preliminary Audit
- Detailed Audit

Preliminary Energy Audit Methodology

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

Detailed Energy Report

Ten Steps Methodology for Detailed Energy Audit

Step No	PLAN OF ACTION	PURPOSE / RESULTS
	Phase I –Pre Audit Phase	
Step 1	• Plan and organise • Walk through Audit • Informal Interview with Energy Manager, Production / Plant Manager	• Resource planning, Establish/organize a 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
Step 2	• Conduct of brief meeting / awareness programme 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	
Step 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)
Step 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.
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Step 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
Step6	• Analysis of energy use	• Energy and Material balance & energy loss/waste analysis
Step 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
Step 8	• Cost benefit analysis	• Assess technical feasibility, economic viability and prioritization of ENCON options for implementation • Select the most promising projects • Prioritise by low, medium, long term measures
Step9	• Reporting & Presentation to the Top Management	• Documentation, Report Presentation to the top Management.
	<u>Phase III –Post Audit phase</u>	
Step10	• Implementation and Follow-up	Assist and Implement ENCON recommendation measures and Monitor the performance • Action plan, Schedule for implementation • Follow-up and periodic review

DETAILED AUDIT REQUIREMENTS

The information to be collected during the detailed audit includes: -

1. Energy consumption by type of energy, by department, by major items of process equipment, by end-use

2. Material balance data (raw materials, intermediate and final products, recycled materials, use of scrap or waste products, production of by-products for re-use in other industries, etc.)

3. Energy cost and tariff data

4. Process and material flow diagrams

5. Generation and distribution of site services (eg.compressed air, steam).

6. Sources of energy supply (e.g. electricity from the grid or self-generation)

7. Potential for fuel substitution, process modifications, and the use of co-generation systems (combined heat and power generation).

8. Energy Management procedures and energy awareness training programs within the establishment.

The audit team should collect the following baseline data:

- Technology, processes used and equipment details

- Capacity utilisation

- Amount & type of input materials used

- Water consumption

- Fuel Consumption

- Electrical energy consumption

- Steam consumption

- Other inputs such as compressed air, cooling water etc

- Quantity & type of wastes generated

- Percentage rejection / reprocessing

- Efficiencies / yield

Energy Audit: Types And Methodology

- 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.

What is energy wastage?

- Energy waste means consumption of electricity, water and gas when that not performs any useful action.
- One of main reason of energy waste occurs is energy consumption devices are not managed and maintained properly.

Energy wastage are grouped in three categories;

- Long term energy waste – permanent problems.
- Regular energy waste – daily event which is predictable
- Intermittent energy waste – irregular events

Sources of wastage

- **Stand-by energy consumption**
- When someone watching TV for 4 hours. Average power consumption of TV per hour 70 Watts*4=280 Watts.
- When putting TV in stand-by mode, the electricity still consumed by TV as 8 Watts*20=160 Watts.
- As a result we are using 50% of excess power to put our TV in Stand-by mode and releasing lots of green house gas that our environment.
- **Poor maintenances:**
- Electronic equipment consume 20% more energy when it's maintained poor way.
- Frequently opening refrigerator causes 50 to120 kWh a year which is enough for washing machine to work 50 times.
- How many times you opening refrigerator without any idea what you do next after opening.
- After doing that the compressor starts working hard to maintain temperature inside the refrigerator.

Impact in environment

- Energy and environmental problems are closely related, since it is nearly impossible to produce, transport, or consume energy without significant environmental impact.
- The environmental problems directly related to energy production and consumption include air pollution, water pollution, thermal pollution, and solid waste disposal.
- The emission of air pollutants from fossil fuel combustion is the major cause of urban air pollution

- Diverse water pollution problems are associated with energy usage. One major problem is oil spills. In all petroleum-handling operations, there is a finite probability of spilling oil either on the earth or in a body of water.
- Coal mining can also pollute water. Changes in groundwater flow produced by mining operations often bring otherwise unpolluted waters into contact with certain mineral materials which are leached from the soil and produce an acid mine drainage.
- Solid waste is also a by-product of some forms of energy usage. Coal mining requires the removal of large quantities of earth as well as coal.
- In general, environmental problems increase with energy use and this combined with the limited energy resource base is the crux of the energy crisis.
- An energy impact assessment should compare these costs with the benefits to be derived from energy use.

Measures to reduce wastage

1. Switching to energy compact fluorescent lights:

Lighting holds 5% of household's greenhouse gas emission, and compact fluorescent bulb uses 75% less powers. But this bulb costs more but you save money by saving energy and this bulb have more lifetime than other bulbs.

2. **Switch off appliances, not in stand-by:**

Appliances on stand-by mode consumes up to 15% of electricity bill. Switch off them and remove it from wall when not in use.

3. Cook food in low flame:

Many people think cooking in high flame will cook faster. But some scientist says cook a food in high flame until cooking vessel reaches boiling point and then lower the flame. And also cooking in low flame is also good for health.

Case study by Times of India

- In new Delhi, year 2014-2015 over 3 billion units of electricity were wasted in the transmission highway which blocked trading.
- 2013-2014 higher wastage of 5.3 billion units.
- Power is traded on bourses through the mechanism called splitting.
- South region is a region which suffers a lot. Network congestion cost at least Rs5000 crores in last three years during 19 billion units could not flow into congestion.

- Absence of access of surplus power, cost of supplies was higher
- As there were problem in the way of capacity transmission highway were planned with singular focus on wheeling power under long term supply agreement.
- Distribution utilities are unable to forecast demand accurately, with the factor such as seasonal variations, social events, political factors.

ENERGY CONSERVATION

- India is world ‘s 2nd largest nation by population. The consumption of all forms of energy is very high in the country. Due to urbanization, growth in population, growth in IT sector the energy consumption in India has increased sharply .
- Availability of energy is a measure of the development of a society. Hence for sustainable growth of a nation the energy need has to be met.
- India, in spite of all the measures, faces problem in meeting the demand of all groups of people. It is seen that there exist a considerable gap demand and supply of power.
- New generation can be one of the solutions to meet the demand gap. But with fossil fuels depleting and renewable cost per MW being very high it is not economical to invest in new generation.
- Further the environmental impact of new generation is a big challenge. Under such circumstance the focus shifts from generation to conservation of energy at the consumer end.

ENERGY SCENARIO IN INDIA

- The installed capacity in India is 305555MW of which 69.56% is from thermal source, 14.06% from hydro source, 14.47% from renewable and 1.89% from nuclear energy.
- Domestic sector consumes around 25% of the total energy while industry consumes 36%. Domestic consumption is the second major energy consuming sector.
- Central power corporation accounts for 24.97% of the total power generated, state power corporation accounts for 33.635 of the total power generated while private sectors contribute 41.66% of the total power generation.

ENERGY CONSERVATION AT THE END USER

- The gap between generation and demand of energy is inevitable as on today. Due to environmental, financial and fuel depletion new generation is not an viable option.
- The solution lies in DSM by increasing end user efficiency. It is estimated that about 15000MW of energy can be saved through DSM. In domestic sector the most common options for energy efficiency are lighting, fans, AC, etc.
- There is a large potential to save energy by using energy efficient lights and fans. It is a DSM measure which helps to reduces load requirement on the station. Conservation of energy leads to reduction in energy requirement.
- In addition, improvement in the load factor can result in improving the utilization and reduce the need for peak load stations.

LIGHTING SOURCES AND THEIR EFFICIENCY

- The various electrical lighting sources line Fluorescent light, gas discharge lights, LED based lights, CFLs have different luminous efficacy.
- The use of high efficiency light sources requires lower rating and in tum reduce the energy consumption.
- The high energy efficiency lamps LED lamps have higher life. Luminous efficacy of different light sources is listed in table

Table I: luminous efficacy of different light sources

Source	Incandescent lamp	Fluorescent lamps	CFL	LED	High intensity discharge lamps
Luminous efficacy lumen/watt	10-30	60-70	50-80	80-100	120-150

- LED lamps are more energy efficient as the driving circuit requires less power. It is safer than CFL and has high life. Hence in spite of its high cost LED lamps are preferred.
- Due to its high life the payback will be within few months. This makes LED lamps the most energy efficient alternative.

CASE STUDY

A CASE STUDY OF ENERGY CONSERVATION AT A RESIDENTIAL COMPLEX

- A apartment complex ―Chirag Residency¦ situated at Byatarayanapura, Bangalore was selected for the study.
- The apartment has 32 houses of which 24 are 2 BHK house and 8 are 3 BHK house. The energy bills for 1 year were collected and average of the consumption was calculated.
- The number of tube lights, fans, type of TV and average usage was identified in a discussion with the residents.
- The summary of the information gathered are listed in Table II

Table II: Details gathered at Chirag residency.

Sl. No.	Flat No.	Average monthly consumption in kwh	No. of TL	Wattage in watts	Hours of usage	No. of Fans	Average Wattage	Hours of usage	TV
1	101	195	6	36	5	4	40	6	LED
2	102	206	8	36	5	6	40	6	LED
3	103	189	6	36	5	4	40	6	CRT
4	104	176	6	36	7	4	40	6	LED
5	105	191	6	36	5	4	40	6	LED
6	106	206	6	36	5	6	40	6	LED
7	107	215	6	36	5	4	40	4	LED
8	108	149	5	36	5	4	40	6	LED
9	201	183	6	36	5	4	40	6	CRT
10	202	204	7	36	5	6	40	4	LED
11	203	176	6	36	5	4	40	6	CRT
12	204	162	5	36	7	4	40	6	LED
13	205	182	6	36	5	4	40	6	LED
14	206	223	7	36	5	6	40	6	LED

ENERGY SAVING OPTIONS AND ANALYSIS

- Based on the data collected the analysis was done to identify the various energy saving options as listed in table III.
- The maximum saving potential has been considered for the calculation which assumes that all energy inefficient components/equipment's are replaced by energy efficient equipment's.

TABLE III: Energy saving options at Chirag residency:

Sl. No.	Energy saving option	Power saved in KW	Usage duration in Hrs	Energy saved per day in KWH	Energy saved per month in KWH
1	Replace Tube lights in the houses by 18W LED	=193*(36-18)/1000 = 3.474	5.25	18.24	547.2
2	Replace Fans with 30W EE fans	=144*(60-30)/1000 = 4.32	5.875	25.38	761.4
3	Replace CRT based TV's with LED based TV	= 9* (40-15)/1000= 0.225	6	1.35	40.5
4	Use 18W LED for common area lighting	=20* (40-18)/1000 = 0.44	4	1.76	52.8
5	use 85W LED lamp for yard lighting	=4*(250-85)/1000 = 0.66	4	2.64	79.2
	Total saving				**1481.1**

Table IV: Average saving per house

Sl. No.	Energy saving in KWH	Cost saved in Rs.	Average energy saved per house in KWH	Average cost saved per house in Rs.
1	1481.1	7405.5	46.28	231.42

CONCLUSION

- It was observed that the implementation of energy efficient methods at the end user application has a high potential to reduce the monthly energy consumption by around 25-30%.
- Use energy conservation along with measures to improve the utilization in order to improve the load factor can be a solution to the present energy crisis.
- DSM will also be a future need to save environment from over usage of energy and save the world from global warming.

Energy Conservation Measures

- An Energy conservation measure (ECM) is any type of project conducted, or technology implemented, to reduce the consumption of energy in a building.
- The types of projects implemented can be in a variety of forms but usually are designed to reduce utility costs: water, electricity and gas being the main three for industrial and commercial enterprises.
- The aim of an ECM should be to achieve a savings, reducing the amount of energy used by a particular process, technology or facility.

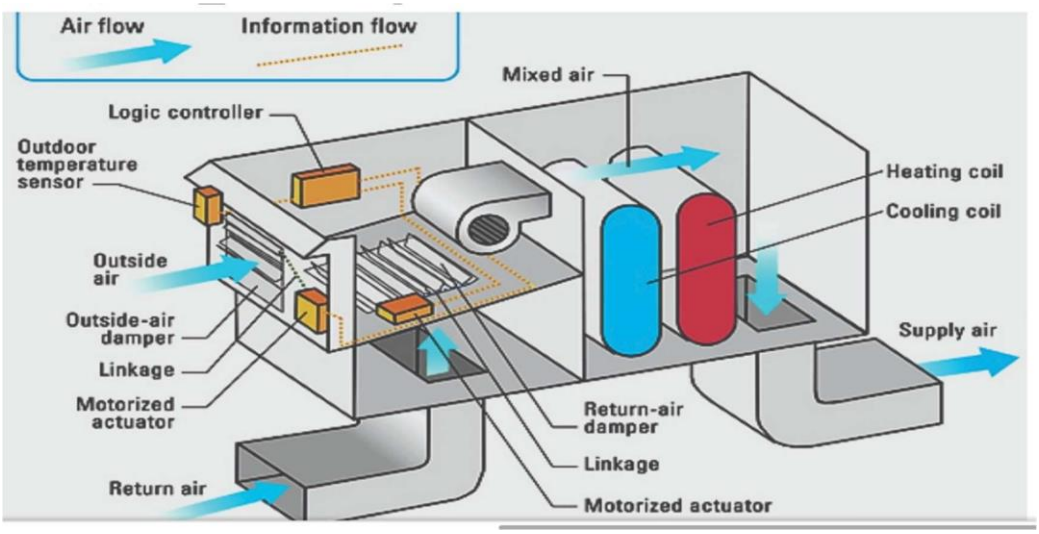
Energy-Saving products

Lighting

- On average, lighting represents about 22% of a building's annual energy use.
- Lighting upgrades offer substantial energy savings and can be bundled with other measures to help reduce the total payback period for a project.
- In most cases lighting improvements should be the first energy conservation upgrade.
- Of the 35 facilities audited, upgrades from a T12 to a T8 fluorescent lighting system were recommended for 19.
- The magnetic ballasts used with T12 bulbs must be changed to an electronic ballast when switching to a T8 lighting system.
- If fluorescent lights are used more than 30 to 35 hours a week (even less if your electricity costs are high), consider a retrofit to T8 bulbs and electronic ballasts.
- Purchase compact fluorescent light bulbs that screw directly into incandescent fixtures for energy savings.
- Exit signs retrofitted to compact fluorescent bulbs or light-emitting diodes (LED's) will save you money, guaranteed!

HVAC Systems

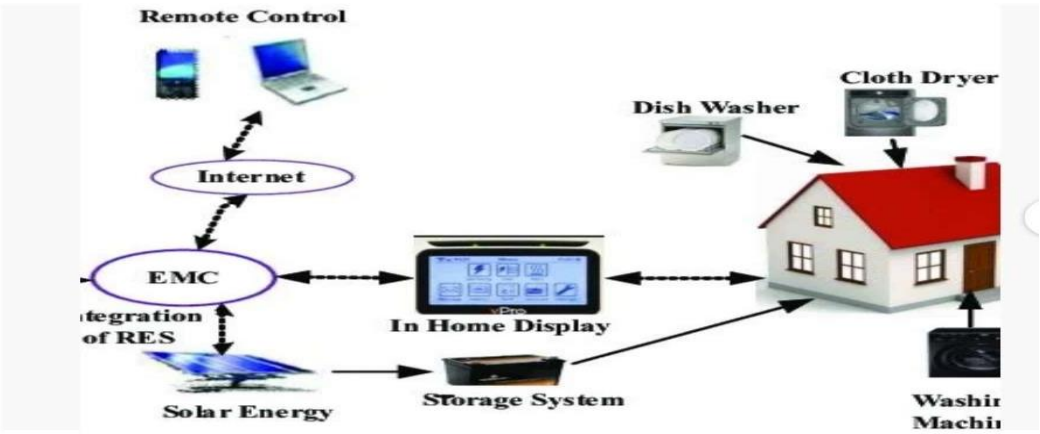
- Few heating, ventilation, and air-conditioning (HVAC) systems were recommended for upgrade in these audits.
- Even without complete HVAC upgrades, system control upgrades and annual maintenance represent opportunities to save money.
- Many of the facilities' HVAC systems were adequately maintained, but had design and specification problems including inadequate ventilation rates, uncalibrated and broken controls, and poor air-intake filtration.



Energy efficiency in HAVC system

Energy Management systems

- Energy management systems integrate almost all of a building's energy functions into a master control station, enabling higher efficiency and reduced maintenance.
- It's like a brain for your building. These systems are expensive.
- When you are upgrading to newer thermostats, lighting sensors, boilers, or other items, consider purchasing items that will be compatible with an energy management system.



Architecture of energy management system.

Other Measures That Save Energy

- It may not be economical to replace some items based solely on energy efficiency.
- The energy savings from replacing an older window with a new, energy-efficient window does not justify the replacement cost.
- However, if the window is damaged and needs to be replaced, the added cost of an energy-efficient window will generally be more than repaid by savings in energy costs over the life of the window.
- When electric motors fail, they should be replaced with high- or premium-efficiency models. Before purchasing a replacement, verify that the size of the motor is correct.
- According to the Department of Energy, 90% ofmotors in the United States are oversized.
- The EPA estimates that 60% of fans in the United States are oversized.
- When an older electric motor rated greater than 7.5 horse-power is replaced with a premium-efficiency motor, energy savings can pay for the new motor in 1 to 3 years.
- The most energy-efficient model you can find. These are marked with the EnergyStar label (Figure 3).

Figure 3—Energy Star image.

Operation and maintenance

- Some common procedures that offer immediate savings at little or no cost include:
- Keep everything clean. Lighting and heating systems lose significant amounts of their output when they are covered with dust, dirt, or scale.
- Inspect and repair your weatherstripping at least once a year.
- Make sure your thermostats are correctly calibrated. Older types often “float.”

Operation and maintenance

- During winter, set your thermostats back at night.
- During summer, increase your cool- air intake at night.
- Utility bills are not fixed costs and should be actively managed.
- Graphing your utility costs is a great way to monitor energy use. Unexplained cost spikes should be probed.

ENERGY AUDIT METHODS AND ITS PAYBACK IN YEARS

Energy Conservation Measure	Number of Average Recommendations	Payback in Years*
Lighting		
T12 to T8 fluorescent lighting retrofit	19	8.8
Lighting occupancy sensors	9	4.6
Exit sign retrofit	5	7.4
Incandescent to T8 fluorescent lighting retrofit	3	7.9
Halogen/compact fluorescent replacement	3	3.3
High-pressure sodium upgrades	2	8.1
HVAC (Heating, Ventilation, and Air-Conditioning) Systems		
Ventilation system modification	4	7.5
Thermostat night setback	3	2.8/Immediate**
Thermostat upgrade	3	7.5
Thermostat calibration	2	Immediate
Ventilation control calibration/installation	2	4.6
Heating system upgrade	2	10.8
Air-conditioning system upgrade	2	8.6
Building Operations and Maintenance		
Energy management system	3	7
Winter shutdown	2	3
Weatherstripping	2	5.1
Insulation	2	
Window upgrade/replacement	2	14.9
Miscellaneous		
Electric motors	3	7.3
Hot water heater	2	3.6
Water-saving systems	2	16.6
Groundwater cooling	1	16

BENEFITS OF ENERGY AUDIT

- Energy-saving measures discovered by these audits can help you know where your facility's energy savings are most likely to come from.
- Lighting systems offer a low-risk starting point on the path to energy savings.
- Large investments in equipment will not produce the projected benefits if the operation and maintenance schedule is inadequate.

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