G. PULLAIAH COLLEGE OF ENGINEERING AND TECHNOLOGY

Accredited by NAAC with 'A' Grade of UGC, Approved by AICTE, New Delhi

Permanently Affiliated to JNTUA, Ananthapuramu

(Recognized by UGC under 2(f) and 12(B) & ISO 9001:2008 Certified Institution)

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On

Energy Auditing and Demand Side Management

By

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Importance of Energy for India and World

India is a rapidly growing economy which needs energy to meet its growth objectives in a sustainable manner. The Indian economy faces significant challenges in terms of meeting its energy needs in the coming decade. The increasing energy requirements coupled with a slower than expected increase in domestic fuel production has meant that the extent of imports in energy mix is growing rapidly. India is among the top five Green-house-gas (GHG) emitters globally.

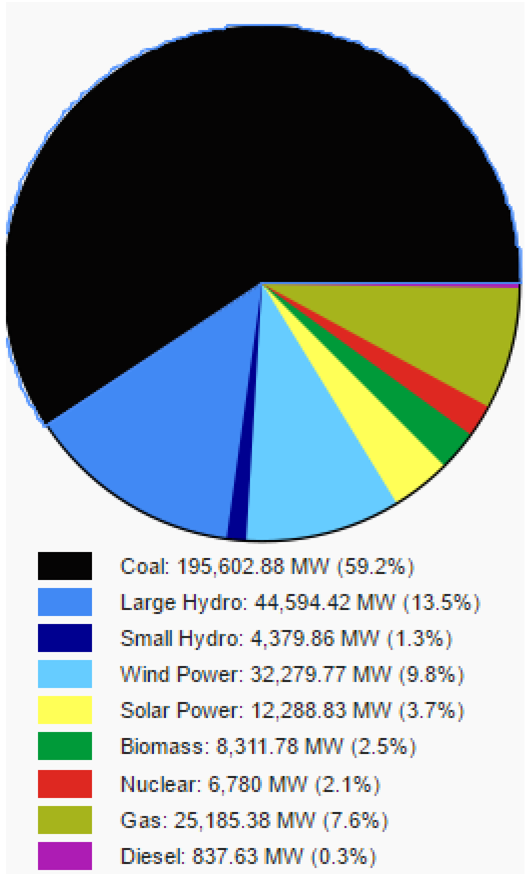
Although India is increasing dependent on commercial fuels, a sizeable quantum of energy requirements (40% of total energy requirement), especially in the rural household sector, is met by non-commercial energy sources, which include fuel wood, crop residue, and animal waste, including human and draught animal power. However, other forms of commercial energy of a much higher quality and efficiency are steadily replacing the traditional energy resources being consumed in the rural sector.

Energy Situation India and World:

The utility electricity sector in India has one National Grid with an installed capacity of 330.26 GW as on 31 May 2017. Renewable power plants constituted 30.8% of total installed capacity.[4] During the fiscal year 2015-16, the gross electricity generated by utilities in India was 1,116.84 TWh and the total electricity generation (utilities and non utilities) in the country was 1,352 TWh or 1,075.64 kWh per capita.

India is the world's third largest producer and fourth largest consumer of electricity. Electric energy consumption in agriculture was recorded highest (17.89%) in 2015-16 among all countries. The per capita electricity consumption is low compared to many countries despite cheaper electricity tariff in India.

In order to address the lack of adequate electricity availability to all the people in the country by March 2019, the Government of India launched a scheme called "**Power for All**". This scheme will ensure continuous and uninterrupted electricity supply to all households, industries and commercial establishments by creating and improving necessary infrastructure. Its a joint collaboration of GoI with states to share funding and create overall economic growth.



The total installed utility power generation capacity as on 30 April 2017 with sector wise & type wise break up is as given below.

Sector	Thermal (MW)				Nuclear (MW)	Renewable (MW)		Total (MW)	%
	Coal	Gas	Diesel	Sub-Total Thermal		Hydro	Other Renewable		
Central	55,245.00	7,490.83	0.00	62,735.83	6,780.00	11,651.42	0.00	81,167.25	25
State	65,145.50	7,257.95	363.93	72,767.38	0.00	29,703.00	1,963.80	104,447.28	32
Private	74,012.38	10,580.60	473.70	85,066.68	0.00	3,240.00	55,283.33	143,590.01	43
All India	194,402.88	25,329.38	837.63	220,569.88	6,780.00	44,594.42	57,260.23	329,204.53	100

India’s energy consumption is set to grow 4.2% a year by 2035, faster than that of all major economies in the world, according to BP Energy Outlook.

India, Asia’s second biggest energy consumer since 2008, had in 2015 overtaken Japan as the world’s third largest oil consuming country behind the US and China.

World energy consumption is the total energy used by the entire human civilization. Typically measured per year, it involves all energy harnessed from every energy source applied towards humanity's endeavours across every single industrial and technological sector, across every country. It does not include energy from food, and the extent to which direct biomass burning has been accounted for is poorly documented. Being the power source metric of civilization, World Energy Consumption has deep implications for humanity's socio-economic-political sphere.

Institutions such as the International Energy Agency (IEA), the U.S. Energy Information Administration (EIA), and the European Environment Agency record and publish energy data periodically. Improved data and understanding of World Energy Consumption may reveal systemic trends and patterns, which could help frame current energy issues and encourage movement towards collectively useful solutions.

Year	Primary energy supply (TPES)[2]	Final energy consumption[2]	Electricity generation
1973	71,013 (Mtoe 6,106)	54,335 (Mtoe 4,672)	6,129
1990	102,569	–	11,821
2000	117,687	–	15,395
2010	147,899 (Mtoe 12,717)	100,914 (Mtoe 8,677)	21,431
2011	152,504 (Mtoe 13,113)	103,716 (Mtoe 8,918)	22,126
2012	155,505 (Mtoe 13,371)	104,426 (Mtoe 8,979)	22,668
2013	157,482 (Mtoe 13,541)	108,171 (Mtoe 9,301)	23,322
2014	155,481 (Mtoe 13,369)	109,613 (Mtoe 9,425)	23,816

World **Total Primary Energy Supply** (TPES), or "primary energy" differs from the world final energy consumption because much of the energy that is acquired by humans is lost as other forms of energy during the process of its refinement into usable forms of energy and its transport from its initial place of supply to consumers. For instance, when oil is extracted from the ground it must be refined into gasoline, so that it can be used in a car, and transported over long distances to gas stations where it can be used by consumers. World final energy consumption refers to the fraction of the world's primary energy that is used in its final form by humanity.

In 2014, world primary energy supply amounted to 155,481 terawatt-hour (TWh) or 13,541 Mtoe, while the world final energy consumption was 109,613 TWh or about 29.5% less than the total supply. World final energy consumption includes products as lubricants, asphalt and petrochemicals which have chemical energy content but are not used as fuel. This non-energy use amounted to 9,404 TWh (809 Mtoe) in 2012.

Energy Audit :

An energy audit is an inspection, survey and analysis of energy flows, for energy conservation in a building, process or system to reduce the amount of energy input into the system without negatively affecting the output(s). In commercial and industrial real estate, an energy audit is the first step in identifying opportunities to reduce energy expense and carbon footprints.

The purpose of an energy audit is to determine how energy is used in an existing facility, and to quantify it. This helps to identify opportunities to improve the effectiveness with which energy is used. Energy audits can be done for all kinds of installations such as industries, utilities, commercial or office facilities, and homes.

Need for Energy Audit:

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.

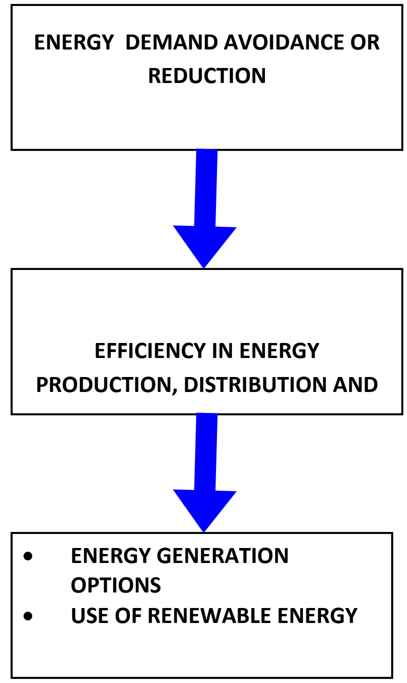
ENERGY MANAGEMENT STRATEGY :

The energy management strategy could vary from site to site. A broad strategy is depicted in the figure below.

Step 1: Energy demand reduction or avoidance

The first priority would be to reduce or avoid demand for energy. For example, the possibility for designing a building with optimum level of daylight, thereby reducing use of electricity for lighting.

Step 2: Energy Efficiency



The next step is to consider how to improve energy efficiency in energy generation systems (eg, diesel generators) and energy end use systems (eg, air conditioning system).

Step 3: Energy production options and use of Renewable Energy

The first 2 steps will help to minimize the energy requirements of the facility and identify all energy flows in the system. This will be the right stage to decide on any further changes for the energy supply and production options. This might include looking at options for:

- Increasing or decreasing the size of existing energy production systems (eg, adding or removing a diesel generator set)
- Use of renewable energy
- Co-generation
- Fuel substitution.

Among the major consumption of Electricity, Electrical motors stood the top among them.

Energy efficient motors use less electricity, run cooler, and often last longer than NEMA (National Electrical Manufacturers Association) B motors of the same size.

To effectively evaluate the benefits of high efficiency electric motors, we must define "efficiency". For an electric motor, efficiency is the ratio of mechanical power delivered by the motor (output) to the electrical power supplied to the motor (input).

Efficiency = (Mechanical Power Output / Electrical Power Input) x 100%

Thus, a motor that is 85 percent efficient converts 85 percent of the electrical energy input into mechanical energy. The remaining 15 percent of the electrical energy is dissipated as heat, evidenced by a rise in motor temperature. Energy efficient electric motors utilize improved motor design and high quality materials to reduce motor losses, therefore improving motor efficiency. The improved design results in less heat dissipation and reduced noise output.

Most electric motors manufactured prior to 1975 were designed and constructed to meet minimum performance levels as a trade-off for a low purchase price. Efficiency was maintained only at levels high enough to meet the temperature rise restrictions of the particular motor. In 1977, the (NEMA) recommended a procedure for labeling standard three-phase motors with an average nominal efficiency. These efficiencies represent an industry average for a large number of motors of the same design. Table 1 compares the current Standard full load nominal efficiencies for standard and energy efficient motors of various sizes. Note that these efficiencies are averages for three-phase Design B motors. (Design B motors account for 90 percent of all general purpose induction motors. See NEMA Specifications Publication MG-1-1.16 for classifications of induction motors.) Motors of other types (Design A, C, or D) have slightly different efficiencies, while single phase motors have substantially lower efficiencies. Energy efficient motors are only marketed with NEMA B speed-torque characteristics.

Using of Power factor improvement equipments will decrease the consumption inturn they will increase the efficiency.

In general power is the capacity to do work. In electrical domain, electrical power is the amount of electrical energy that can be transferred to some other form (heat, light etc) per unit time. Mathematically it is the product of voltage drop across the element and current flowing through it.

Considering first the DC circuits, having only DC voltage sources, the inductors and capacitors behave as short circuit and open circuit respectively in steady state. Hence the entire circuit behaves as resistive circuit and the entire electrical power is dissipated in the form of heat.

Here the voltage and current are in same phase and the total electrical power is given by

Electrical Power = Voltage across element × Current through the element

Units are Watt or Joule/ sec

The term power factor comes into picture in AC circuits only. Mathematically it is cosine of the phase difference between source voltage and current. It refers to the fraction of total power (apparent power) which is utilized to do the useful work called active power.

Need for Power Factor Improvement

Real power is given by $P = VI\cos\phi$. To transfer a given amount of power at certain voltage, the electrical current is inversely proportional to $\cos\phi$. Hence higher the pf lower will be the current flowing. A small current flow requires less cross sectional area of conductor and thus it saves conductor and money.

From above relation we saw having poor power factor increases the current flowing in conductor and thus copper loss increases. Further large voltage drop occurs in alternator, electrical transformer and transmission and distribution lines which gives very poor voltage regulation.

Further the KVA rating of machines is also reduced by having higher power factor as,

$KVA = KW/\cos\varphi$

Hence, the size and cost of machine also reduced. So, electrical power factor should be maintained close to unity.

Methods of Power Factor Improvement

Capacitors

Synchronous Condenser

Phase Advancer

And the Second most energy consumption devices are lighting and to calculate the energy we need instruments.

Lighting:

Lighting is an essential service in all the industries. The power consumption by the industrial lighting varies between 2 to 10% of the total power depending on the type of industry. Innovation and continuous improvement in the field of lighting, has given rise to tremendous energy saving opportunities in this area.

Basic Terms in Lighting System and Features

Lamps

Lamp is equipment, which produces light. The most commonly used lamps are described briefly as follows:

• **Incandescent lamps:**

Incandescent lamps produce light by means of a filament heated to incandescence by the flow of electric current through it. The principal parts of an incandescent lamp, also known as GLS (General Lighting Service) lamp include the filament, the bulb, the fill gas and the cap.

• **Reflector lamps:**

Reflector lamps are basically incandescent, provided with a high quality internal mirror, which follows exactly the parabolic shape of the lamp. The reflector is resistant to corrosion, thus making the lamp maintenance free and output efficient.

• **Gas discharge lamps:**

The light from a gas discharge lamp is produced by the excitation of gas contained in either a tubular or elliptical outer bulb. The most commonly used discharge lamps are as follows:

• Fluorescent tube lamps (FTL)

• Compact Fluorescent Lamps (CFL)

• Mercury Vapour Lamps

• Sodium Vapour Lamps

• Metal Halide Lamps

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.

The following are the instruments used for audit.

Fuel Efficiency Monitor

combustion analyzer

Contact thermometer

infrared thermometer

Water flow meter

Speed Measurement devices

Leak detectors

Lux meters

Introduction to Demand Side Management

Energy demand management, also known as demand-side management (DSM) or demand-side response (DSR), is the modification of consumer demand for energy through various methods such as financial incentives and behavioral change through education.

DSM techniques

- Direct load control
- Load limiters
- Commercial/industrial programs
- Frequency regulation
- Time of use pricing
- Demand bidding
- Smart metering and appliances
- Multi utility power exchange model

Cost-effectiveness analysis (CEA) is a form of economic analysis that compares the relative costs and outcomes (effects) of different courses of action. Cost-effectiveness analysis is distinct from cost–benefit analysis, which assigns a monetary value to the measure of effect. Cost-effectiveness analysis is often used in the field of health services, where it may be inappropriate to monetize health effect.

About the Cost Benefit Method

Companies use the cost benefit method to help make financial decisions, particularly those that involve the purchase of new equipment. The cost benefit method involves placing factors in two columns on paper. In the first column, the company lists all of the financial benefits the new equipment or software will provide. Such benefits might include improved productivity, lower supply costs and increased business. In the second column, the company lists the concrete and peripheral costs of the new equipment or software. This includes the basic cost of the equipment, any business lost during the transition to the new equipment, training costs, the cost of changing suppliers, and the like. Administrators, managers or executives look for options whereby the financial benefits outweigh the costs.

Cons of the Cost Benefit Method

The cost benefit method uses hard numbers to inform decisions, and some of these numbers can be misleading at first glance. When using the cost benefit method, you must be aware of all of the intangible benefits that may come from the business decision. For example, a switch to new software may allow the company to attract a larger pool of qualified employees, or a particular advertising strategy may weigh better with customers and improve customer loyalty. The large cost of a decision may quickly overshadow many of the intangible benefits if they are not accurately calculated.

About Cost Effectiveness Evaluation

A cost effectiveness evaluation is more complex than the cost benefit method because it involves more components. This method may be favored before the cost benefit method to narrow down a list of potential programs or new equipment to purchase. Rather than looking solely at the monetary value of the change, this method looks at the broader effects of the program. For example, a company may evaluate which employees will receive the greatest benefits from a specific training program and whether the costs of that training program will still be beneficial if certain employees leave the company.

Cons of Cost Effectiveness Evaluation

Because the cost effectiveness evaluation method does not always take into account all of the costs of a new program or equipment, it may fail to consider items such as the cost of training new employees or other additional costs that will accompany the program and equipment . Often this method takes into account only individuals currently involved in the business or program and does not account for newcomers who will need to be trained or what will happen if key individuals leave the business, taking specific skills sets with them.