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Energy Saving Technologies in Industries- An overview

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Abstract- Energy management includes planning and operation of energy-related production and consumption units. Objectives are resource conservation, climate protection and cost savings, while the users have permanent access to the energy they need. It is connected closely to environmental management, production management, logistics and other established business functions. Advancements in energy saving technologies can play an important role in further improving energy efficiency in the near, medium and long term. "Energy is a critical part of boosting prosperity and eradicating poverty". The objective of having energy efficient electrical systems is to have energy-efficient delivery systems thereby keeping the losses in electrical infrastructure to minimum and also electrical system should have suitable safety mechanisms for providing reliable power supply for continuous operation. Nowadays 85% of industries are wasting capital or investing more money in clearing energy bills. Current research shows that there is a direct correlation between energy efficiency and a reduction in greenhouse gas emissions. As such, environmental sustainability another major benefit of eliminating wasted energy usage during the production process. Other studies also point out that improvements in energy usage have a direct influence on product quality. In this paper energy scenario around the world, importance of energy efficiency and available energy efficient technologies to be adopted are discussed.

Index Terms- Energy consumption, Energy efficiency, Energy saving technologies and Electrical system design.

I. Introduction

Energy technology is an inter disciplinary engineering science having to do with the efficient, safe, environmentally friendly and economical extraction, conversion, transportation, storage and use of energy, targeted towards yielding high efficiency whilst skirting side effects on humans, nature and the environment. Day by day usage of energy is going increasing and everyone has to think of it and has to necessary steps in order to achieve "Zero waste energy". My research areas are energy audit, electrical safety audit and energy management in industries with special focus on mining industries. Currently I am doing energy audit and energy management in metal mining industries.

1.1 Energy Consumption around the world

World marketed energy consumption is projected to increase by 33% from 2010 to 2030. Total world energy use rose from 82,919 ZW in 1980 to 116,614 ZW in 2000 and then is expected to reach 198,654 ZW in 2030. The most rapid growth in energy demand from 2006 to 2030 is projected for nations outside the Organization for Economic Cooperation and Development (non-OECD nations). Total non-OECD energy consumption was increased by 73% compared to a 15% increase in energy use among the OECD countries **[1].**

1.2. Industrial energy consumption in India:

India is projected to sustain the world's second-highest rate of GDP growth, averaging 5.6% per year from 2006 to 2030. This translates into a 2.3% average annual increase in delivered energy to the industrial sector. India's economic growth over the next 25 years is expected to derive more from light manufacturing and services than from heavy industry, so that the industrial share of total energy consumption falls from 72% in 2006 to 64% in 2030 **[1].**

1.2.1. Generation of electricity:

- The all India gross electricity generation from utilities, excluding that from the captive generating plants, was 55,828 Giga Watt-Hours (GWh) during 1970-71. It rose to 1,10,844 GWh during 1980-81, to 2,64,329 GWh during 1990-91 and to 9,23,203 GW during 2011-12.
- The production of electricity from utilities has increased from 8,44,846 GWh during 2010-11 to 9,23,203 GWh during 2011-12, registering an annual growth rate of about 9.27%.
- Total Electricity generation in the country, from utilities and non-utilities taken together, during 2011-12 was 10,51,375 GWh. Out of this 7,59,407 GWh was generated from thermal and 1,30,510 GWh was from hydro and 33,286 GWh was generated from nuclear sources. Total output from non-utilities was 1,28,172 GWh **[2].**

The total potential for renewable power generation in the country as on 31.03.12 is estimated at 89774 MW (Table 1.3). This includes wind power potential of 49130 MW (54.73%), SHP (small-hydro power) potential of 15399 MW (17.15%), Biomass power potential of 17,538 MW(19.54%) and 5000 MW (5.57%) from bagasse-based cogeneration in sugar mills **[2].**

1.3. Importance of energy efficiency in industry

Energy conservation is necessary to reduce the increasing global warming. Individuals and organizations should conserve energy in order to decrease the energy costs and increase the economic security. Industrial and commercial users can increase efficiency and thus maximize profit **[3].** Energy efficiency in the industrial sector began to be considered one of the main functions in the 1970s, Since then, the world has trimmed its energy budget by utilizing higher efficiencies, while still growing economically, and has realized the importance of protecting the environment.

Industrial consumption will more result in Concentration of greenhouse gases such as carbon dioxide, Sulphur dioxide, Nitrogen oxides and carbon monoxide which will have more impact on earth's climate.

II. ENERGY SAVING TECHNOLOGIES

2.1. Solar Light pipes:

The device shows the potential to daylight the inner parts of building and the theoretical calculations show that we are able to reduce 160 to 240 lux level without the use of any electrical energy source. If one corridor that for most office building the expected level of luminance is 300 lux that achieve 240 lux is considered a major achievement.

In time where energy costs become exceeding high, then buildings will become more and more dependant all passive (non use of renewable sources of energy). The light pipe will lower energy consumption, improve the quality of light in the inner parts of building up to depths of 2 meters (or more) and also enable office buildings to have deeper floor depths **[4].**

The light pipe solar energy lighting system delivers the clean light energy into building spaces and thereby saving electrical energy for lighting during daytime **[5].**

2.2. Use of LED Lights:

Transparent plastic sheets can be used for illuminating the work area during daytime **[5].** L.E.D. replacements that can be used are less power consuming and produce better illumination. However it was practically measured at Tirap OCP, NEC, total power saving can be 70329 KW and in terms of money 379772.28 Rs can be saved. Thus, L.E.D. lighting system is superior over other conventional lighting systems like incandescent, metal halide, fluorescent, etc. Thus it is recommended that L.E.D. lighting system should come as an appropriate replacement of the usual conventional lighting systems **[6].**

2.3. Air pre-cleaners:

As our most of the machines work in dusty environment, an Air precleaner reduce the filtering burden of the air cleaner element and helps the engine perform efficiently.

2.4. Maximum Demand Controllers:

In general in industries High-tension (HT) consumers have to pay a maximum demand charge in addition to the usual charge for the number of units consumed. This charge is usually based on the highest amount of power used during some period during the metering month. Maximum Demand Controller is a device designed to meet the need of industries conscious of the value of load management. Demand control scheme is implemented by using suitable control contactors. Audio and visual annunciations could also be used **[7].**

Considerable savings can be realized by monitoring power use and turning off or reducing non-essential loads during such periods of high power use. This is very much useful in mining industries as they were investing much capital in paying maximum demand charges.

2.5. Automatic power factor controller:

In general in most of the industries power factor can be controlled with installation capacitor banks. In installation of capacitor banks there are various types of methods of installation of capacitor in order to improve power factor such as individual capacitors, fixed capacitors, automatic capacitors and combination of capacitors **[8].**

2.5.1. Methods of improving power factor:

1. Streamlining the process by improving the electrical performance of the plant.
2. Replacing induction motors by synchronous motors of equal rating.
3. Replacement of under loaded motors with low rated motors.
4. Reduction of voltage of motors, which are regularly under loaded.
5. Restricting no load operation of motor.
6. Improving the motor repair quality.
7. Installation of capacitors.
8. Replacement or relocation of under loaded transformers **[9].**

By improving the power factor of the load supplied from a transformer, the current through the transformer will be reduced thereby allowing more loads to be added. In practice it is less expensive to improve the power factor rather than replacing transformer by higher rating whichever suitable depends on requirements.

2.6. Fuel efficient engines :

These engines deliver more power and higher torque at lesser RPM and this will reduce fuel consumption of dumpers **[5]..** Fuel efficient engines can be tremendous opportunity for reducing fuel cost and reduces carbon pollution. Building and selling clean, fuel-efficient vehicles will encourage greater innovation and can put country on the right path to a stronger economy, a safer climate, and less reliance on oil. This is very much required for countries like India as they were being more rely on import of oil for industrial purposes **[10].**

Nowadays these fuel efficient engines are being used for trucks, cars and other passenger and goods carriers. This is nothing but achieving or framing new clean vehicle standards. This can be used in many industries for movable vehicles and operating vehicles etc.

2.7. Unmanned weighing bridge:

Unmanned weighing bridges avoid queuing of dumpers at weighing bridges and considerable savings in fuel is achieved due to automated weighing process **[5].**

2.8. Automatic power factor relay:

It controls the power factor of the installation by giving signals to switch on or off power factor correction capacitors. Relay is the brain of control circuit and needs contactors of appropriate rating for switching on/off the capacitors. There is a built-in power factor transducer, which measures the power factor of the installation and converts it to a DC voltage of appropriate polarity. This is compared with a reference voltage, which can be set by means of a knob calibrated in terms of power factor **[7].**

2.9. Intelligent Power Factor Controller (IPFC):

This controller determines the rating of capacitance connected in each step during the first hour of its operation and stores them in memory. Based on this measurement, the IPFC switches on the most appropriate steps, thus eliminating the hunting problems normally associated with capacitor switching **[7].**

According to simulation results by G. J. Delport and I. E. Lane, it was shown that various parameters such as electricity tariffs, process limitations, system configuration, production constraints and management requirements and variation of energy barriers like machine (capacity) constraints that are to be considered in mine energy planning for effective utilization of energy with cost benefit analysis **[11].**

2.10. Energy efficient motors:

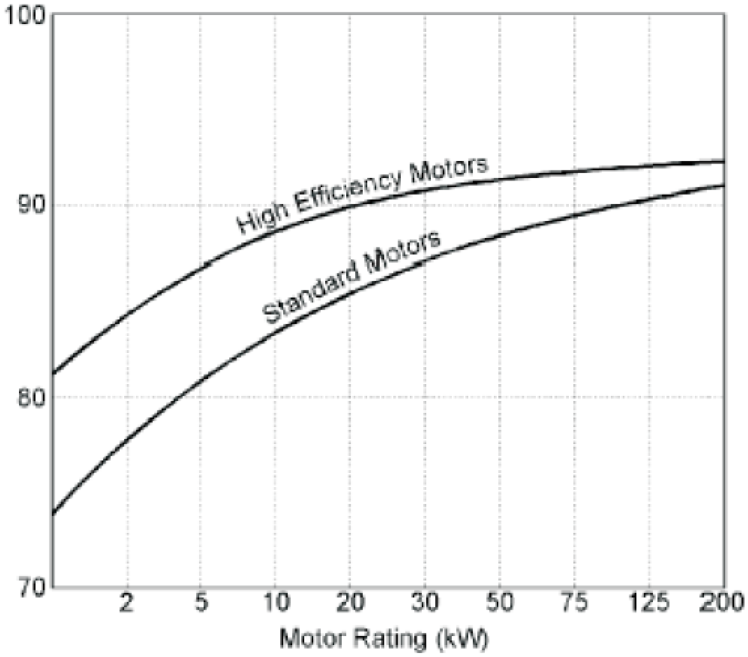
Energy-efficient electric motors reduce energy losses through improved design, better materials, and improved manufacturing techniques.

Table 1: watt loss area and efficiency improvement by EE Motors

Watts Loss Area	Efficiency Improvement
1. Iron	Use of thinner gauge, lower loss core steel reduces eddy current losses. Longer core adds more steel to the design, which reduces losses due to lower operating flux densities.
2. Stator I^2R	Use of more copper and larger conductors increases cross sectional area of stator windings. This lowers resistance (R) of the windings and reduces losses due to current flow (I).
3. Rotor I^2R	Use of larger rotor conductor bars increases size of cross section, lowering conductor resistance (R) and losses due to current flow (I).
4. Friction & Windage	Use of low loss fan design reduces losses due to air movement.
5. Stray Load Loss	Use of optimised design and strict quality control procedures minimizes stray load losses.

Above mentioned benefits can be achieved through energy efficient motors where constructional features have been explained step by step in above table.

Figure 1: Standard Vs High efficiency Motor Characteristics (3 Phase Induction Motor)



In above graph, it was clearly presented comparison of high efficient motors with standard motor as motor rating on x-axis and efficiency on y-axis.

2.11. Soft starter:

Soft starters provides a reliable and economical solution to the problems like excessive wear and premature failure of chains, belts, gears, mechanical seals, etc by delivering a controlled release of power to the motor, thereby providing smooth, stepless Acceleration and deceleration. Motor life will be extended as damage to windings and bearings is reduced. Soft Start & Soft Stop is built into 3 phase units, providing controlled starting and stopping with a selection of ramp times and current limit settings to suit all applications **[7].**

Advantages of Soft Starter:

– Less mechanical stress
– Improved power factor.
– Lower maximum demand.
– Less mechanical maintenance

2.12. Variable speed drives:

Most variable torque drives have Proportional Integral Differential (PID) capability for fan and pump an application, which allows the drive to hold the set point based on actual feedback from the process, rather than relying on estimation. High levels of accuracy for other applications can also be achieved through drives that offer closed-loop operation. Closed-loop operation can be accomplished with either a field-oriented vector drive, or a sensor less vector drive. The field oriented vector drive obtains process feedback from an encoder, which measures and transmits to the drive the speed and/or rate of the process, such as a conveyor, machine tool, or extruder. The drive then adjusts itself accordingly to sustain the programmed speed, rate, torque, and/or position **[7].**

Variable speed drives, on the other hand, gradually ramp the motor up to operating speed to lessen mechanical and electrical stress, reducing maintenance and repair costs, and extending the life of the motor and the driven equipment. There are various types of drives that present in market depends upon specific purpose of industry. Those are:

2.12.1. Eddy current drives:

This method employs an eddy-current clutch to vary the output speed. The clutch consists of a primary member coupled to the shaft of the motor and a freely revolving secondary member coupled to the load shaft. The secondary member is separately excited using a DC field winding. The motor starts with the load at rest and a DC excitation is provided to the secondary member, which induces eddy-currents in the primary member. By varying the DC excitation the output speed can be varied to match the load requirements. The major disadvantage of this system is relatively poor efficiency particularly at low speeds **[7].**

2.12.2. Slip Power Recovery Systems:

Slip power recovery is a more efficient alternative speed control mechanism for use with slip ring motors. In essence, a slip power recovery system varies the rotor voltage to control speed, but instead of dissipating power through resistors, the excess power is collected from the slip rings and returned as mechanical power to the shaft or as electrical power back to the supply line. Because of the relatively sophisticated equipment needed, slip power recovery tends to be economical only in relatively high power applications and where the motor speed range is 1:5 or less **[7].**

2.12.3. Fluid Coupling:

Fluid coupling is one way of applying varying speeds to the driven equipment, without changing the speed of the motor. Fluid coupling has a centrifugal characteristic during starting thus enabling no-load start up of prime mover, which is of great importance. By varying the quantity of oil filled in the fluid coupling, the normal torque transmitting capacity can be varied. The maximum torque or limiting torque of the fluid coupling can also be set to a pre-determined safe value by adjusting the oil filling **[7].**

2.13. Energy efficient transformer:

Most energy loss in dry-type transformers occurs through heat or vibration from the core. The new high-efficiency transformers minimize losses occurring in conventional type transformers. The conventional transformer is made up of a silicon alloyed iron (grain oriented) core. The iron loss of any transformer depends on the type of core used in the transformer. However the latest technology is to use amorphous material - a metallic glass alloy for the core and it can reduces energy losses over conventional (Si Fe core) transformers is roughly around 70%, which is quite significant and we can achieve maximum efficiency at low load also. Though these transformers are a little costlier than conventional iron core transformers, the overall benefit towards energy savings will compensate for the higher initial investment **[7].** These results in lower transmission losses in the transformer compared to the normal transformer. As the heating in the transformer is also less it also results in fewer failure of transformer because of high winding temperature.

2.14. Electronic Ballast:

In an electric circuit the ballast acts as a stabilizer. Fluorescent lamp is an electric discharge lamp. The two electrodes are separated inside a tube with no apparent connection between them. When sufficient voltage is impressed on these electrodes, electrons are driven from one electrode and attracted to the other. The current flow takes place through an atmosphere of low pressure mercury vapor. Since the fluorescent lamps cannot produce light by direct connection to the power source, they need an ancillary circuit and device to get started and remain illuminated. The auxiliary circuit housed in a casing is known as ballast.

The high frequency electronic ballast overcomes the above drawbacks. The basic functions of electronic ballast are:
1. To ignite the lamp
2. To stabilize the gas discharge
3. To supply the power to the lamp

One of largest advantages of electronic ballast is the enormous energy savings it provides. This is achieved in two ways. The first is its amazingly low internal core loss, quite unlike old fashioned magnetic ballasts. And second is increased light output due to the excitation of the lamp phosphors with high frequency **[7].**

2.15. Energy efficient Lighting controls:

There are various technologies which can be used for lighting controls like application of occupancy sensors, time based controls, day light controls and localized switching controls. Parameters to be considered for optimum lighting controls are different from technology to technology. It depends upon site conditions and the type of control we want.

Air-conditioning and lighting are two of the major uses in electricity in every sector and building type across Malaysia and accounts for approximately 60% of national electricity use **[12].**

Thus there is a great potential for saving electricity, reducing the emission of pollutant gases associated with electricity production, and reducing consumer energy costs through the use of more efficient air-con and lighting technologies as well as advance air-con and lighting design practices and control strategies **[13].**

III. Concept of Electrical system Design

The following are the key components / guidelines for designing energy efficient electrical systems.

1. Power distribution systems for equipments, including outdoor and indoor substations, transformers, process control systems, industrial electrical service stations and protections systems.
2. Power outlet systems for movable electrical machineries or equipments, material handling systems and transportation systems.

3. Auxiliary systems like air conditioning and refrigeration's, compressed air systems, lightings, fire alarm systems, communications and computer based equipments.
4. DG sets/ co generation equipments/UPS/Inverters.

3.1. Basic considerations of flexible and energy efficient electrical systems are:

1. Safety of life and properties including machineries/equipments.
2. Overall cost including the running costs.
3. Providing quality service.
4. Adherence to laid down procedures with accountability
5. Reliability of the system input supply and tolerance limits of interruptions.
6. Simplicity/flexibility of operations and maintenance
7. Location of plant substations and its deployment.
8. Data of electrical machineries/equipments, regulation and initial cost, including capitalization.
9. Technical parameters and specifications of materials to follow standards in construction, installations, protections, operations and maintenance.
10. Flexibility of plant distribution systems **[9].**

3.2. Power backup systems:

3.2.1. DG Sets:

Nowadays, with drastically increase in power shortage, poor power quality, disturbances, increased energy costs, industries are put to tremendous obstacles resulting in production losses and this has made industries to buildup own generating or power backup systems. This made following advantages for industries:

1. Continuous power supply, free from utility power breakdown, grid disturbances etc. leading to better productivity, less interruptions in process restart systems.
2. Good power systems control obtained when operated in parallel with the utility supply system
3. Possibility of heat and electrical energy generation resulting in energy conservation and reduced energy costs.
4. Excess of electrical energy conservation can be supplied to the utility grid and can earn income or wheeling charges.
5. It can be well utilized as standby power supply mode and peak loading mode **[9].**

3.2.2. UPS / Inverters:

An interruptible power supply, UPS or battery back-up, is an electrical apparatus that provides emergency power to load when the input power supply system's fails. A UPS differ from emergency power supply system's **[14].**The efficiency level of inverters varies from 92-95% based on capacity **[9].** A UPS is typically used to protect hardware such as computers, data centers, telecommunication equipment or other electrical equipment where an unexpected power disruption could cause injuries, fatalities, serious business disruption or data loss. Most UPS devices provide an instant backup power supply as well as surge protection with units ranging in size, smallest for desktop computers and large ones for entire rooms or buildings **[15].**

IV. CONCLUSIONS

In the above paper available and practicable energy saving technologies has been presented for benefit of industries for achieving energy efficiency. There are several technologies to improve existing systems for energy efficiency or otherwise we can go for adoption of alternate source of energy such as solar, wind, biomass, and oceanic energy etc. electrical safety audit and energy management definitely will be the greater importance and fruitful for coming generation and for attaining sustainable development.

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