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Energy Conservation In Electrical System

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Abstract:

Electrical energy is universally accepted as an essential commodity for human beings. Energy is the prime mover of economic growth and is vital to the sustenance of a modern economy. Future economic growth crucially depends on the long-term availability of energy from sources.

Areas of application of Energy Conservation are Power Generating Station, Transmission & Distribution system, Consumers premises. Steps are to be taken to enhance the performance efficiency of generating stations. Energy Conservation technology adopted in Transmission & Distribution system may reduce energy losses, which were in tune of 35% of total losses in Power system. Acceptance of Energy conservation technology will enhances the performance efficiency of electrical apparatus used by end users. Implementation of Energy conservation technology will lead to energy saving which means increasing generation of energy with available source.

Scope of the paper is about Implementations of Energy conservation technologies, case studies, related to Electrical systems adopted by industries, Municipal Corporation, Hospitals, residential consumers, Utilities. This paper also covers Roll of Government, State nodal agencies, Energy Act, and Energy Policies.

Energy Conservation In Electrical Field

(Full-length paper)

1.0 Introduction; Energy is the primary and the most universal measures of all kinds of work by human being and nature. Electrical energy is proved to be an ideal energy in all sorts of energy available in nature.

Energy is the prime mover of economic growth and is vital to the sustenance of a modern economy. Future economic growth crucially depends on the long-term availability of energy from sources that are affordable, accessible and environmentally friendly.

2.0 Energy Scenario:

Energy is prime factor for national economic development. India ranks sixth in the world in total energy consumption and needs to accelerate the development of the sector to meet its growth aspirations. Per capita energy is use in India is much below compared to many countries.

Installed capacity of India: 110,000MW
Installed capacity of Maharastra: 20,289.5MW
Available power: 13,375MW
Peak demand: 18,049MW
Power shortage: 4,774MW
Limited Fossil fuel stock up to 50 to 100 years only

3.0 Need of energy conservation:

Fossil fuels like coal, oil that has taken years to form is on the verge of depleting soon. In last 200 years we have consumed 60% of all resources. For sustainable development we need to adopt energy efficiency measures. Today 85% of primary energy sources come from non-renewable and fossil sources. These reserves increasing consumption and will exist for future generations.

Energy survey conducted by **Ministry of Power** in 1992 reveled that there is requirement of improvement in energy generation efficiency, improvement in energy transportation (transmission & distribution systems) and enhancing the performance efficiency of use end apparatus. Study of **'Energy strategies for Future'** evolved two things - efficient use of energy, energy conservation and use of Renewable Energy. Energy conservation emerges out to be the first and least cost option.

3.1 What is energy conservation?

Energy conservation means reduction in growth of energy consumption and is measured in physical terms.

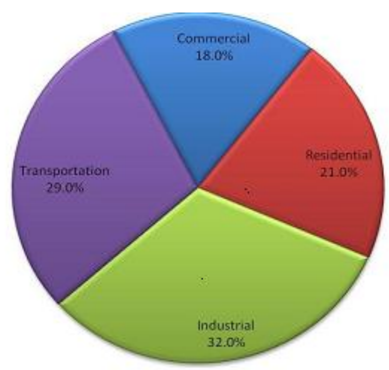
Energy conservation is the practice of decreasing the quantity of energy used while achieving a similar outcome of end use. (This practice may result in increase of financial capital, environmental value, national security, personal security and human comfort.)

Energy conservation also means reduction or elimination of unnecessary energy used and wasted.

4.0 Area of application of Energy Conservation:

Electrical system is a net work in which power is generated using non-renewable sources by conventional method and then transmitted over longer distances at high voltage levels to load centers where it is used for various energy conversion process. End user sector are identified as three major areas -Power Generating station, Transmission & Distribution systems, and Energy consumers. Consumers are further classified as Domestic, commercial and Industrial consumers.

Areas	**Consumption (Year-2007)**
Domestic	21%
Commercial	18.0%
Industrial	32%
Transportation	29%



4.1 EC in Power generating station:

To generate 1MW power generation cost is Rs 4.5 to 5.25 crores and T& D cost is Rs.2 crores . But cost of saved power is Rs.1Crores/Mw.The important note is time period to set a power plant is 5 years; to set up transmission line 1 year and to plan energy conservation is only 1 month. We have less opportunity for EC in generating area but we can improve the performance efficiency of generators by optimization of load, optimal distribution of load among different units, periodical maintenance and also increasing the capacity by adopting advanced technology using renewable energy sources.

4.2 EC in Transmission & Distribution:

In India the power transmission and distribution (T&D) system is a three tire structure comprising of state grids, regional grids and distribution network. To meet the energy demand power system networks are interconnected through INTRA-REGIONAL LINK.

The inter-regional power transmission capacity of India at end of 2007 was 14000 MW. T&D system in India is characterized by heavy losses of about 34.54% according to statistics of 2005-06, as compared to 10-15% in developed countries

Power losses in T&D system can be classified as Technical losses and Commercial losses**.**

Power losses in T&D system	
Technical losses	Commercial losses
• Transformer losses • Transmission line losses • Inter-link losses • Distribution losses	• Metering • Inefficient management • Improper maintenance

4.2.1- Technical Losses In T&D System:

Power losses occurring in T&D sector due to imperfection in technical aspect which indirectly cause loss of investment in this sector, are technical losses. These technical losses are due to inadequate system planning, improper voltage and also due to poor power factor etc.

Components	Nature of losses	% Losses
Transformer Losses	Electrical Losses= I^2R losses Magnetic Losses = Core losses	Power transformer contributes nearly 40% to 50% of total transmission and distribution losses.
Transmission line losses:	Line losses = $3I^2R$ loss	17%
Inter-link losses:	Line losses = $3I^2R$ loss	
Distribution Losses:	I^2R loss in distribution line High reactive burden. Poor p.f. Harmonic currents. Unbalanced load. Excessive neutral current.	These losses range from 10% to 62%. The average losses are found to be 25%.

4.2.2-Commercial Losses: Commercial losses are those, which are directly responsible for wastage of money invested in transmission and distribution system. These losses are effects of inefficient management, improper maintenance etc. Corruption is also the main reason contributing to the Commercial losses. Metering losses includes loss due to inadequate billings, faulty metering, overuse, because of meters not working properly and outright theft. Many of the domestic energy meters fail because of poor quality of the equipment.

4.3 ENERGY CONSERVATION TECHNIQUES:

4.3.1 EC Techniques In Transformers:

i) Optimization of loading of transformer:

- By proper Location of Transformer preferably close to the load center, considering other features like centralized control, operational flexibility etc. This will bring down the distribution loss in cables**.**
- Maintaining maximum efficiency to occur at 38% loading (as recommended by REC), the overall efficiency of transformer can be increased and its losses can be reduced

- Under fluctuating load condition more than one transformer is used in Parallel Operation of Transformers to share the load & can be operated close to the maximum efficiency range

ii) By Improvisation In Design And Material Of Transformer:

- To reduce load losses in Transformer, use thicker conductors so that resistance of conductor reduces and load loss also reduces.
- To reduce Core losses use superior quality or improved grades of Cold Rolled Grain Oriented (CRGO) laminations.

iii) Replacing By Energy Efficient Transformers:

- By using energy efficient transformers efficiency improves to 95 % to 97%.
- By using Amorphous transformers efficiency improves to 97 % to 98.5%.
- By using Epoxy Resin cast/ Encapsulated Dry type transformer- efficiency improves to 93 % to 97%.

4.3.2 Energy Conservation In Transmission Line:

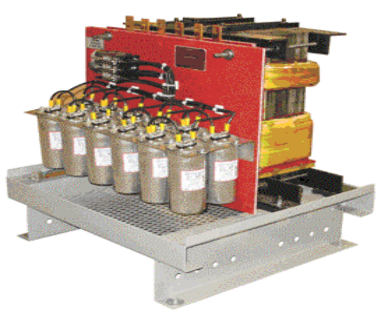
- To reduce line resistance-'R' solid conductors are replaced by stranded conductors (ACSR or AAC) and by bundled conductors in HT line.
- High Voltage Direct Current (HVDC) is used to transmit large amount of power over long distances or for interconnections between asynchronous grids
- By transmitting energy at high voltage level reduces the fraction of energy lost due to Joule heating. (V α1/I so I^2 R losses reduces).
- As load on system increases terminal voltage decreases. Voltage level can be controlled by using voltage controllers and by using voltage stabilizer
- If required reactive power transmitted through transmission lines, it causes more voltage drop in the line. To control receiving end voltage, reactive power controllers or reactive power compensating equipments such as Static VAR controllers are used.

4.3.3 Energy Conservation In Distribution Line:

a) Optimization of distribution system: The optimum distribution system is the economical combination of primary line (HT), distribution transformer and secondary line (LT), To reduce this loss and improve voltage HT/LT line length ratio should be optimized.

b) Balancing of phase load- As a result of unequal loads on individual phase sequence, components causes over heating of transformers, cables, conductors, motors. Thus, increasing losses and resulting in the motor malfunctioning under unbalanced voltage conditions.

c) Harmonics: With increase in use of non-linear devices, distortion of the voltage and current waveforms **occurs**, known as **Harmonics. Due to presence of** harmonic currents excessive voltage and current in transformers terminals, malfunctioning of control equipments and Energy meter, over effect of power factor correction apparatus, interference with telephone circuits and broad casting occurs. Distribution Static Compensator (DASTACOM) and Harmonic filters can reduce this harmonics.



d) Energy Conservation by using power factor controller:

Low power factor will lead to increased current and hence increase losses and will affect the voltage. We can use

Power Factor Controller or Automatic Power Factor Controller that can be located near receiving substations, load centers or near loads.

e) Energy Conservation By Demand side management control

Demand-side management is used to describe the actions of a utility, beyond the customer's meter, with the objective of altering the end-use of electricity - whether it be to increase demand, decrease it, shift it between high and low peak periods, or manage it when there are intermittent load demands - in the overall interests of reducing utility costs. Nearly energy of 15,000 MW can be saved through end-use energy efficiency.

By using D**SM saving** potential in…

Industry and Agriculture - 30-35%

Commercial / Government establishments and residential houses. -25-30%

4.4 - Energy Conservation In Lighting system:

Good lighting is required to improve the quality of work, to reduce human's / worker's fatigue, to reduce accidents, to protect his eyes and nervous system. In industry it improves production, and quality of products / work. To view economy of lighting system, cost of initial installation cost, running cost, and effect on production / work are to be considered as main parameters. The power consumption by the industrial lighting is nearly 2 to 10 % of total power consumption, depending on type of industries.

a) Optimum use of natural light: Whenever the orientation of a building permits, day lighting has to be used in combination with electric lighting. The maxim use of sunlight can be get by means of transparent roof sheets, north light roof, etc

b) Replacing incandescent lamps by Compact Fluorescent Lamps (CFL's): CFL's are highly suitable for places such as Living rooms, Hotel lounges, Bars, Restaurants, Pathways, Building entrances, Corridors, etc.

Area	Existing lamp		Proposed lamp		Power savings	
Industry	GLS	13w	CFL	9w	4 w	31%
	GLS	200w	Blended	160w	40w	20%
Domestic	GLS	60w	CFL	25w	35w	58%

c) Replacing conventional fluorescent lamp by energy efficient fluorescent lamp: Energy efficient lamps are based on the highly sophisticated technology. They offer excellent color rendering properties in addition to the very high luminous efficacy.

Area	Lamp Type				Power Saving	
	Existing		Proposed		Watts	Efficiency
Industry	TL	40w	TLD	36w	4w	10%
Street lighting	TL	2*40 w	TL	2*36 w	08w	06
Domestic	TL	40w	T-8	28w	12w	30

d) **Replacement of Mercury/Sodium Vapor Lamp by Halides Lamp:** MHL provides high colour rendering index and offer efficient white light. Hence for critical applications where higher illumination levels are required, these lamps are used. They are highly suitable for applications such as assembly line, inspection area, painting shops etc.

Area	Existing lamp	Proposed lamp	Power savings	
Industry	HPMV- 400w	MHL- 250w	5 w	17%
Commercial	HPSV- 150w	MHL- 250w	150w	35%
Street lighting	GLS - 200w GL- 300w	ML- 160w ML- 250w	40 w 50 w	07% 17%

e) **Replacing HPMV Lamps by High pressure sodium Vapour Lamp (HPSV):** Where color rendering is not critical for such applications e g street lighting, yard lighting because CRI of HPSV is low but offer more efficiency.

Area	Existing lamp	Proposed lamp	Power savings	
Street lighting	HPMV - 125w HPMV- 250w	HPSV 70w HPSV 150w	25 w 100 w	44% 40%
Yard lighting	HPMV- 250w	HPSV 150w	100 w	40 %

f) Replacing filament lamps on panels by LED: LED lamps consumes **less** power (1 W lamp), withstand high voltage fluctuation in the power supply, longer operating life (>100,000 hrs). Hence nowadays they are also used in street lighting, signaling, advertising boards, even as replacement for tube light or CFL.

g) Replacement of conventional ballast by Electronic ballast: Installation of high frequency (28 – 32Mhz) electronic ballast in place of conventional ballasts helps to reduce power consumption up to 35%.

h) **Installation of separate transformer for lighting:** In most of the industries, the net lighting load varies between 2 to 10%. If power load and lighting load fed by same transformer, switching operation and load variation causes voltage fluctuations. This also affects the performance of neighboring power load apparatus, lighting load equipments and also reduces lamps. Hence, the lighting equipment has to be isolated from the power feeders. This will reduce the voltage related problems, which in turn provides a better voltage regulation for the lighting This also increases the efficiency of the lighting system.

i) Installation of servo stabilizer for lighting feeder: Wherever, installation of separate transformer for lighting is not economically attractive and then servo stabilizer can be installed for the lighting feeders.

j) Control over energy consumption pattern: Occupancy Sensors, Daylight Linked Control are commonly used in commercial buildings, malls, offices, where more no. Of lights are to be controlled as per operational hours microprocessor based Light control circuits are used. As a single control unit it can be programmed to switch on /off as per the month wise, year wise and even season wise working schedule.

k) **Periodic survey and adequate matainance program:** Illumination level reduces due to accumulation of dirt on lamps and luminaries. By carrying periodic maintenance i.e. cleaning, dusting of lamps and luminaries will improve the light output / luminance. As part of maintenance programme, periodic surveys of installation, lightning system with respect lamp positioning and illumination levels, proper operation of control gears should be conducted to take advantage of energy conservation opportunities as user requirements changes.

4.5 Energy Conservation In Motors: Considering all industrial applications 70% of total electrical energy consumed by only electric motors driven equipments.

a. **Improving power supply quality:** Maintaining the voltage level within the BIS standards i.e. with tolerance of +/-6%and frequency with tolerance of +/-3% motor performance improves and also life.
b. **Optimum loading:** Proper selection of the rating of the motor will reduce the power consumption. If the motor is operating at less than 50% of loading (η<50%)significant power saving can be obtained by replacing with properly sized high efficiency motors. If the motor is operating at loads below 40% of it's capacity, an inexpensive and effective measure might be to operate in star mode.

c. **Improving transmission efficiency:** Proper selection of power transmission means (belts, gears) will reduces transmission losses.

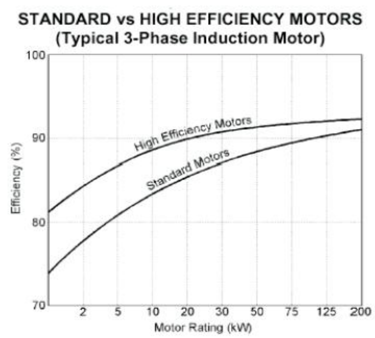
d. Stopping idle or redundant running of motors or lights will save 100% power.

e. **By use of Soft Starter:** Soft starters are essentially stator voltage controllers; helps to over come above problem. It helps to **restrict starting current** and also provide **smooth start and stop operation.**

Application	*No. Of working hours*	*No. Of jobs*	*Energy consumed in kWh*	*Savings in kWh*	*Savings in %*
Grinding machine					
Without soft starter	7	55	168.0	---	---
With soft starter	7	51	136.8	31.2	18.6
Lathe machine (5.5 kW)					
Without soft starter	7	231	96.4	---	---
With soft starter	7	228	76.4	19.6	20.4

f. **By improving power factor:** For improving p.f., connect the capacitor bank, which will improve the p.f. of the system from installation to generating station. Maximum improvement in overall system efficiency is achieved, which also reduces max. demand of the system and that will reflect in energy bill.

g. **Use of high efficiency or Energy efficient motors**



The energy efficient motors have reduced losses through improved design, better materials and improved manufacturing techniques. Generally motor life doubles for each 10 ^{0}C reduction in operating temperature. While selecting EEM, select with 1.15service factor, design for operation at 85% of rated load.

5.0 Case study: Thane Municipal corporation

Thane Municipal Corporation initiated the project of energy conservation in year 2001 by identifying the area- municipal building, municipal hospital, street lights, pumping station sewage pumping station.

The initial energy status was as…

- Municipal Buildings: 2970 kW
- Municipal Hospital: 1276 kW
- Streetlight: 7364 kW
- Water supply: 6634 kW
- Sewerage pumping stations: 1299 kW

Total: 19573 kW (19.5 MW)

List of energy conservation techniques adopted:

Area	Technique	Total saving

Municipal Buildings	• Preventing wastage & leakages in AC system • Revision of contract maximum demand with MSCDL • Improving the power factor to unity • Use of electronic ballast & T8 tube lights • Creating awareness of energy saving among the employees	Rs 1523.4 lacs (331 units) Up to year 2006
Streetlight	• Using microprocessor based cyclic timers • Energy efficient components (SV Lamps) for street light • Adaptation of solar based LED lights	
Municipal Hospital	• Use of electronic ballast & T8 tube lights • Adopting solar water heating system • Creating awareness of energy saving among the employers • Optimization of air conditioned load & light load	Rs 15.46 lacs/annum
Water supply	• Improving the power factor to unity • Use of Time Of Day (TOD) Tariff • Replacement by efficient pumps • By undertaking water audit project	Rs 24.96 lacs /annum
Sewerage Pumping stations	• Improving the power factor to unity • Optimization of load on transformer • Voltage stabilizers	Rs 12.3 lacs /annum

Through energy conservation cell awareness program, periodical maintenance program utilization of alternative energy sources, energy generation (methane gas), quality control & use of in-house man power TMC obtained the success in all its energy conservation programs For its efforts TMC received first prize in '**State Level Award For Excellence In Energy Conservation & Management'** for year 2004 & 2006 First prize in '**National Energy Conservation Award 2005'.**

6.0 Conclusion: Everything what happens in the world is the expression of flow of energy (Electrical) in one of its forms**.** In development process to cope with increasing energy demands, conservation and energy efficiency measures are two parallel paths.

"It takes … **one hour** to promote energy conservation, but only **one sec.** to save energy. "

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