Electrical Energy conservation in India - Challenges and Achievements

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Abstract—
The gap between electrical energy supply and demand is continuously increasing despite huge outlay for energy sector since independence.This gap between supply and demand of energy can be bridged with the help of energy conservation which is considered as a new source of energy and envinronmental friendly.The energy conservation is cost effective with a short pay back period and modest investment.There is a good scope of energy conservation in various sectors,viz domestic,industry,agriculture.The planners have already started appreciating the role and significance of energy conservation in future energy scenario of India.An attempt is made in this paper to acess the achievements and further challenges of electrical energy conservation in Indian context.

Index Terms— energy conservation, challenges

1 INTRODUCTION

INDIA today has a vast population of 1000 millions out of which 72.2 percent are living in rural areas. Energy and development are inter-related. In order to have sustainable growth rate, it is imperative to have sufficient energy for systematic development in various sectors. India ranks 5th in the world, interms of energy consumption,. Energy sector has received top priority in all the five year plans so far. Though installed capacity of electric power has increased from 1362MW at the time of independence in 1947 to 150000 MW in 2008. India is the Fifth largest producer of electrical energy in the world.

- Despite such achievements the gap between demand and supply of electrical energy is increasing every year and power sector is highly capital – intensive. Thus the deficit in installed capacity was nearly 10000MW per year or a deficit of 52513 Million Units in 2005-06. [Fig 1].

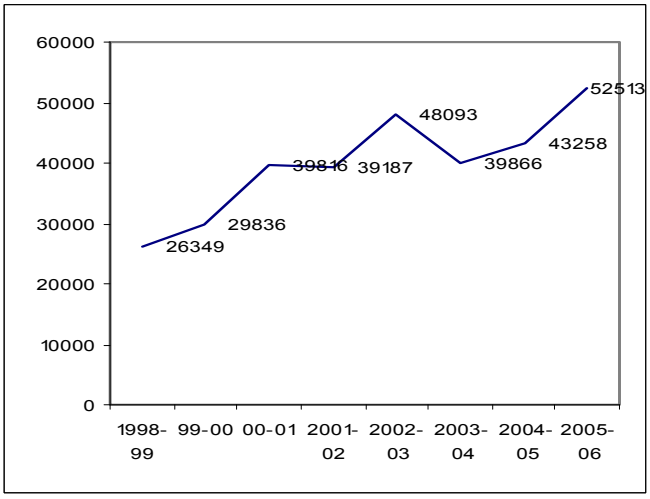

Figure 1 Energy gap [MU] between supply and demand
(Source: Rural Electric Corporation)

- The demand for power is projected to grow by 14 percent per year. In 2007 average deficit of electrical energy was 7% and peak time deficit of 12.6%. [Figure 2].

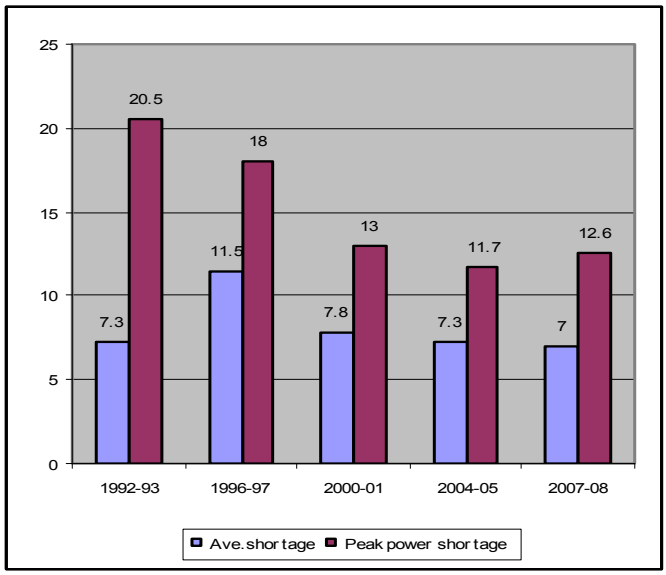

Figure 2 Percentage Electrical energy average & peak power shortage
(Source: Rural Electric Corporation)

- The proven reserve of fossil fuel in India is not very large.A major share of scarce foreign currency is earmarked for importing petroleum products. The bill of which is continuously increasing. The coal reserve of 84 billion tons is likely to be exhausted in another 150 years. New major hydal projects are not taken up in the last 20 years due to several reasons of environmental. The planners have adopted the western model of centralized energy system without necessary modification to suit Indian conditions. This has eluded the desired results.
- India is the fifth largest emitter of carbon dioxide 1100MT in the world after United States of America (5800MT), China (4732MT), Russia (1592MT) and Japan (1215MT).
- Additional 100000MW is required by 2012 with estimated cost of Rs 80000 billion. Hence additional power generation requires huge money alongwith environmental constraints.And the immediate available alternative

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solution is, using the available energy intelligently -i e energy conservation.

- Conservation is cheaper than new production. It is a silent generator with no fuel input and clean energy. It is also termed as energy produced at 'Zero Cost'.
- Conservation has two fold approach, one using available electrical energy efficiently and the other reduction in the losses.

Time has come when India should plan its own strategies in electrical energy sector based on available resources, funds, requirements and past experience. Decentralised energy systems based on energy conservation should form the core of energy planning in India. Due to highly inefficient utilization of energy in various sectors, there is tremendous scope of energy conservation in India.

Presently the energy conservation would assume more significant globally on the basis of the effect of burning of coal fossil fuel on environment, particularly global warming, rather than the depletion of fossil fuel reserves and other considerations. It is imperative for India to seriously work towards energy conservation through energy saving actions and energy efficiency improvement programmes.

2 THE SCOPE AND POTENTIAL

The developing countries like India are obliged to maintain a certain growth rate for which energy is a basic ingredient. Failure to meet the energy demand for the basic needs of the economy will cause inflation, unemployment and socio-economic disorder. The centralized major electrical energy projects are capital-intensive, require long gestation period and result in the degradation of the environment and ecology. With only 1% of the world's fossil fuel reserve and nearly $1/6^{th}$ of humanity, the efficiency options the only most cost effective approach to bridge energy gap in India. Energy efficiency and conservation in the past have been neglected on the assumption of continuous availability of fossil fuel. It is abundantly clear that the gap between energy demand and supply cannot be bridged by capacity addition alone. It would be appropriate to search for some other alternatives.

India has a vast scope in the field of energy conservation. Outdated technologies mixed with poor maintenance have made Indian systems highly energy inefficient.

Energy conservation is defined as the "Strategy of adjusting and optimizing energy using systems and procedures to reduce energy requirements per unit of output without affecting socio-economic development or causing disruption in life style". The principal effort should be directed at obtaining more work from the fuel already being consumed. Energy consumption does not mean going without. Developing country like India is either to live with frequent power cuts or to mitigate the shortage by energy efficiency and integrated utilization of non-conventional energy sources. Energy utilisation in the year 2007 is available in table I that indicates the potential for conservation.

1) Transmission and Distribution Losses

Five year plans of Government of India were focused on electricity generation and recently there is more attention towards transmission. India has a complex, vast transmission and distribution network. Hence transmission and distribution losses in Indian power sector are rather high (table II).

In developed other countries, the losses are between 8 to 9

Sector	Percentage
Wastage	33
Industry	23
Domestic	17
Agriculture	16
Service	9
Others	2

Table I Electrical energy utilization in 2007
(Source: Rural Electric Corporation)

Transmission line 220 kV	1,03,724 ckm
Transmission line 400 kV	56,090 ckm
Sub stations 220kV	1,38,312
Sub stations 400 kV	73,175

Table II Transmission & distribution line details as on 31-12-2007 (Source: Rural Electric Corporation)

percent. Country like China, having conditions quite similar to India has been able to contain its transimmission & distribution losses to 10% level.

In order to estimate the cost effectiveness of the various modern techniques available for reduction of transmission and distribution losses in the context of Indian environment, it is essential to have an idea regarding the energy losses taking place at the various places at the various stages of transmission and distribution of power as well as a further breakup of the line losses and transformation losses [Figure 3].

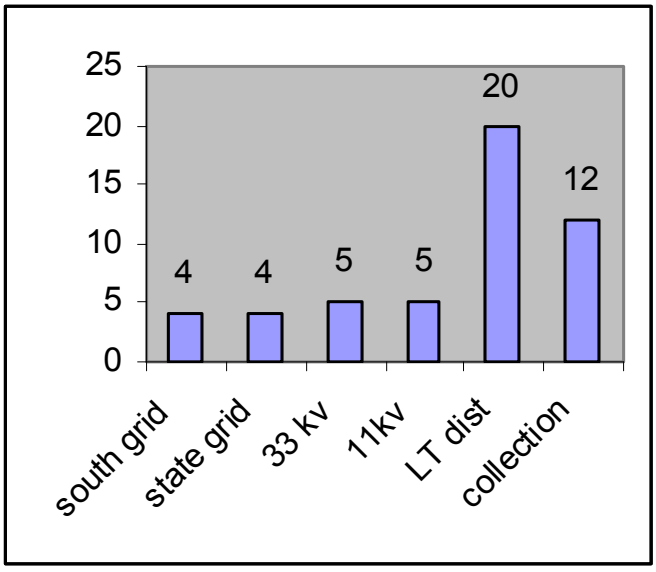

Figure 3 Percentage Aggr. Technical &Commercial losses
(Source: Rural Electric Corporation)

However, reliable and systematic data of this nature are not readily available for Indian Power System. Thus strategies have to be formulated on the basis of whatever relevant data are available.

The transmission and distribution losses can be divided in to two parts, namely high voltage transmission and low voltage distribution.Out of total 18% targeted to be achieved; it has been assumed that it would be possible to restrict the contribution of transmission losses by the following technical means--

- achieving optimal reactive balance in the transmission network.
- adoption of higher transmission voltage.
- Improved design of distribution substations.
- Selection of higher or more appropriate primary system voltages.(in relation to sub -transmission and bulk supply voltages)
- Improved design of energy efficient distribution transformers, switching and protection circuits.
- Improved design of line supports, proper size of conductors and joints.
- Revised service quality criteria.
- improved grid management and operation techniques.
- Use of small independent grid like renewable systems like Photovoltaic module in remote and faraway rural areas.

Thus the transmission losses can be reduced to optimistic 10% level. Several studies have shown that the additional investment towards conservation is very much less, compared with augmenting additional energy capacity. Also the payback period is less than 6-8 years.

2) Areas of Energy Conservation

The main areas where conservation is possible are as follows-

1) Improvement in power factor would result in reduction in actual maximum demand on system. The tariff structure provides for rebate on power factor above 0.95.
2) Improvement in plant load factor (PLF) results in optimum utilization of plant capacity and increasing in production. Rescheduling of various plant loads results in reduction in energy bill by operating some of machines during off-peak hours.
3) Induction motors consume 80% of the electrical energy in industries, for applications like pumping, compressing, prime movers etc.It has been observed that many of these motors are loaded to the extent of 50% or even less. Hence under-loading of motors leads to poor power factor and lower efficiency. As per an estimate by increasing the motor efficiency by 2 % will release additional capacity of 1100MW with less capital investment.[4] Use of proper size motors application of variable speed drives for variable loading applications particularly in case of compressors, fans, pumps and blowers are found to be economical propositions.
4) Various furnaces, electrolysis baths and vessels operating at higher temperature are found to have inadequate insulation. Higher surface temperature means loss of electrical form of energy by radiation. This can easily be prevented by applying proper insulation to limit the surface temperature rise above ambient up to 20° C.

3. Recent Concepts of Energy Conservations

The world at large underwent unhindered industrial and economic growth during the low cost energy era. The hallmark of technologies and processes that evolved was their relatively high energy intensities. A major lesson of the oil crunch was that energy efficiency is a tangible resource by itself that competes economically with contemporary energy supply options. In addition four major national priorities economic competitiveness, utilization of scarce capital for development, environmental quality and energy security through oil independence provide an urgent rationale for energy saving.

Energy conservation offers a practical means of achieving development goals. It enhances the international competitiveness of industry in world market by reducing the cost of production. It optimizes the use of capital resources by diverting lesser amounts in conservation investments as against huge capital investments in power sector. It helps environment in the short run by reducing pollution and in the long run by reducing the scope of global climate changes. It strengthens India's security at a time when domestic oil production has begun to level off and dependency on oil imports is increasing. No other energy supply option can provide these benefits.

Energy conservation also implies the substitution of costly imported energy by cheaper and more plentiful indigenous sources to supplement conventional sources. Energy conservation is a decentralised issue and largely depends on the individual unlike decisions of energy supply which are highly centralized. Every individual who consumes energy in some form or other required to participate in energy saving measures.

In order to have energy efficiency strategies really effective following conceptual changes are imperative.-

- Conservation must be recognized as a New Source of Energy "a benign and clean source". Electricity conserved is electricity generated; it is in fact much more than that. It preserves the scarce fossil fuel and prevents environmental degradation.
- End use management of energy demand should not be met by increased supply only.
- Energy efficiency is the most cost effective way to bridge the gap between supply and demand.
- In the past the energy planning was based on continuous supply of fossil fuel. Energy services provided are more important than per capita consumption of energy consumption. It is logical to think of achieving higher growth rate with reduced energy consumption.
- The economics of major power projects ignore the time value of money. For instance, it adds the current expenditure of capital for many years to get the total cost of the project. The gestation period of the project is ignored. Thus the projects which yield physical benefits after many years are treated at par with projects that yield immediate benefits. Thus very little attention is paid to when the returns are obtained.

4. APPROACHES AND CHALLENGES

I Approaches

The various approaches of energy conservation are divided into short-term, medium-term and long term measures. All the short-term and medium-term measures may be taken up immediately so that their benefits can be realized within 5-8 years. And long-term measures initiated will yield results after 10 years. The efforts in energy efficiency should be done with full missionary zeal and dedication. Any half hearted approach is bound to fail. Followings are some of the features of energy efficiency programme approach.

1) Software components include promotion, motivation, education, dissemination of information, data bank, and promotion of Research and development activities, studies on demand management.
2) Hardware components include energy efficient projects, models of efficient technologies
3) Stages of energy efficiency includes several activities resulting in various degree of energy saving and investments like.

4) Soft or Managerial solutions requiring little or no investment. It is obvious that, the savings are 10% to 15%, require cooperation from all concerned for immediate benefits.
5) Modest investments investment for replacing some parts of the existing system leading to reduction of higher 15% to 30% savings.
6) Using new or alternative technologies.

II Challenges

An important factor of in achieving energy efficiency and conservation target is the response of the end-user. Further the attitudinal change in the behavior of the end- user is the key point of success. Often the response is not cooperative as there is an information gap in this area. Proper information, data base on consumption, efficiencies of energy in various end users play effective role in energy education. Some of the challenging factors are as below.

1) Energy auditors and managers have technological support of accurate measurement techniques since the quantization is the primary step towards conservation.
2) In India the tariff of electricity is not a true indicator of the cost of production of electricity. The tariffs are highly subsidized particularly for agriculture and domestic sectors. This is due to the fact that the energy is under Central, State and Public sectors.
3) Motivating the masses toward energy efficiency and energy conservation has given very less results. Efforts from the agencies have been half hearted, isolated and lacked coordination.

One watt saved at the point of consumption is more than 1.5 watts generated. While it costs approximately Rs 4 Crores and 4-5 year to create 1 MW of new generation capacity with additional expenditure on transmission and distribution system, the same amount spent on energy conservation could provide 2-3 MW of avoidable generation capacity and yield result in 1-2 years.

5 ENERGY CONSERVATION EFFORTS BY GOVERNMENT OF INDIA

Government of India has initiated several measures of energy conservation and focused on the following key features in Energy Conservation Act 2001.It has identified pulp and paper, chloralkali, cement, fertilizer, steel and power plants as energy intensive plants.

- Bureau of Energy Efficiency
- Energy Conservation Target saving 400 Crores
- Identification of energy intensive building codes
- Labeling of Appliances
- Energy Efficient technology for pumps and motors
- Energy Audit of Government Buildings
- Professional certification and Accreditation
- School Education and Energy Conservation

These programs are showing good results but more promising new approaches need to be tested with the angle of global warming Carbon Dioxide, environmental issues. Still there are ample opportunities for energy efficiency and energy conservation (Fig 4) as below.-

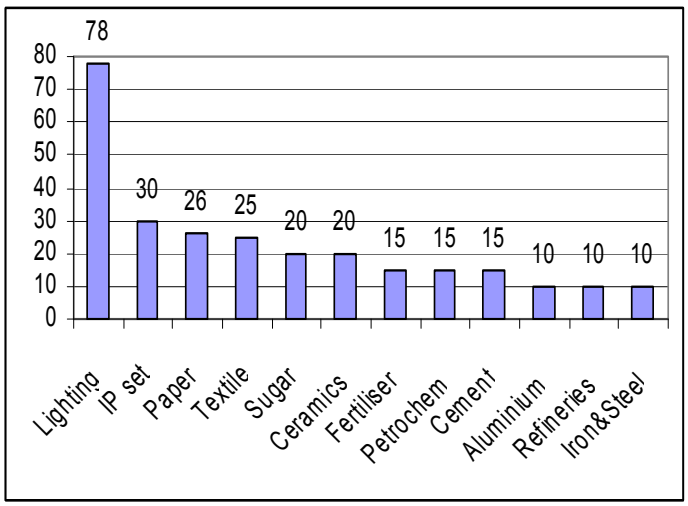

Fig 4 Sector wise saving potential in percentage

1) Domestic Sector: In this sector the maximum consumption of electricity is in water heating, lighting, fans and other gadgets. By reducing temperature setting of electrical water heater by10 degree Celsius Rs 1000 per annum can be saved in electricity bill. Water heating can be switched to solar water heating (presently having soft loan at 4% interest from Ministry of New Energy Sources) instead of electrical water heater or geyser.

Energy dependency on artificial lighting can be reduced by maximum use of sun light.Efficient devices like Compact Fluorescent Lamps (CFL), WLEDs (White Light Emitting Diodes) consume less power and longer life time. [6]

2) Agricultural Sector*:* The farmers in the country have installed about 19 million pumps operated by electricity. These consume 150 billion kWh of electricity. The pumping systems adopted have remained inefficient and the consumption of electricity has been more than 50 percent more than what it should be. It is obvious that the excessively wasteful consumption of energy reduces the irrigation cost for farmers. It is possible and necessary to rectify our existing pumping system by providing shunt capacitors on motor terminals, thus reducing frequent burnouts due to low voltage. Conservation of energy also results in reduction of commercial losses to State Electricity Boards. [4]

3) Industrial Sector*:* Industries consume maximum energy and they found to be not so efficient. However many industries are paying attention to energy auditing and conservation opportunities since it reduce their cost of production. Following are some of the options possible for different industries. [1]

a. Aluminium industry smelting process consumes more than 90% of the total energy consumption. Improved energy efficient designs like ALCOA, Carbothermic will reduce the consumption and contribute for improving specific energy consumption.
b. Iron and steel plants have energy conservation in coke ovens, basic oxygen furnace (BOF), sinter plants, blast furnaces, reheating furnaces, utilities etc.
c. Fertilizer plants of nitrogenous, phosphatic, potassic and complex have opportunities of energy saving in several of its processes.
d. Cement industries can have measures of energy conservation by improving kiln operational efficiency, optimizing grinding efficiency, pre-calcinators, oxygen enrichment, variable speed drives. By using these power

consumption in modernized plants is 65-90 kWh for 1 ton of cement compared with 95-120 kWh in old plants.[2]

e. Textile industries are equipped with highly energy inefficient and old type coal fired boilers and motors. Hence modifications in this will help for energy conservation.[5]

Many industries like paper, sugar, ceramics, aluminium manufacturing, and medium and small scale industries are using old type furnaces, boilers, induction motors, diesel-generator sets, etc for several applications. They need to be modified or replaced by energy efficient and environment friendly equipments

Energy is in short supply in India and expensive for industries. With use of more energy efficient technologies, many businesses could cut their energy consumption by up to 20 %. Energy efficient technologies can help protect the global climate, especially since fossil fuels, which are responsible for the greenhouse effect, will almost certainly continue to generate a large percentage of our energy for a long time to come.

6 CONCLUSIONS

In today's energy dependent times, the needs for ensuring energy conservation and energy efficiency has become more crucial.Some of the important conclusions are listed as below;

1) The energy efficiency and conservation should be viewed as new source of energy and it is the energy produced at very low cost. Having short payback period, it will help in reducing the gap between demand and supply.

2) It is absolutely necessary to bring attitudinal change in all energy users in respect of energy efficiency. This can be achieved to a large extent by imparting energy education in school level itself.

3) Energy efficiency is to be given due importance at the planning stage itself of the new industries.

4) Government, Industries and public participation can form -

- Immediate measures -with small direct investment and lower payback periods.
- Medium term measures- slightly higher investments, minimum gestation period, moderate pay back periods.
- Long term measures- Heavy investment, high gestation period, prolonged pay back periods.

5) The government should provide more attractive incentives in terms of soft loans for purchasing energy efficient machineries and subsidies for employing energy conserving measures.

6) Energy Conservation Act- 2001 by Government of India is the first step in this direction and has given encouraging results. Recent programs are showing good results but more promising new approaches need to be tested to determine if they can address poverty, equity, environmental and public health concerns in the context of on going global restructuring of power sector reforms.

7) A national movement for energy conservation can significantly reduce the need for fresh investment in energy supply systems in coming years. It is imperative that all-out efforts are made to realize this potential. Energy conservation is an objective to which all the citizen in the country can contribute. Whether a household or a factory, a small shop or a large commercial building, a farmer or an office worker, every user and producer of energy can and must make this effort for his own benefit, as well as that of the nation. Energy conserving is the need for better future.

8) A systematic study and action plan approach for enegy efficiency and energy conservation, augmenting the electrical energy generation from conventional and renewable resources will address the increasing energy demands of future India. Time has come to define and act in this direction.

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BIOGRAPHIES

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