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Energy& Environmental Problems Facing the Third World and Their Probable Solutions for Sustainable Development.

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ABSTARCT

This paper briefly discusses some important energy problems facing the third world countries and presents the current electric generation scenario in most of the developing countries with facts and figures in respect of India. It is hoped that, with systematic, advance planning, through measures like co-generation, energy management, and energy conservation, the electric energy supply scenario of AD 2020 will be free of the perennial problems of power shortages, voltage fluctuations etc.

INTRODUCTION

Conventionally, electric energy is obtained by conversion from fossil fuels (coal, oil, natural gas) and nuclear and hydro sources. Heat energy released by burning fossil fuels or by fission of nuclear material is converted to electricity by first converting heat energy to the mechanical form through a thermo cycle, and then converting mechanical energy through generators to the electrical form. The thermo cycle is basically a low efficiency process – the highest efficiencies for modern large size plants range up to 40% while smaller plants may have considerably lower Efficiencies. The earth has fixed non-replenish able resources of fossil fuels and nuclear materials, with certain countries over-endowed by nature and others deficient. Hydro energy, through replenishable, is also limited in terms of power. The world's increasing power requirements can only be partially met by hydro sources. Furthermore, ecological and biological factors place a stringent limit on the use of hydro sources for power production.(The USA has already developed around 50% of its hydro potential; and hardly any further expansion is planned because of ecological considerations.)

With the increasing per capita energy consumption and exponentially rising population, technologists already see the end of the earth's non-replenishable fuel .A co-ordinate worldwide action plan is, therefore, necessary to ensure that energy supply to humanity at large is assured for a long time and at low cost and minimum pollution. Some of the facts to be considered and actions to be taken are:

1. *Curtailment of energy consumption:*
2. *Intensification of efforts to develop alternative sources of energy including renewable energy sources like solar, wind tidal energy etc. (Ref no.)*
3. *Recycling of nuclear wastes.*
4. *Development and application of antipollution technologies:*

Electric energy today constitutes about 30% of the total annual energy consumption on a worldwide basis. This figure is expected to rise in favour of electric energy as oil supply for industrial uses becomes more scarce. Electricity, unlike water and gas, cannot be stored economically (except in very small quantities in batteries), and also the electric utility can exercise little control over the load (power demand) at any time. The power system must, therefore, be capable of matching the output from generators to the demand at any time at a specified voltage and frequency. The difficulty encountered in this task can be imagined form the fact that load variations over a day comprise three components- a steady component known as base load; a varying component whose daily pattern depends upon the time of day, weather, season, a popular festival, etc; and purely randomly varying component of relatively small amplitude. The characteristics of daily load curve on a gross basis are indicated by peak load and the time of its occurrence and load factor defined as: [5]

$$\frac{average\ load}{\max imum\ (peak)\ load} = \text{less than unity}$$

The average load determines the energy consumption over the day, while the peak load along with considerations of standby determines the plant capacity for meeting the load.

A high load factor helps in drawing more energy from a given installation. As individual load centres have their own characteristics, their peaks in general have a time diversity, which when utilized though transmission inter-connection, greatly aids in jacking up load factors at an individual plant-excess power of a plant during light periods is evacuated through long distance high voltage transmission lines, while a heavily loaded plant receives power.

Diversity Factor. [1]

A high diversity factor could be obtained by

1. giving incentives to farmers and/ or some industries to use electricity at night or during light-load periods;
2. using day-light saving, as many countries do;
3. staggering of office timings;
4. having different time zones in the country such as in USA, Australia, etc;
5. Having a two-part tariff in which the consumer has to pay an amount dependent on the maximum demand he makes, plus a charge for each unit of energy consumed. Sometimes a consumer is charged on the basis of kVA demand instead of kW to penalize loads of a low power factor. Two other factors used frequently are the plant capacity factor and the plant use factor.

Energy Conservation [6]

Energy conservation is the cheapest new source of energy. A dollar saved is better than a dollar earned as one does not have to pay tax on savings. An important energy-saving concept of co-generation [3] must be adopted. Co-generation is defined as the simultaneous generation of electrical power and process steam. This is now attracting world attention. In fact in USA there is a plan for meeting the additional demand of power, not by installing new generating capacities, but by co-generation, other conservation means, and various energy-management strategies. The main advantage of a co-generation is its very high thermodynamic efficiency of 80% or more.

Co-generation of steam and power is highly energy efficient and is particularly suitable for chemical, paper, textile, food, fertilizer and petroleum-refining industries. If these industries have in-plant generation using a co-generation concept, it will help in solving the energy shortage problem in a big way. Further, they will not have to depend on the grid power which is not very reliable. Of course, they can sell the excess power, if any, to the government for use in deficient areas. They may also sell power to neighboring industries, a concept called wheeling power [1].

Conventional Sources of Electric Energy Generation

Major conventional sources of electric energy generation are (i) thermal (by coal/oil/gas); (ii) hydro; and (iii) nuclear.

Hydro plants do have ecological consideration but there still exists great hydroelectric potential in many third world countries such as Brazil (90% hydro) and this should be utilized as load grows. Nuclear plants are controversial. There are safety and environmental concerns; yet nuclear energy must be used for power generation.

Fusion is futuristic. The generation of electricity via fusion would solve the long-term fuel shortage with a minimum of environmental problem. A commercial reactor by AD 2020 is expected. Coal is only available for the next 100 to 200 years. With this in mind there is considerable international effort being made for the development of alternative/new unconventional/clean new natural renewable sources of energy.

Energy Storage

Unfortunately, electric energy cannot be stored like gas and water and has to be generated as and when required. However several ways of energy storage are being tried. They are: (i) pumped storage plants; (ii) compressed air; (iii) hydrogen gas; and (iv) secondary batteries .v) Fuel Cells.

Renewable Energy Sources

Most of the new, alternative sources (some of the them have in fact been known and used for centuries now) are nothing but manifestations of solar energy, e.g. wind, sea waves, ocean thermal energy conversion (OTEC), etc.

Geothermal Energy [7]

In a geothermal power plant, heat deep inside the earth acts as a source of power. There has been some use of geothermal energy in the form of underground steam in the USA, Italy, New Zealand, Mexico, Japan, the Philippines and some other countries. In India feasibility studies for a 1MW station at Puggy Valley in Ladakh are being carried out. Another geothermal field has been located at Chumantang. There is a number of hot springs in India, but the total exploitable energy potential seems to be considerable.

The present installed geothermal plant capacity in the world is about 500 MW and the total estimated capacity is only about 2000 MW. Since the pressure and temperature are low, the efficiency is even less than conventional fossil-fuelled plants, but the capital costs are less and the fuel is available free of cost.

Wind Energy [8]

Wind is essentially created by the solar heating of the atmosphere. Several attempts have been made since 1940 to use wind to generate electric energy and development is still going on. However, the techno-economic feasibility has now been established.

Wind as a power source is attractive because it is plentiful, inexhaustible and non-polluting. Further, it does not impose an extra heat burden on the environment. Unfortunately, it is unsteady and undependable. Control equipment has been devised to start the wind power plant whenever the wind speed reaches 30km/h. Methods have also been found to generate constant frequency power with varying wind speed and consequently varying speeds of windmill propellers. Wind power may prove practical for small power needs in isolated sites; but for maximum flexibility, it should be used in conjunction with other methods of power generation to ensure continuity.

Solar Energy [7]

The average incident solar energy received on the earth's surface is about 600 W/m^2, but the actual value varies considerably. It has the advantages of being free of cost, non-ex-haustible and completely pollution-free. On the other hand, it has several drawbacks-the energy density per unit area is very low; it is available for only part of the day. Cloudy and seasonal variations reduce the energy received therefore, harnessing solar energy for electricity generation throws up some challenging technological problems, the most important being that of the collection and concentration of solar energy and its conversion to electrical form through efficient and comparatively economical means.

At present two technologies are being developed for conversion of solar energy to the electrical form. In one technology, collectors with concentrators are employed to achieve temperatures high enough $(\geq 700^0 C)$ to operate a heat engine at reasonable efficiency to generate electricity (**solar thermal**). However, there are considerable engineering difficulties in building a single tracking howl with a diameter exceeding 30m to generate perhaps 200 kW. The scheme involves large and intricate structures involving huge capital outlay and as of today is far from being competitive with conventional electricity generation.

Electricity may be generated form a Solar Pond by using a special 'low temperature' heat engine coupled to an electric generator [2]. A solar pond at EinBorek in Israel produces a steady 150 kW from 0.74 ha at a busbar cost of about $ 0.10/kWh.

Direct conversion to electricity ***(photovoltaic generation);*** This technology converts solar energy to the electrical form by means of silicon wafer photoelectric cells known as 'solar cells'. Their theoretical efficiency is about 25% but the practical value is only about 15%. But that does not matter, as solar energy is basically free of cost. The chief problem is the cost and maintenance of solar cells. With the likelihood of a breakthrough in the large-scale production of cheap solar cells with amorphous silicon, this technology may compete with conventional methods of electricity generation, particularly as conventional fuels become scarce.

Wave Energy

The energy content of sea waves is very high. In India, therefore, with several hundreds of kilometers of coastline, a vast source of energy is available. The power in the wave is proportional to the square the amplitude and to the period of the motion. Therefore, the long period (~ 10s), large amplitude (~ 2m) waves are of considerable interest for power generation, with energy fluxes commonly averaging between 50 and 70 kW/m width of the oncoming wave. Though the engineering problems associated with wave-power are formidable, the amount of energy that can be harnessed is large and development work is in progress.

Tidal Power Plants

A tidal power plant is successfully working in France on the river La Rance having tidal height of 9.2 m and tidal flow of 18,000 m^3/sec. Several such sites exist in India. e.g. (Kutch and Sunderbans) and must be developed.

Ocean Thermal Energy Conversion (OTEC)

The ocean is the world's largest solar collector. Temperature different of 20^0C between the warm, solar absorbing surface water and the cooler 'bottom' water can occur. This can provide a continually replenished store of thermal energy which is in principle available for conversion to other energy forms. OTEC refers to the conversion of some of this thermal energy into work and thence electricity.

Magnetohydrodynamic (MHD) Generation

In thermal generation of electric energy, the heat released by the fuel is converted to rotational mechanical energy by means of a thermo cycle. The mechanical energy is then used to rotate the electric generator. Thus two stages of energy conversion are involved in which the heat to mechanical energy conversion has an inherently low efficiency. Also, the rotating machine has its associated losses and maintenance problems. In MHD technology, electric energy is directly generated by the hot gases produced by the combustion of fuel without the need for mechanical moving parts. And hence the efficiency is more than conventional thermal plant. (Around 50%)

Conclusions

The main reason for power shortage include; delay in commissioning the installed capacity, poor capacity utilization of power plants, poor availability of plants due to bad or unplanned maintenance. In India the availability is for 3600 hours as against 5600 hours in Japan.

Now people are also thinking of decentralized (distributed/dispersed) power generation, integrated and hybrid energy systems consisting of grid power in combination with biomass, wind, solar and micro-mini hydel plants especially for rural areas. Centralized grid power will of course continue to be there but it must be made available economically, reliably and with minimum possible environmental effects.

References

1. D.P. Kothari, and I.J. Nagrath Modern Power System Analysis, 4/e McGraw Hill, New York, 2011.(Spanish Translation available, see reference 4.)
2. D.P. Kothari and J.J. Nagrath Electric Machines, 4th edn Tata McGraw Hill, New Delhi, 2010.
3. Robert Noyes (Ed.), Cogeneration of Steam and Electric Power, Noyes Data Corporation, USA, 1978.
4. D.P.Kothari and I.J Nagrath SystemasElectricos

DePotencia, 3/e McGraw Hill, Mexico.(2008).

5. D.P.Kothari and I.J.Nagrath, Power System Engineering, 2nd edition, Tata McGraw Hill, New Delhi, 2007.
6. D.P.Kothari and J.S.Dhillon, Power System Optimization 2nd edition, PHI, 2011.
7. D.P Kothari, K C Singal and Rakesh Ranjan, Renewable Energy Resources and Emerging Technologies 2nd Edn, PHI, New Delhi, 2011.
8. D P Kothari and Umashankar, Wind Energy Systems and Applications, Narosa, New Delhi, 2013.