

Electrical power generation system Indian scenario and the vision

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ABSTRACT

In view of the ever increasing per capita energy consumption and exponentially rising population the earth's non replenish able fuel resources are not likely to last for a long time. Thus a coordinated worldwide action plan is, therefore, necessary to ensure that energy supply to humanity at large is assured for a long time and at low economic cost. The various factors need to be considered and action to be taken accordingly energy consumption curtailment, to initiate concerted efforts to develop alternative sources of energy including unconventional sources, Recycling of nuclear waste, development and application of antipollution technologies.

Key words- Antipollution technologies; recycling of nuclear waste; Unconventional sources

1. INTRODUCTION

Electrical Engineering deals primarily with electricity and magnetism and is devoted to the utilization of the force of nature and material for the benefit of mankind. It encompasses many aspects of other engineering science, mathematics and the physical sciences. It includes research, invention, development, design, application and education. Amassing the vast sources of energy and transforming them to the most convenient form, that is electrical for the

overall benefit of the society for sustenance is the prime objective. The per capita power consumption is considered as a scale for measurement of development. The economic acceleration would greatly depend upon a commercially viable and a technically vibrant power sector that is able to attract fresh investments. It is a demand of time to generate electricity in large quantity for prosperity and development of the nation. Energy probably was the original stuff or creation. It appears in many forms, but has one thing in common energy is possessed of the ability to produce a dynamic, vital effort shows itself by excited animated state assumed by material which receives energy.

2. ENERGY SCENARIO

2.1 WORLD ENERGY SCENARIO

As regards energy consumption, 16% of the global population in the OECD countries would consume, by the year 2030, more than 40% of energy and the balance about 84% of the global population in the non-OECD areas would consume a little less than 60% of the total energy consumed in the world. No doubt, during the period 2005 to 2030, the rate of growth of energy consumption in the non-OECD countries would be higher than in OECD countries and would vary between 1.3% in the Russian-Caspian area to 3.2% in the Asia Pacific areas, as opposed to the rate of

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growth of energy consumption during this period in the OECD countries being in the range of 0.6% in North America to 0.9% in the Asia Pacific region. Still as mentioned earlier, by the year 2030, 16% of global population would consume as much as 40% of the energy and the balance 84% of the global population would consume less than 60% of energy. Providing access to adequate energy to their people is really a challenge for developing countries.

2.2 INDIAN ENERGY SCENARIO

2.2.1 ENERGY RESOURCES IN INDIA

The natural resources for electricity generation in India are unevenly dispersed and concentrated in a few pockets. Hydro resources are located in the Himalayan foothills and in the north-eastern region (NER). Coal reserves are concentrated in Jharkhand, Orissa, West Bengal, Chhattisgarh, parts of Madhya Pradesh, whereas lignite is located in Tamil Nadu and Gujarat. North Eastern Region, Sikkim and Bhutan have vast untapped hydro potential estimated to be about 35000 MW in NER, about 8000 MW in Sikkim and about 15000 MW in Bhutan. The distribution of energy resources and consumption centers are extremely unbalanced. The load centres are scattered at far-off places away from resource rich areas. Recent government initiatives for establishment of special economic zones have also given rise to new potential load centers. Projects are proposed to be located mostly at pit head/resource areas with each location having capacities in the range of 5,000-10,000 MW.

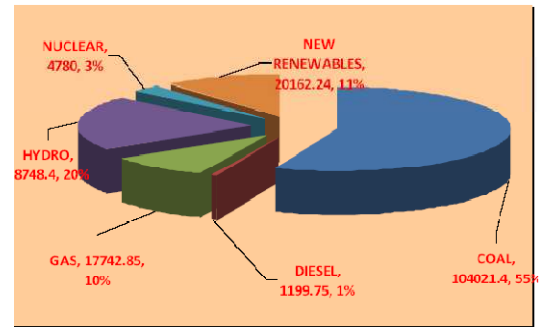


Fig 1. All India Installed Capacity

2.2.2 DEMAND

Electricity sector in India is growing at rapid pace. The present Peak Demand is about 1, 15,000 MW and the Installed Capacity is 1, 52,380 MW with generation mix is thermal (63%), hydro (25%), Nuclear (9%) and renewable (9%). The projected Peak Demand in 2013 is about 150 GW and in 2017 is more than 200 GW. The corresponding Installed capacity requirement in 2013 is about 220 GW and in 2017 is more than 300 GW.

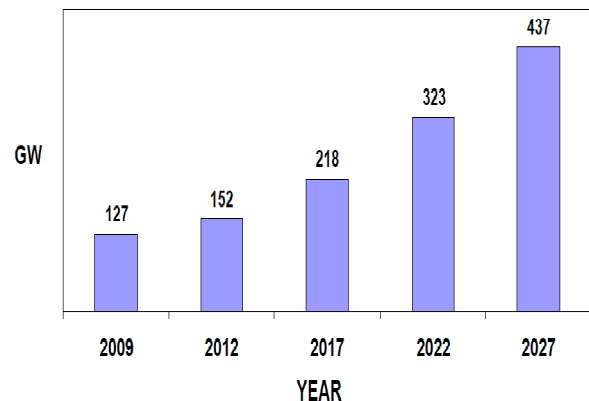


Fig 2. Projected Peak Demand in India

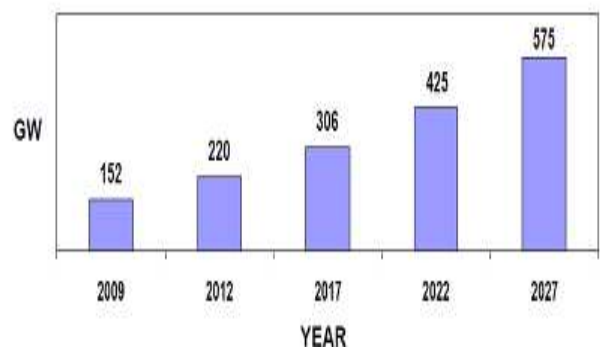


Fig 3. Projected Installed Capacity Requirements

2.3 INDIAN POWER SECTOR AT A GLANCE

The Indian power sector has made remarkable progress since Independence. The total installed capacity has gone up from 1,362 MW in 1947 to more than 2, 00,000 MW in 2013 and the transmission network has increased from the isolated system concentrated around urban and industrial areas to country wide National Grid. However, the demand of electricity has always been overstepping the supply. The importance of electricity as a prime mover of growth is very well acknowledged and in order to boost the development of power system the Indian government has participated in a big way through creation of various corporations viz State Electricity Boards (SEB), National Thermal Power Corporation (NTPC), National Hydro-Electric Power Corporation (NHPC) and Power Grid Corporation Limited (PGCL) etc. However, even after this the country is facing power shortage in terms of energy as well as peak demand to the tune of 10.9% and 13.8% respectively. Here are some facts about the scenario of power sector in India:

- 17 percent of world's population.
- Population growth rate of 1.58 percent annually.
- GDP growth rate of 6 – 9 percent.
- 6th (IEA Report) largest energy producer of the world.
- Ranks 5th in energy consumption.

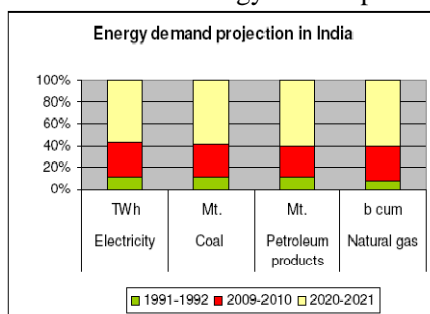


Fig 4. Energy demand projection in India

2.4 SOURCES OF ENERGY AND POWER GENERATION

2.4.1 CONVENTIONAL SOURCES OF ENERGY

1. THERMAL SYSTEM

Converting heat energy of fuels like coal, petrol etc in to Electrical energy. At present 54.09% or 93918.38 MW of total electricity production in India is from Coal Based Thermal Power Station. A coal based thermal power plant converts the chemical energy of the coal into electrical energy. This is achieved by raising the steam in the boilers, expanding it through the turbine and coupling the turbines to the generators which converts mechanical energy into electrical energy

2. HYDROELECTRIC SYSTEM

In hydroelectric power plants the potential energy of water due to its high location is converted into electrical energy. The total power generation capacity of the hydroelectric power plants depends on the head of water and volume of water flowing towards the water turbine.

3. NUCLEAR SYSTEM

Converting heat obtained by nuclear fission reaction in to electrical energy. Nuclear power is the fourth-largest source of electricity in India after thermal, hydro and renewable sources of electricity. India has 19 nuclear power plants in operation generating 4,560 MW while 4 other are under construction and are expected to generate an additional 2,720 MW. India is also involved in the development of fusion reactors through its participation in the ITER project.

4. DIESEL ELECTRIC SYSTEM

Diesel engine is used as the prime mover. The diesel based power plants in India had an overall installed capacity of 1,199.75 MW (as stated by the Central Electricity Authority). Typically, the diesel powered thermal power stations are either run from isolated areas or to supply maximum load-requirements.

5. GAS TURBINE POWER SYSTEM

Gas turbine is used as the prime mover. The gas turbine is the most versatile item of turbo machinery today. It can be used in several different modes in critical industries such as power generation, oil and gas, process plants, aviation, as well domestic and smaller related industries. A gas turbine essentially brings together air that it compresses in its compressor module, and fuel, that are then ignited. Resulting gases are expanded through a turbine. That turbine's shaft continues to rotate and drive the compressor which is on the same shaft, and operation continues.

2.4.2 NON CONVENTIONAL SOURCES OF ENERGY

Renewable Energy Sources are those energy sources which are not destroyed when their energy is harnessed. Human use of renewable energy requires technologies that harness natural phenomena, such as sunlight, wind, waves, water flow, and biological processes such as anaerobic digestion, biological hydrogen production and geothermal heat. Amongst the above mentioned sources of energy there has been a lot of development in the technology for harnessing energy from the wind.

2.4.3 THE NEED FOR RENEWABLE ENERGY

Renewable energy is the energy which comes from natural resources such as sunlight, wind, rain, tides and geothermal heat. These resources are renewable and can be naturally replenished. Therefore, for all practical purposes, these resources can be considered to be inexhaustible, unlike dwindling conventional fossil fuels. The global energy crunch has provided a renewed impetus to the growth and development of Clean and Renewable Energy sources. Clean Development Mechanisms (CDMs) are being adopted by organizations all across the globe. Apart from the rapidly decreasing reserves of fossil fuels in the world, another major factor working against fossil fuels is the pollution associated with their combustion. Contrastingly,

renewable energy sources are known to be much cleaner and produce energy without the harmful effects of pollution unlike their conventional counterparts. Non conventional sources of energy are not being met the ever increasing energy demands. These conventional sources of energy are also depleting and may be exhausted at the end of the century or beginning of the next century. The various non conventional energy sources are as follows.

1. SOLAR ENERGY SYSTEM

Solar energy system converts solar energy in to electrical energy. Solar energy can be utilized in two major ways. Firstly, the captured heat can be used as solar thermal energy, with applications in space heating. Another alternative is the conversion of incident solar radiation to electrical energy, which is the most usable form of energy. This can be achieved with the help of solar photovoltaic cells or with concentrating solar power plants.

2. WIND ENERGY SYSTEM

The wind energy is an indirect source of energy can be used to run a wind mill which in turn drives a generator to produce electricity. Wind is the motion of air masses produced by the irregular heating of the earth's surface by sun. These differences consequently create forces that push air masses around for balancing the global temperature or, on a much smaller scale, the temperature between land and sea or between mountains. Wind energy is not a constant source of energy. It varies continuously and gives energy in sudden bursts. About 50% of the entire energy is given out in just 15% of the operating time. Wind strengths vary and thus cannot guarantee continuous power. It is best used in the context of a system that has significant reserve capacity such as hydro, or reserve load, such as a Desalination plant, to mitigate the economic effects of resource variability.

3. TIDAL ENERGY SYSTEM

Tidal energy is due to gravitational force of attraction between the earth and sun and between earth and moon. Tides are generated by gravitational forces of the sun and the moon on

the earth's waters. The moon roughly exerts twice the tide raising force of the sun due to the proximity of the moon. Very simply put, the gravitational forces of the moon and the sun create bulges" in the earth's oceans. These bulges result on the two tides of the earth a day. This is the dominant tidal pattern in most of the oceans of the world.

4. OCEAN THERMAL ENERGY SYSTEM

Ocean thermal energy system uses the temperature difference between top and bottom sea water. Just as land is heated by the sunlight, sea surface is also heated by the sun. While the average sea surface temperature is 17 degree, at temperate places it is usually as high as 23 - 24 degrees. Sunlight cannot penetrate much of deep sea water. It can heat up only the upper 200 meters or so. Below this depth the sea water becomes cooler and cooler. At about a depth of 500 meters the sea water is only about 12 degrees and at the depth below 1000 meters it is just 4-5 degrees. Much below this, the temperature drops to freezing 4 degrees or less. Thus the temperature difference which exists between the warm surface sea water (28° - 30° C) and deep sea cold water (7° - 15° C) could be effectively utilized for generation of power. This is called Ocean Thermal Energy Conversation (OTEC).

5. MHD SYSTEM

MHD system produces electric power using high temperature plasma moving through an intense magnetic field. A magneto hydrodynamic generator (MHD generator) is a magneto hydrodynamic device that transforms thermal energy and kinetic energy into electricity. MHD generators are different from traditional electric generators in that they operate at high temperatures without moving parts. MHD was developed because the hot exhaust gas of an MHD generator can heat the boilers of a steam power plant, increasing overall efficiency. MHD was developed as a topping cycle to increase the efficiency of electric generation, especially when burning coal or natural gas. MHD dynamos are the complement of MHD propulsors, which have

been applied to pump liquid metals and in several experimental ship

6. GEOTHERMAL ENERGY SYSTEM

Geothermal energy system means the heat energy of the interior of earth. Geothermal energy is the thermal energy which is generated and stored within the layers of the Earth. The gradient thus developed gives rise to a continuous conduction of heat from the core to the surface of the earth. This gradient can be utilized to heat water to produce superheated steam and use it to run steam turbines Technologies in use include dry steam power plants, flash steam power plants and binary cycle power plants. Geothermal electricity generation is currently used in 24 countries, while geothermal heating is in use in 70 countries Estimates of the electricity generating potential of geothermal energy vary from 35 to 2,000 GW. Current worldwide installed capacity is 10,715 megawatts (MW), with the largest capacity in the United States (3,086 MW). El Salvador, Kenya, the Philippines, Iceland and Costa Rica generate more than 15 percent of their electricity from geothermal sources.

7. FUEL CELL SYSTEM

Fuel cell system directly converts chemical energy in to electrical energy. the total electricity generation capacity in India was almost 100,000 MW, the bulk of which came from coal-fired power plants .On a per capita basis, electricity sold to consumers in India was a paltry 0.3 MWh as compared to 11 MWh in the U.S. Obviously, with development, per capita electricity consumption in India is bound to increase in the future. Although generation capacity has been growing at 5% annually, growth needs to be 15% to meet the target economic growth rate of 10%.

8. BIOMASS SYSTEM

Plants capture the energy of the sun through the process of photosynthesis. On combustion, these plants release the trapped energy. This way,

biomass works as a natural battery to store the sun's energy and yield it on requirement. Biomass power & cogeneration program is implemented with the main objective of promoting technologies for optimum use of country's biomass resources for grid power generation. Biomass materials used for power generation include bagasse, rice husk, straw, cotton stalk, coconut shells, soya husk, de-oiled cakes, coffee waste, jute wastes, groundnut shells, saw dust etc.

9. SMALL HYDROPOWER

Hydropower installations up to 10MW are considered as small hydro power and counted as renewable energy sources. These involve converting the potential energy of water stored in dams into usable electrical energy through the use of water turbines. Run-of-the-river hydro electricity aims to utilize the kinetic energy of water without the need of building reservoirs or dams.

2.5 PROSPECTS FOR RENEWABLE ENERGY

India is committed towards increasing the share of renewable power in the electricity mix to 15 per cent by the year 2020. Indian energy sector is expected to be at par with the global stipulations on carbon emissions and sustainability through various changes in the current set-up. The launch of Jawaharlal Nehru National Solar Mission, a joint initiative of the Ministry of New and Renewable Energy and Ministry of Power, is one of the most important environment friendly energy solutions available in India. The National Solar Mission targeting 20,000 MW grid solar Power, 2,000 MW of off-grid capacity including 20 million solar lighting systems and 20million square meters solar thermal collector area by 2022 is under implementation. Last year witnessed a significant growth in number of new initiatives in the renewable energy sector. The wind energy sector picked up momentum by adding over 2,800 MW capacities resulting in grid-connected renewable power capacity crossing the 22,000 MW milestones. During 2013, grid-connected solar power plants crossed the 100 MW

milestones as well. Further, over 1000 remote villages were elaters through renewable energy systems during this year. Wind power is the fastest growing renewable energy sectors in India. A total capacity of 15, 880 MW of wind power has been installed in the country. A capacity of around 2827 MW has been installed during 2013. Following the Central Government's decision to enforce the Energy Conservation Building Code minimize the use of energy and recommendations to the state governments to follow the same with suitable amendments warranted by local circumstances and requirements, the state of Haryana has enforced the provisions of the code. The code is applicable to all buildings and complexes having a connected load of 500 KW and more, or having a contract demands of 600 KVA and more.

2.6 OVERVIEW RENEWABLE ENERGY

The country has significant potential of generation from renewable energy sources. All efforts are being taken by Government of India to harness this potential. The Total Renewable Installed Capacity comprises of;

- Wind: 14104.62 MW
- Small Hydro Plants 3120.83 MW
- Biomass & Gasifies 2787.63 MW
- Solar power & Urban & Industrial waste 149.16 MW

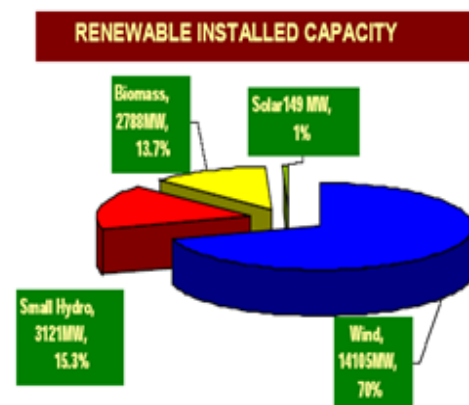


Fig 5. Renewable Installed Capacities

2.7 LOOK IN TO FUTURE.

1. RENOVATION AND MODERNIZATION OF GENERATION SECTOR

For improvement of performance of existing old power plants a massive renovation and modernization program need to be launched. Increase the efficiency of coal-based power plants. The fuel conversion efficiency of the existing population of thermal power stations is on average around 30 per cent. Super-critical boilers can provide an efficiency of 38-40 per cent. No new thermal power plant should be allowed without a certified fuel conversion efficiency of at least 38 per cent.

2. DEVELOPMENT OF NATIONAL GRID

In order to increase the transmission capability of power the important role plays by national grid development. It is envisaged to add new inter-regional capacities of 20700 MW at 220 kV and above during the Eleventh Plan period. This would increase the total inter-regional transmission capacity of national power grid at 220 kV and above from 14100 MW (by the end of the Tenth Plan) to 37750 MW.

3. STRENGTHENED ROLE OF RENEWABLE IN THE SECTOR

To boost investment in renewable energy, it is essential to introduce clear, stable and long-term support policies. A number of policy measures at national level, which could be applied concurrently, would significantly improve the frame work for renewable energy in India. However, they must be carefully designed to ensure that they operate in harmony with existing state level mechanisms and do not lessen their effectiveness.

4. IMPLEMENTATION OF MODERN TECHNIQUES FOR ELECTRIC POWER CONSERVATION (DSM)

DSM is the planning, implementation and monitoring of utility activities designed to

influence customer use of electricity in ways that will produce the desired changes in the load, shape of the utility. An integrated approach to DSM and successful implementation of DSM schemes results in capital expenditure, maintenance, operating costs, fuel savings, improved system efficiencies and reduced system losses and improved plants life.

5. INTRODUCING COGENERATION SYSTEMS

India have a large number of sources for the electricity generation and the energy from all available resources should be converted to electricity for better operation, utilization in order to meet growing electricity demand. The Central and State Grid networks are being contemplated for efficient and uninterrupted supply of energy, but such complex networks have large number of problems. To solve such problems, the Cogeneration, be implemented which is gaining popularity now days. The Total Energy System consists of generator for producing electricity and the waste heat from prime mover fuel is utilized for air-conditioning etc. Introduction of cogeneration will reduce transmission and distribution cost.

6.ADOPTION OF INNOVATIVE BUSINESS MODELS

Emerging opportunities in the sector along with increasing presence of the private sector would also drive adoption of newer business/operating models. On one hand, large players may move towards integrated presence in the value chain; at the same time many new entrants are expected to establish niche presence the market. Power tolling, direct supply to bulk customers, peak demand based capacities etc. could emerge in a big way in the future.

2.8 POWER CRISES IN INDIA: SOME OF THE REASONS OF THE POWER SHORTAGE ARE AS UNDER

- Limited fuel
- Equipment Shortage
- Land Acquisition and Environment Clearance

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- Transmission & Distribution Losses
- Aging Power Plants and Transmission network
- Sharp increase in demand
- Interstate Dispute
- Delay in construction of projects
- faulty planning
- interstate disputes
- plant outage
- transmission losses
- shortage of coal
- poor utilization of generating equipment

2.9 ENERGY INDEPENDENCE BY 2030

By 2030, the total energy requirement for the country would increase to 400,000 MWs from the existing 185,000MWs. Ideally India has to plan for 215,000 MWs of power to be realized from renewable energy sources like hydel, wind, solar, nuclear and conversion of municipal waste into energy by 2030. The country has capability to generate additional 50,000 MWs of hydel power by creating regional waterways. India can generate solar energy to the extent of 60,000MWs by having large scale solar power. Gujarat State has already generated 680 MWs of solar electric power through public private partnership program and the power is being fed to the grid. India has to generate 50,000 MWs of nuclear power, particularly using the thorium route within the next decade and has to generate 65,000 MWs of power using wind energy. If we work on these targets, we will be getting nearly 225,000 MWs of electric power. Here we have to consider the reduction in load factor in solar, wind and hydel which will necessitate generation of 20 to 30% excess power beyond the 400,000 MWs. This can certainly be achieved by converting all the municipal wastes into electric energy which can easily generate over 10,000MWs of power. Movement towards energy independence would also demand accelerated work in operationalizing the production of energy from the coal sector through integrated gasification and combined cycle route, so that the existing coal based power plant get clean coal and subside the carbon-dioxide dumping in atmosphere.

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