Overview of Renewable Energy Potential of India

RATHOD NITIN RAMRAO
RATHOD NITIN RAMRAO, HOD, MECHANICAL DEPARTMENT, M.S.POLYTECHNIC, MAHARASHTRA, INDIA

ABSTRACT

India has a vast supply of renewable energy resources, and it has one of the largest programs in the world for deploying renewable energy products and systems. Indeed, it is the only country in the world to have an exclusive ministry for renewable energy development, the Ministry of Non-Conventional Energy Sources (MNES). Since its formation, the Ministry has launched one of the world's largest and most ambitious programs on renewable energy. Based on various promotional efforts put in place by MNES, significant progress is being made in power generation from renewable energy sources. In October, MNES was renamed the Ministry of New and Renewable Energy.

Specifically, 3,700 MW are currently powered by renewable energy sources (3.5 percent of total installed capacity). This is projected to be 10,000 MW from renewable energy by 2012.

The key drivers for renewable energy are the following:

- *The demand-supply gap, especially as population increases*
- *A large untapped potential*
- *Concern for the environment*
- *The need to strengthen India's energy security*
- *Pressure on high-emission industry sectors from their shareholders*
- *A viable solution for rural electrification*

Also, with a commitment to rural electrification, the Ministry of Power has accelerated the Rural Electrification Program with a target of 100,000 villages by 2012.

The Ministry of Power has set an agenda of providing Power to All by 2012. It seeks to achieve this objective through a comprehensive and holistic approach to power sector development envisaging a six level intervention strategy at the National, State, SEB, Distribution, Feeder and Consumer levels.

1. Introduction

In recent years, India has emerged as one of the leading destinations for investors from developed countries. This attraction is partially due to the lower cost of manpower and good quality production. The expansion of investments has brought benefits of employment, development, and growth in the quality of life, but only to the major cities. This sector only represents a small portion of the total population. The remaining population still lives in very poor conditions.

India is now the eleventh largest economy in the world, fourth in terms of purchasing power. It is poised to make tremendous economic strides over the next ten years, with significant development already in the planning stages. This report gives an overview of the renewable energies market in India. We look at the current status of renewable markets in India, the energy needs of the country, forecasts of consumption and production, and we assess whether India can power its growth and its society with renewable resources..

1.1 General Information: What are the energy trends in India?

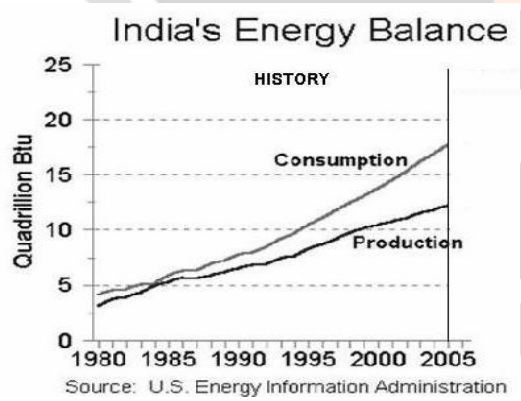
To better understand the current situation in India and the future of the renewable energies market, it is important to look at the trends in energy consumption, growth of the current grid, and the availability of transportation and equipment used there.

In line with additions to installed capacity, total generation by public utilities increased rapidly, from 5106 GWh in 1950 to 264,231 GWh in 1990/91, registering an annual growth rate of 10.4 percent over this period. Until the 1980s, the growth rate in hydro and thermal generation was comparable, but during the 1980s, hydro generation increased at a rate of only 4.4 percent compared to a growth rate of 11.6 percent in thermal generation.

Since thermal generation is based on burning coal or oil, increases in CO2 emissions, which damage the environment and affect global warming, accompany this growth. As the graph below shows, it also increases the dependence on imports, which will continue into the future unless the policy changes.

a) Energy consumption and production up to 2005

Since the 1980's, and still currently, India has encountered a negative balance in overall energy consumption and production. This has resulted in the need to purchase energy from outside the country to supply and fulfil the needs of the entire country. As we will demonstrate later, the Government is more sensitive to renewable energy potential and has started to put reforms and projects, incentives and legislation in place to convince investors and companies to make the shift. These will be discussed in a later section.



India has had a negative Energy Balance for decades, which has forced the purchase of energy from outside the country.

b) The breakdown of energy sources for power production of India in 2005

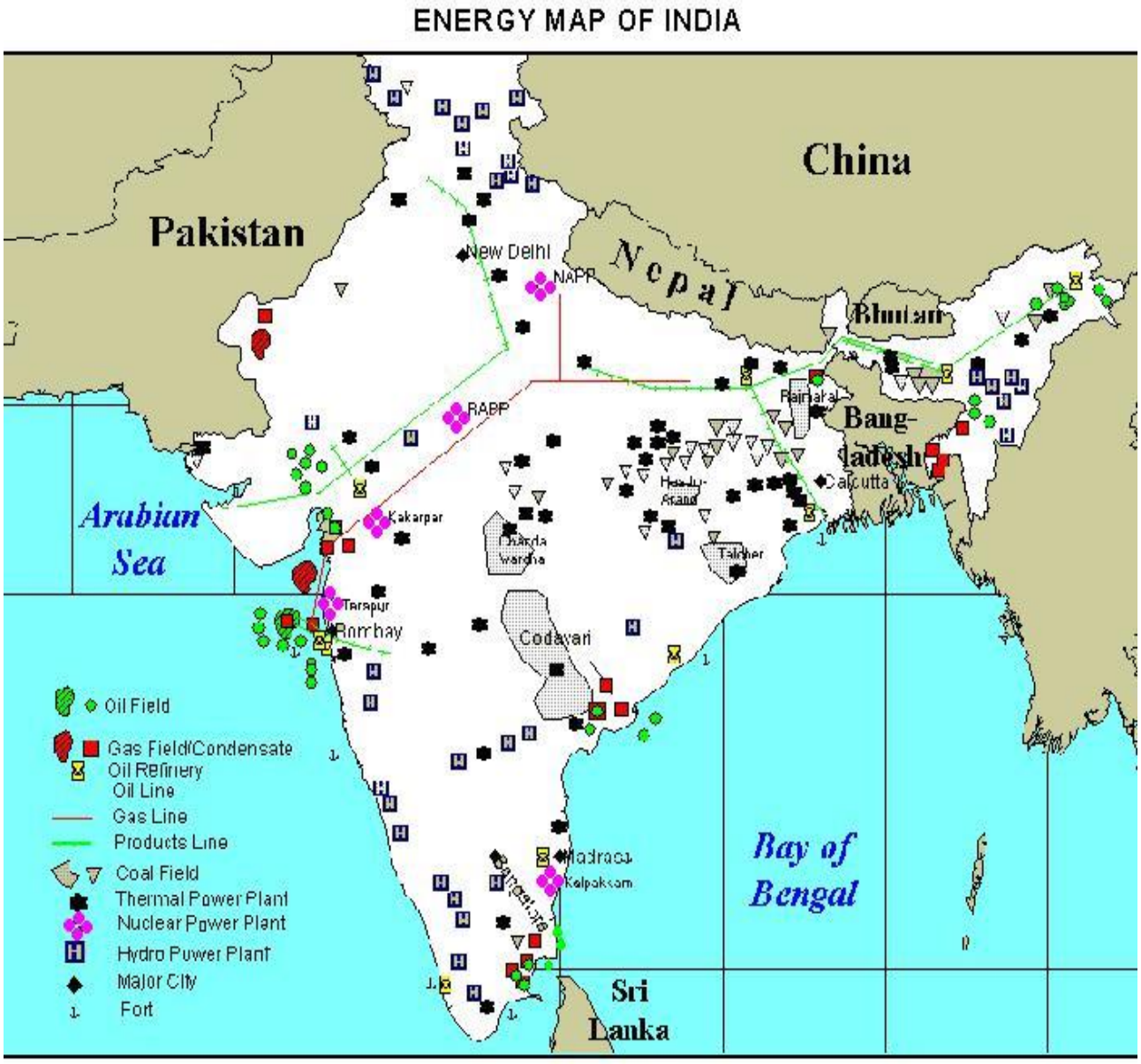
India is a large consumer of coal, which makes up more than 57% of its total consumption. However, more than 1/3 of energy consumed comes from renewable resources, predominantly from large hydropower. India relies heavily on coal energy to produce electricity. A strong second is hydro power, followed by natural gas. The consumption of all renewable energies represents fully one third of the total consumption. This is a significant figure, and we will see later that this sector has a great future. Following is a table of the actual plants and installations for producing power

based on to renewable energies. We will show that only a small fraction of the potential capacity of renewable energies is currently being tapped.

c) Distribution of the different kinds of plants and lines of transportation

As mentioned, India relies principally on coal for 57% of total energy consumption. As we can see on the map, coal production is extensive and is located in central and north-eastern parts of the country. Hydro power plants are distributed along the west coast from the southern tip to about ¾ the way up the coast, in the extreme north, and some in the east from rivers flowing from the Himalayas.

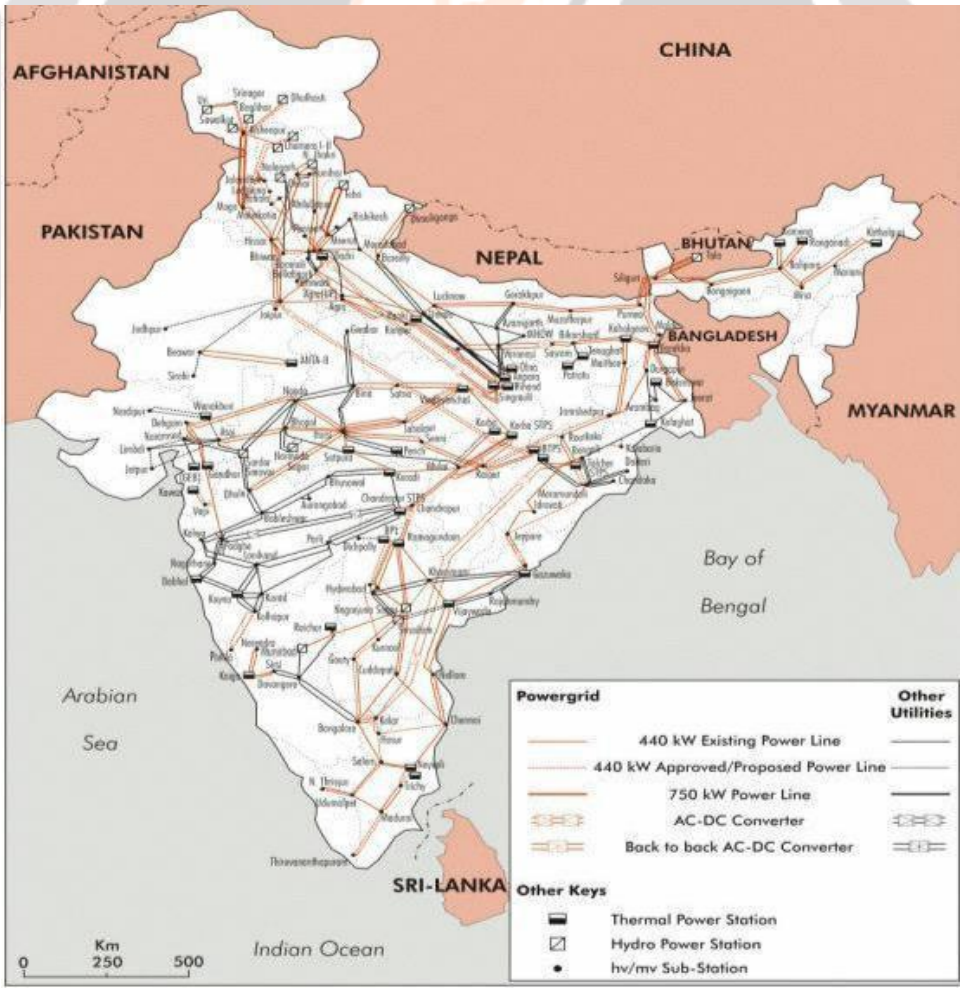
Except for the fact that the gas and products line don't extend, the country has the largest railway network in Asia and the second largest in the world under a single management. Roads are taking developmental changes to the most remote corners of the country.



Transmission of electricity is defined as bulk transfer of power over a long distance at a high voltage, generally of 132 kV and above. In India bulk transmission has increased from 3708 ckm in 1950 to more than 265,000 ckm today. The entire country has been divided into five regions for transmission systems, namely, Northern Region, North Eastern Region, Eastern Region, Southern Region and Western Region. The interconnected transmission system within each region is also called the regional grid.

d) India Energy grid

Nearly 85% of the villages have been electrified, and there is a nationwide grid for the transmission and distribution of power



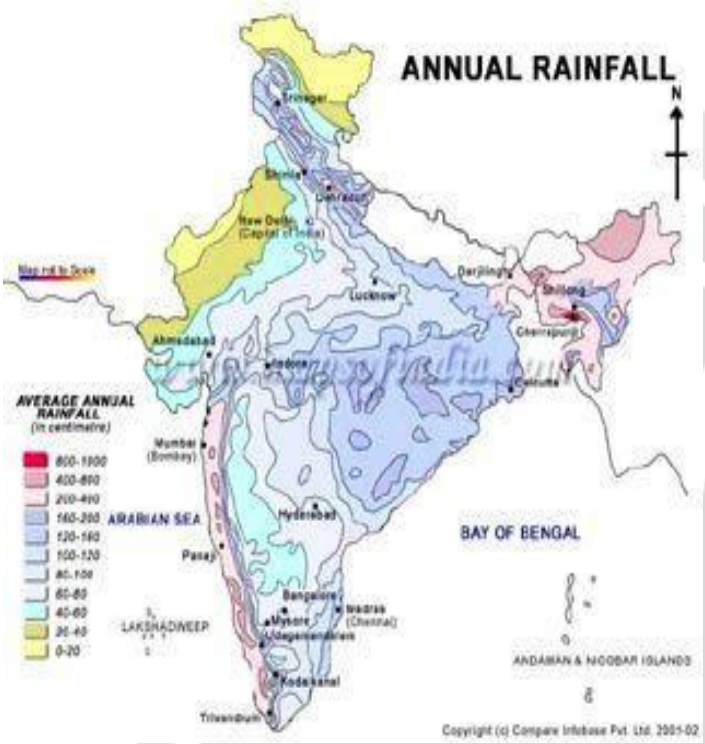
The electric network is extensive throughout India with 440 kW or 750 kW power lines. The main power grid is still concentrated in the north on a north-west/south-east axis, from

Afghanistan to the Bay of Bengal and on a second axis from Bombay on the central west coast to the north-east of India, through Bhutan.The above map indicates that new 440kW power lines have been approved or proposed to expand the network further. Those proposed lines will be located mainly on the east coast.

2.Sources of renewable energy available in India: What renewable energies are in the Indian market?

We know where the non renewable energies – coal, oil and gas – are located and how these fuels are transported, combusted, and the power transmitted throughout the country over the power grid. Now, let's look at the renewable energies – hydro, solar, wind and biomass – and see where they are found.

a) Hydro power



The hydroelectric power refers to the energy produced from water (rainfall flowing into rivers, etc). Consequently, rainfall can be a good indicator to investors looking for a location to implement or build a new hydroelectric power plant in India.

It is, in fact, the case, if we compare the map of Annual Rainfall and the "Energy Map of India" on page 6, that hydropower plants are situated in regions of the major rainfall.

The dominant annual rainfall is located on the north/eastern part of India: Arunachal Pradesh, Assam, Nagaland, Manipur and Mizoram, and also on the west coast between Mumbai (Bombay) and Mahe.

primary hydroelectric power plants: Bihar (3), Punjab, Uttaranchal, Karnataka, Uttar Pradesh, Sikkim, Jammu & Kashmir, Gujarat, and Andhra Pradesh (2).If we consider the annual rainfall of Bangalore (central south), we see that most of the rainfall occurs from May to November. Consequently, we can predict that hydro energy could be harnessed during the rainy season. Good water management and storage allows for continuous electrical generation throughout the year.

Advantages of Hydro power

In India, small hydro is the most utilized renewable energy source for energy production.

Some key figures concerning small hydro in India:

- Less than 25 MW is in the "small hydro" designation
- There is a potential of 15,000 MW
- Installed is 1,520 MW to date
- 4,096 potential sites have been identified
- Technology is mature and reliable
- Two types of technology are used:
  - High-head systems
  - Low-head systems

- Ministry of Non-conventional Energy Sources is focused on:
  - nation-wide resource assessment
  - setting up of commercial projects
  - renovation and modernization
  - development and up-gradation of water mills industry based research and development

b).Solar Energy

Because of its location between the Tropic of Cancer and the Equator, India has an average annual temperature that ranges from 25°C – 27.5 °C. This means that India has huge solar potential. The sunniest parts are situated in the south/east coast, from Calcutta to Madras. Solar energy has several applications: photovoltaic (PV) cells are placed on the roof top of houses or commercial buildings, and collectors such as mirrors or parabolic dishes that can move and track the sun throughout the day are also used. This mechanism is being used for concentrated lighting in buildings. Photovoltaic (PV) cells have a low efficiency factor, yet power generation systems using photovoltaic materials have the advantage of having no moving parts. PV cells find applications in individual home rooftop systems, community street lights, community water pumping, and areas where the terrain makes it difficult to access the power grid. The efficiency of solar photovoltaic cells with single crystal silicon is about 13 % - 17%. High efficiency cells with concentrators are being manufactured which can operate with low sunlight intensities. India has an expanding solar energy sector: 9 solar cell manufactures, 22 PV module manufactures, and 50 PV systems manufacturers. Therefore, technology resources exist in country and a growing market would lead to job growth in country.

c).Wind Energy

India is surpassed only by Germany as one of the world's fastest growing markets for wind energy. By the mid 1990s, the subcontinent was installing more wind generating capacity than North America, Denmark, Britain, and the Netherlands. The ten machines near Okha in the province of Gujarat were some of the first wind turbines installed in India. These 15-meter Vestas wind turbines overlook the Arabian Sea. Now, in 2006, there is an installed capacity of 4,430 MW; however, ten times that potential, or 46,092 MW, exists.

Advantages of Wind Power:

- It is one of the most environment friendly, clean and safe energy resources.
- It has the lowest gestation period as compared to conventional energy.
- Equipment erection and commissioning involve only a few months.
- There is no fuel consumption, hence low operating costs.
- Maintenance costs are low.

The capital cost is comparable with conventional power plants. For a wind farm, the capital cost ranges between 4.5 crores to 5.5 crores, depending on the site and the wind electric generator (WEG) selected for installation. The pollution saving from a WEG With an average output of 4,000 kWh per year, savings have been estimated as follows:

- Sulphur - dioxide (SO_2): 2 to 3.2 tonnes
- Nitrogen - oxide (NO) ; 1.2 to 2.4 tonnes
- Carbon - dioxide (CO_2) : 300 to 500 tonnes
- Particulates: 150 to 280 kg.

The essential requirements for a Wind farm

An area where a number of wind electric generators are installed is known as a wind farm. The essential requirements for establishment of a wind farm for optimal exploitation of the wind are the following:

- High wind resource at particular site.
- Adequate land availability
- Suitable terrain and good soil condition
- Maintenance access to site
- Suitable power grid nearby
  Techno-economic selection of specific turbines
- Scientifically prepared layout

Wind energy generation has limitations which will influence the extent and type of role it will ultimately play in overall generation of electricity in India

Limitation of a Wind farm

- Wind machines must be located where strong, dependable winds are available most of the time.
- Because winds do not blow strongly enough to produce power all the time. Energy from wind machines is considered "intermittent," that is, it comes and goes. Therefore, electricity from wind farms must have a back-up supply from another source.
- As wind power is "intermittent," utility companies can use it for only part of their total energy needs.
- Wind towers and turbine blades are subject to damage from high winds and lighting. Rotating parts, which are located high off the ground can be difficult and expensive to repair.
- Electricity produced by wind power sometimes fluctuates in voltage and power factor, which can cause difficulties in linking its power to a utility system.
- The noise made by rotating wind machine blades can be annoying to nearby neighbors.
- Some environmental groups have complained about aesthetics and avian mortality from wind machines

d).Biomass energy

Biomass includes solid biomass (organic, non-fossil material of biological origins), biogas (principally methane and carbon dioxide produced by anaerobic digestion of biomass and combusted to produce heat and/or power), liquid biofuels (bio-based liquid fuel from biomass transformation, mainly used in transportation applications), and municipal waste (wastes produced by the residential, commercial and public services sectors and incinerated in specific installations to produce heat and/or power). The most successful forms of biomass are sugar cane bagasse in agriculture, pulp and paper residues in forestry and manure in livestock residues. It is argued that biomass can directly substitute fossil fuels, as more effective in decreasing atmospheric CO2 than carbon sequestration in trees. The Kyoto Protocol encourages further use of biomass energy. Biomass may be used in a number of ways to produce energy. The most common methods are: Combustion Gasification Fermentation Anaerobic digestion India is very rich in biomass. It has a potential of 19,500 MW (3,500 MW from bagasse-based cogeneration and 16,000 MW from surplus biomass). Currently, India has 537 MW commissioned and 536 MW under construction. The facts reinforce the idea of a commitment by India to develop these resources of power production.

Following is a list of some States with most potential for biomass production:

Andhra Pradesh (200 MW)

Bihar (200 MW)

Gujarat (200 MW)

Karnataka (300 MW)

Maharashtra (1,000 MW)

Punjab (150 MW)

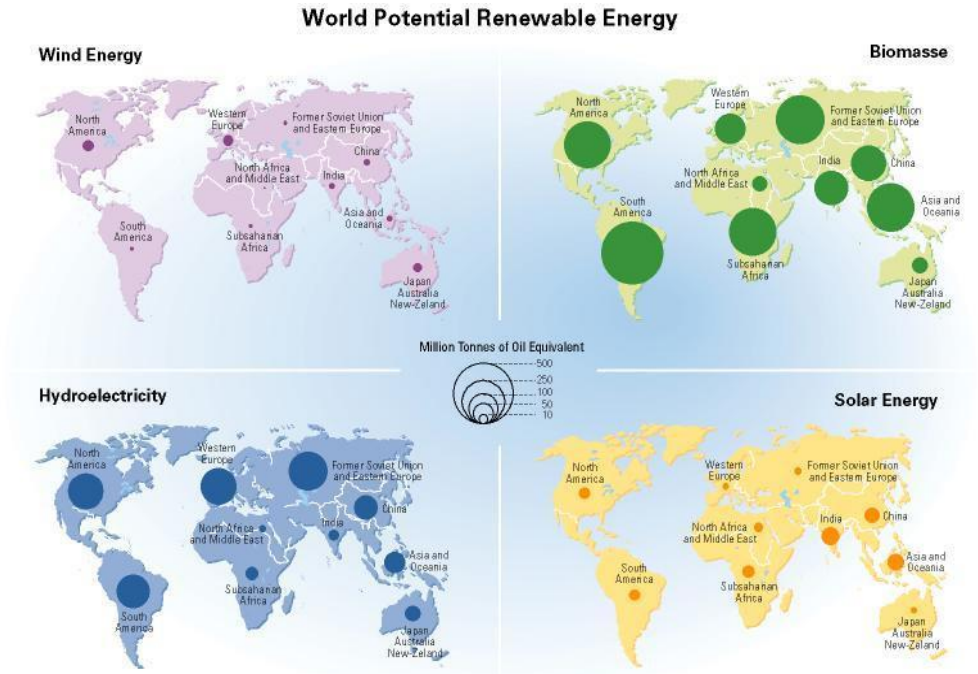
Tamil Nadu (350 MW)

Uttar Pradesh (1,000 MW)

III) Forecasts: What are the general forecasts for the next decades?

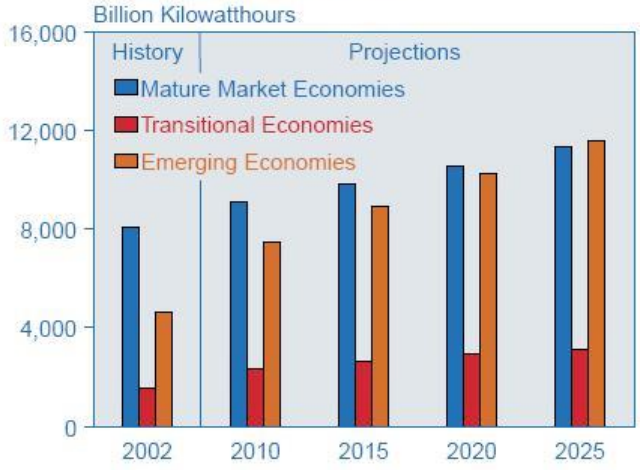
Around the world, a growing number of nations have recognized the economic, social, and environmental benefits of renewable energy and are enacting tax incentives and other policy measures favorable to renewable technologies. In Germany, Japan, Spain, and a handful of other countries, clear government commitments to renewable energy and strong, effective policies have overcome barriers and created demand for these technologies, leading to dramatic growth in renewable industries and driving down costs

a) The position of India in the world potential renewable energ



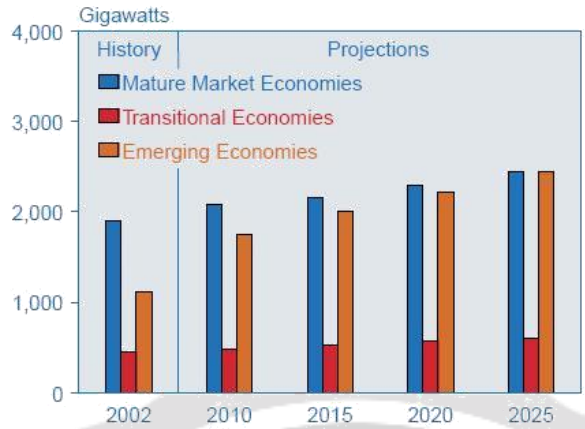
b).The electricity consumption and generation forecasts of India as part of the emerging economies. Growth in net electricity consumption is expected to be most rapid among the emerging economies of the world, including India. According to the EIA, the annual average increase will be about 4.0 percent from 2002 to 2025. Emerging economies are projected to more than double their net electricity consumption, from 4,645 billion kilowatt hours in 2002 to 11,554 billion in 2025. The projected growth in net electricity consumption for emerging market economies is driven in large party by gross domestic product (GDP) and population growth assumption. Because of the links between reliable electricity supply, GDP growth, and living standards, many of the nations with emerging economies are attempting to increase access to reliable electricity supply

Figure 59. World Net Electricity Consumption by Region, 2002-2025



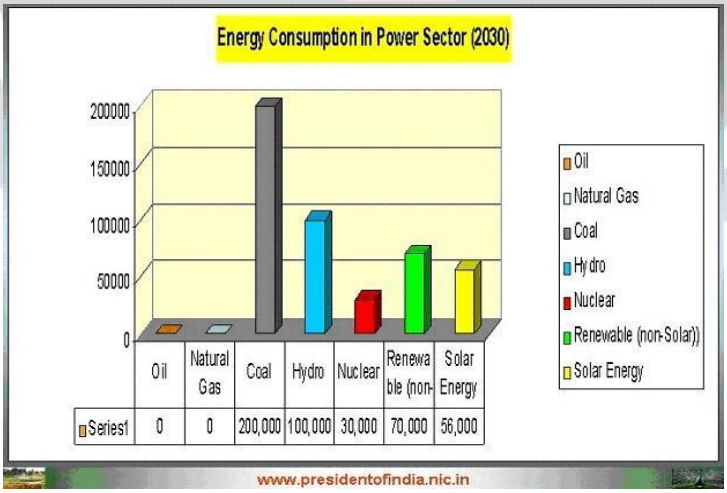
Sources: **2002:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005).

Figure 60. World Electricity Generation Capacity by Region, 2002-2025



Sources: **2002:** Energy Information Administration (EIA), *International Energy Annual 2002*, DOE/EIA-0219(2002) (Washington, DC, March 2004), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2005).

c) Projected energy consumption of India for 2030 Currently, 45 percent of households in India do not have access to electricity. New legislation has set a target of electrifying all households by 2010. As in the past, the ongoing challenge in providing electricity is the ability of the poor to pay. India announced plans in March, 2005, to continue subsidizing electricity consumption for rural and poor households that use less than 30 kilowatt hours per month.



Estimates of Potential Capacities from Renewable Energy Sources (in MWs)

Source	Approx. Potential
Biomass energy	19,500
Solar energy	20,000
Wind energy	47,000
Small hydropower	15,000
Ocean energy	50,000

Source: India Ministry of Non-Conventional Energy Sources

The sum of these renewable resource potentials, 152,000 MW, is greater than the current total installed energy generating capacity of India.

III) GOVERNMENT REGULATIONS: What is the current commitment of the government regarding renewable energies?

India is one of the countries most involved in developing the use of renewable energies and is trying to make the opportunity for investors more attractive than costly.

a) Financing Sources and Incentives

To promote renewable energy technologies in the country, the government has put in place some subsidies & fiscal incentives. The Indian Renewable Energy Development Agency has been set up under Ministry for Non-Conventional Energy Sources and is a specialized financing agency to promote and finance renewable energy projects. Following is a short list of new measures:

- Income tax breaks
- Accelerated depreciation
- Custom duty/duty free import concessions
- Capital/Interest subsidy
- Incentives for preparation of Detailed Project Reports (DPR) and feasibility reports

More details are as follows:

100 percent income tax exemption for any continuous block of power for 10 years in the first 15 years of operations providers of finance to such projects are exempt from tax on any income by way of dividends, interest or long-term capital gains from investment made in such projects on or after June 1, 1998 by way of shares or long-term finance accelerated 100-percent depreciation on specified renewable energy-based devices or projects accelerated depreciation of 80 percent in the first year of operations interest rate subsidies to promote commercialization of new technology lower customs and excise duties for specified equipment exemption or reduced rates of central and state taxes. Ministry for Non-Conventional Energy Sources mix of fiscal and financial benefits: 2/3rd of the project cost subject to a maximum of Rs. 2.00 crore per 100 KW for procurement of modules, structures, power conditioning units, cabling etc. to the implementing agency. The balance cost on land, extension of grid lines, transformers, civil works, foundation and erection and commissioning, etc. is met by the implementing agency. Up to Rs.1.0 lakh for the preparation of Detailed Project Report (DPR) for the grid interactive SPV power projects. 2.5 percent of its share of project cost, subject to a maximum of Rs.5 lakhs for performance evaluation, monitoring, report writing, etc. to the State Nodal Agency. Interest subsidy of up to 4 percent to Financial Institutions including IREDA, Nationalized Banks etc. for captive power projects of maximum capacity 200 KW by industry.

b).Environmental Legislation 2001 Energy Conservation Act Focus on energy efficiency Standards and labeling Designated consumers requirements Energy conservation building codes Energy conservation fund Bureau of Energy Efficiency 2003 Electricity Act Combined several existing pieces of legislation Intended to accelerate

growth of power sector Targets additional 10 percent from renewable by 2012 (1000 MW/year capacity)
Competitive market-based
Features include:

- National Electricity Policy
- Delicensing of generation and captive generation
- Public ownership of transmission companies
- Open access in transmission
- Freedom for distribution licenses
- Establishment of State Electricity Regulatory Commissions
- License-free generation and distribution in rural areas

Provisions and activities impacting the power sector:

Elimination of ceiling on foreign equity participation Streamlining the procedure for clearance of power projects Establishment of the Central Electricity Regulatory Commission Formulating an action plan to set up the National Grid

State reforms impacting the power sector: unbundling the State Electricity Boards (SEB) into separate generation, transmission and distribution companies privatizing the generation, transmission and distribution companies setting up independent state electricity regulatory commissions making subsidy payments for subsidized categories of customers by state governments making tariff reforms by state governments enabling legislation and operational support extended to the SEB/utility improving operations of SEBs, particularly with regard to better management practices, reduction of transmission and distribution losses, better metering and reduction of power theft

6. REFERENCES

- India Ministry of Non-Conventional Energy Sources (MNES) http://mnes.nic.in/
- The President of India www.presidentofindia.nic.in
- The Energy & Resources Institute (TERI) http://www.teriin.org/
- Trade Team Canada Environment (TTC Environment) http://strategis.ic.gc.ca/epic/internet/inenva.nsf/en/h_eg02268e.html
- Maps of India http://www.mapsofindia.com
- U.S. Energy Information Administration (EIA)
- http://mospi.nic.in/mospi_energy_stat.htm
- Global Energy Network Institute (GENI) www.geni.org
- Canada India Business http://canadaindiabusiness.ca/gol/cib/cib.nsf/en/ci00109.html
- ZenithEnergy http://www.zenithenergy.com/index.HTM
- Confederation of Indian Industry (CII) http://www.greenbusinesscentre.com/renenegy.asp
- Centre for Wind Energy Technology www.cwet.tn.nic.in