ENVIRONMENTAL CONCERNS IN POWER GENERATION

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This dissertation is submitted in partial fulfillment of the degree of B.A., LL.B. (Hons.) with Specialization in Energy Laws

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CERTIFICATE

This is to certify that the research work entitled **'Environmental Concerns in Power Generation'** is the work done by **SANDESH SINHA** under my guidance and supervision for the partial fulfillment of the requirement of B.A., LL.B. (Hons.)with Specialization in Energy Laws, degree at College of Legal Studies, University of Petroleum and Energy Studies, Dehradun.

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DECLARATION

I declare that the dissertation entitled **Environmental Concerns in Power Generation** is the outcome of my own work conducted under the supervision of **DR. ASHISH VERMA,** at College of Legal Studies, University of Petroleum and Energy Studies, Dehradun.

I declare that the dissertation comprises only of my original work and due acknowledgement has been made in the text to all other material used.

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TABLE OF CONTENTS

ABBREVIATIONS

APM	Administered Pricing Mechanism
BCM	Billion Cubic Metres
CNG	Compressed Natural Gas
EGoM	Empowered Group of Ministers
E & P	Exploration and Production
GoI	Government of India
GDP	Gross Domestic Product
IEP	Integrated Energy Policy
IHV	India Hydrocarbon Vision
KG	Krishna Godavari
kgoe	Kilograms Oil Equivalent
mmscmd	Million Standard Cubic Metres per Day
MMT	Million Metric Tonnes
mtoe	Million Tonnes of Oil Equivalent
mmbtu	Million Metric British Thermal Units
MMTPA	Million Metric Tonnes Per Annum
MoPNG	Ministry of Petroleum and Natural Gas
MW	Mega Watts
PPA	Power Purchase Agreement
PPP	Purchasing Power Parity
PSC	Production sharing Contract
PSU	Public Sector Undertaking
RIL	Reliance Industries Limited
RNRL	Reliance Natural Resources Limited
scm	Standard Cubic Metre(s)
tcf	Trillion Cubic Feet

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EXECUTIVE SUMMARY

The power sector in India has undergone significant progress after Independence. When India became independent in 1947, the country had a power generating capacity of **2,25,793.10 MW**[1]. Hydro power and coal based thermal power have been the main sources of generating electricity. Generation and distribution of electrical power was carried out primarily by private utility companies. Notable amongst them and still in existence is Calcutta Electric. Power was available only in a few urban centers; rural areas and villages did not have electricity. After 1947, all new power generation, transmission and distribution in the rural sector and the urban centers (which was not served by private utilities) came under the purview of State and Central government agencies. State Electricity Boards (SEBs) were formed in all the states. Nuclear power development is at slower pace, which was introduced, in late sixties. The concept of operating power systems on a regional basis crossing the political boundaries of states was introduced in the early sixties.[2] In spite of the overall development that has taken place, the power supply industry has been under constant pressure to bridge the gap between supply and demand.

The share of hydel generation in the total generating capacity of the country has declined from 34 per cent at the end of the Sixth Plan to 29 per cent at the end of the Seventh Plan and further to 25.5 per cent at the end of Eighth Plan.[3] The share is likely to decline even further unless suitable corrective measures are initiated immediately. Hydel power projects, with storage facilities, provide peak time support to the power system. Inadequate hydel support in some of the regions is adversely affecting the performance of the thermal power plants.[4] In Western and Eastern regions, peaking power is being provided by thermal plants, some of which have to back down during off peak hours.

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[1] Arshay Kapoor, 'Power Sector in India' <http://www.powermin.nic.in/indian_electricity_scenario/introduction.htm> accessed 14 March 2014.

[2] Paper for 13th Jawaharlal Nehru Memorial Lecture, 'Power Sector Reforms', (Institute day celebration of Environmental, Health and Safety Guidelines. 9 January 2009)

[3] Atin Goyal, 'Power Sector in India', (Paper for union international des Avocet's Seminar on Globlization of legal practice in emerging economies of Asia, December 13-15, 1996 at Mumbai).

[4] V.K Shukla, Power Development Programmes: 'Keynote address' (Seminar ministry of power, Mumbai Jan 12-13 2001).

CHAPTER 1: INTRODUCTION

Power is an essential requirement for all facets of our life and has been recognized as a basic human need. It is the critical infrastructure on which the socio-economic development of the country depends. The growth of the economy and its global competitiveness hinges on the availability of reliable and quality power at competitive rates. The demand of power in India is enormous and is growing steadıly. The vast Indian power market, today offers one of the highest growth opportunities for private developers.

India is one of the largest in the terms of population. Thus, the demand for power is extremely high. This factor has triggered the rise of several types of power agencies to fulfill the requirement. In general, the power department of the country falls directly under the Ministry of Power India. The name of the ministry was Ministry of Energy in earlier times. Ministry of Power covers the entire sector of power. The huge variety of the climatic conditions of the country has forced the country to depend on various sources of power. All these types fall directly under the power department. The sub divisions are organized in such a manner, that they are able to interchange among themselves to be able to meet the exact requirement. [5]

India is endowed with a wealth of rich natural resources and sources of energy. Resources for power generation are unevenly dispersed across the country. This can be appropriately and optimally utilized to make available reliable supply of electricity to each and every household. Electricity is considered key driver for targeted 8 to 10% economic growth of India. [6]Electricity supply at globally competitive rates would also make economic activity in the country competitive in the globalized environment.

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[5] Commission of European Communities (CEC), *European community environmental legislation*: 1967-1987. Document Number XI/989/87. (Directorate-General for Environment, Consumer Protection and Nuclear Safety. Brussels, Belgium. 2013)

[6] Arshay Kapoor, 'Power Sector in India' <http://www.powermin.nic.in/indian_electricity_scenario/introduction.htm> accessed 14 March 2014.

As per the Indian Constitution, the power sector is a concurrent subject and is the joint responsibility of the State and Central Governments. The power sector in India is dominated by the government. The State and Central Government sectors account for 58% and 32% of the generation capacity respectively while the private sector accounts for about 10%. The bulk of the transmission and distribution functions are with State utilities. The private sector has a small but growing presence in distribution and is making an entry into transmission. Power Sector which had been funded mainly through budgetary support and external borrowings, was opened to private sector in 1991.

However, the hard side of the entire affair is the fact that, the power department of India has not been able to meet the entire requirement till date. This factor has forced the government to look at various other sources of power as well. Mainly the thermal power is the major source of power of India. Other than the thermal source, India is able to generate hydro electric power, wind power, solar power and several other non conventional power sources. The power source to use completely depends on the region in question. The general landscape of the region would dictate the power source in a huge way. The largest source o power in the country is the thermal energy and thus, coal department happens to be a very important department in more ways than one. [7]

The entire sector completely depends of the availability of coal and the price tag attached. The central electricity authority is the major coordinating body for the ministry of power. The companies tagged within this bracket are mostly government organizations. However, there are certain private power companies as well. Along with the central electricity authority, there are several other organizations which must be named in this regard.[8] The National Hydro Electric Corporation (NHEC), National Thermal Power Corporation (NTPC), Nuclear Power Corporation of India Limited, Power Finance Corporation of India (PFCI), North Eastern Electric Power Corporation (NEEPC), Damodar Valley Corporation (DVC), Rural Electrification Corporation (REC), Bhakra Beas Management Board (BBMB), Satluj Jal Vidyut Nigam (SJVN), Power Grid

[7] International Energy Agency. Fossil Fuel-Fired power Generation. Case Studies of Recently Constructed Coal- and Gas-Fired Power Plants.(IEA 2013)

[8] The Natural Resources Conservation Authority Act. The Natural Resources Conservation Authority (Air Quality) Regulations, 2006. (Jamaica. 2006.)

Corporation of India Ltd (Power Grid India), Tehri Hydro Development Corporation (THDC), Bureau of Energy Efficiency (BEE) and Power Trading Corporation (PTC) are some of the organizations which would fall in this bracket. All these combined fall under the ministry of power India.

It is a massive department and the entire development of the country depends a lot on this department. Mainly, the funds and the finances are provided by the government of India. However, there are certain private companies like Reliance power, which have been able to hit the market. Finances are also obtained from the World Bank and other financial sources. Mainly, the Power Finance Corporation ltd India is responsible for all the finances.[9] This organization is responsible for funding any new project. The most important thing to plan in this sector is the scope for future power stations. It is extremely important to generate more power in lesser time and with the help of lesser raw materials. This is where; nuclear power comes into the picture. The issue still lies with the government to sanction. However, it might prove to be the perfect stepping stone for the future world. There are authorities which are on the lookout for better alternative sources of energy.

The renewable ones are the most researched ones. Solar energy is being tried in various parts of the country. However, a bad side to the energy is the time taken for production and the initial cost factor attached. The thermal power units in India are the most popular ones. However, this is a form of non renewable source of energy and need to be replaced soon. There are certain solar power units in the country as well. The solar power units take a lot of space and time for the entire production process. There are several wind power units as well. However, these units are very much dependent on the location. Thus, this source of energy cannot be generalized. The net contribution of this source to the total power consumption of the country is extremely low. Hydro power units in India are also extremely common. There are several hydro power dams in the country. The Bhakra

[9] Official Journal of the European Communities. 2001. Directive 2001/80/EC of the European Parliament and of the Council of 23 October 2001

Nangal dam and the Damodar valley dam are two examples of this hydro electric power. This source is also based on water supply and cannot be generalized.[10]

The nuclear power units are said to be the future of the country. There are several nuclear power units under construction in the country. The cost factor tagged with the unit is extremely high. Thus, financial budget might be a problem in going for this power source. Bio gas production in India is a very god nature friendly mode of power generation. However, in India, the entire concept is still not being implemented correctly.

Growth of Power Sector

Growth of Power Sector infrastructure in India since its Independence has been noteworthy making India the third largest producer of electricity in Asia. Generating capacity has grown manifold from 1,362 MW in 1947 to 113,506 MW (as on 30.09.2004). The overall generation in India has increased from 301 Billion Units (BUs) during 1992- 93 to 558.1 BUs in 2003- 04.

In its quest for increasing availability of electricity, India has adopted a blend of thermal, hydel and nuclear sources. Out of these, coal based thermal power plants and in some regions, hydro power plants have been the mainstay of electricity generation. Oil, natural gas and nuclear power accounts for a smaller proportion. Of late, emphasis is also being laid on non-conventional energy sources i.e. solar, wind and tidal.

Electricity Consumption

The elasticity ratio (elasticity of electricity consumption with respect to GDP) was 3.06 in the first Plan and peaked at 5.11 during third plan and declined to 1.65 in the Eighties. While consumption went up by 3.14% for every 1% growth in GDP in the first five-year plan period (1951- 56), it went up by only 0.97% in the eighth plan period (1992- 97).[11]

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[10] People's Republic of China. 2003. National Standards of the People's Republic of China. GB 13223-2003, ' Emission Standard of Air Pollutants for Thermal Power Plants' (December 23, 2013.)

[11] U.S. Environmental Protection Agency (EPA),2006. Federal Register / Vol. 71, No. 132, Standards of Performance for Stationary Compression Ignition Internal Combustion Engines; Final Rule,11 July 2013.

The growth in electricity consumption over the past decade has been slower than the GDP's growth. This could be due to high growth of the services sector or it could reflect improving efficiency of electricity use. Moreover, captive generation – which isn't captured by these numbers — has also increased. However, as growth in the manufacturing sector picks up, the demand for power is also expected to increase at a faster rate. Demand will also increase along with electrification. In order to support a rate of growth of GDP of around 7% per annum, the rate of growth of power supply needs to be over 10% annually.[12]

Per Capita Consumption of Electricity

Per capita consumption of electricity is expected to rise to over 1000 kilowatt hours per annum (kwh/ annum) in next 10 years (from present level of 580 kwh). Compare this against over 10,000 kwh/ annum in the developed countries!

Plant Load Factor (PLF)

The actual all India PLF of Thermal Utilities during April 03- March 04 was 72.7% as against the target of 72.0%. 16th Electric Power Survey (EPS) projections. By the year 2012, India's peak demand would be 157,107 MW with energy requirement of 975 BU. [13]

Unbalanced Growth & Shortages

Along with this quantitative growth, the Indian electricity sector has also achieved qualitative growth. This is reflected in the advanced technological capabilities and large number of highly skilled personnel available in the country. While this must be appreciated, it must also be realized that the growth of the sector has not been balanced. The availability of power has increased but demand has consistently outstripped supply and substantial energy & peak shortages of 7.1% & 11.2% prevail in India. Coupled with

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[12] Ashoka D., Saxena M. and Asholekar S.R., 'Coal Combustion Residue-Environmental Implication and Recycling Potential, Resource Conservation and Recycling', Texas Journal on Oil and Gas,3(2005)
[13] Kumar Vimal and Mathur, Mukesh, 'Clean environment through fly as utilization. Cleaner Technology Impacts' MOEF-CPCB, Govt. of India(2013)

this is the urban-rural dichotomy in supply- as per Census 2001, [14]only about 56% of households have access to electricity, with the rural access being 44% and urban access about 82%. In the case of those who do have electricity, reliability and quality are matters of great concern. The annual per capita consumption, at about 580 kWh is among the lowest in the world.

These problems emanate from:

- inadequate power generation capacity
- lack of optimum utilisation of the existing generation capacity
- inadequate inter-regional transmission links
- inadequate and ageing sub-transmission & distribution network leading to power cuts and local failures/faults.
- T&D losses, large scale theft and skewed tariff structure
- slow pace of rural electrification
- inefficient use of electricity by the end consumer
- lack of grid discipline

Blueprint for Power Sector Development

To mitigate the shortages, the Government of India (GoI) has set a goal - Mission 2012: Power for All. A comprehensive Blueprint for Power Sector development has been prepared encompassing an integrated strategy for the sector development with following objectives:-

- Sufficient power to achieve GDP growth rate of 8%
- Reliable of power
- Quality power
- Optimum power cost
- Commercial viability of power industry
- Power for all

[14] M.Ahmaruzzaman, A review of utilization of fly ash In Energy and Combustion. Sci.30, 327-363 (2010)

Meeting the target of providing access to all households by 2012 by adding 100,000 MW capacity and integration of regional grids into the national grids with 30,000 MW of inter- regional transfer capacity by the year 2012 is a daunting task. The task would require massive addition to Generation capacity, Transmission system & Distribution network.

Accordingly, the programmes of the GoI revolve around the following:-
- Access to electricity to be available for all households in the next 5 years.
- Availability of power on demand to be fully met by 2012.
- Energy shortage and peaking shortage to be overcome by providing adequate spinning reserves.
- Reliability and quality of power to be supplied in efficient manner.
- Electricity Sector to achieve financial turnaround and commercial viability.
- Consumers' interests to be accorded top priority

Strategies to achieve 'Power for All':

- Power Generation Strategy with focus on an integrated approach including low cost generation, optimization of capacity utilization, controlling the input cost, optimization of fuel mix, technology upgradation, capacity addition through nuclear and non-conventional energy sources, high priority for development of hydro power, a comprehensive project monitoring and control system
- Transmission Strategy with focus on development of National Grid including Interstate connections, Technology upgradation & optimization of transmission cost.
- Distribution strategy to achieve Distribution Reforms with focus on System upgradation, loss reduction, theft control, consumer service orientation, quality power supply commercialization, Decentralized distributed generation and supply for rural areas.
- Regulation Strategy aimed at protecting Consumer interests and making the sector commercially viable.

- Financing Strategy to generate resources for required growth of the power sector.

Conservation Strategy to optimise the utilization of electricity with focus on Demand Side management, Load management and Technology upgradation to provide energy efficient equipment / gadgets.

- Communication Strategy for political consensus with media support to enhance the general public awareness.

Power Sector Reforms

The power sector continues to be one of the greatest constraints to maintaining growth and further reducing poverty in India. 45% of the households remain unconnected to the public power system, and those who are connected, often receive infrequent and unreliable service, making power supply a brake on private sector development and economic growth. [15]

The State Electricity Boards (SEBs) have been incurring losses and were unable even to make payments to the CPSUs like NTPC, PGCIL etc for purchase of power.[16] The accumulation of outstanding to the CPSUs grew over Rs 40,000 crore, seriously hampering their capacity addition programme. The reform of the power sector is crucial, as financial losses amount to 1.5% of the GDP. To turn around the financial health of the power sector, the GoI has taken up reforms in the power sector for gradual elimination of losses. The reform process in power sector in India was initiated in 1991 and Indian Power sector is witnessing major structural changes.

Performance/ Policy Initiatives / Decision Taken during the year 2003-04

- Electricity Act 2003 has been enacted in July 2003.
- Accelerated Electrification Programme for One Lakh villages and One Crore rural households launched. The scheme outlay of Rs 6,000 cr. comprises grant component of Rs 2,400 cr.

[15] Kumar Vimal and Mathur Mukesh, 'Clean environment through fly as utilization. Cleaner Technology', Impacts, MOEF-CPCB, Govt. of India, 235-255, (2013)
[16] Shrivastava Shikha and Dwivedi Sushma, 'Effect of fly Ash Pollution on Fish Scales', Re. J. of Che. Sci, 1(9), 24-28 (2011)

- 50,000 MW Hydro Initiative launched
- Improvement in Power Supply Position- Since the beginning of the IXth Plan (1996-97), the peak shortfall has reduced from 18% to about 11%. Supply shortfall has also reduced from 11.5% to 7.1%.
- Generation Performance
- Generation during 2003-04 over the previous year improved from 531 BU to 558 BU Overall PLF of generating stations improved from 72.2% to 72.7% while in central sector it improved from 77.1% to 78.7%. [17]

Capacity Addition Target & Achievement

Uninterrupted and reliable supply of electricity for 24 hours a day needs to become a reality for the whole country including rural areas. In order to fully meet both energy and peak demand by 2012, enough generating capacity has to be created with some spare generating capacity so that the system is also reliable. The sector is to be made financially healthy so that the state government finances are not burdened by the losses of this sector and should be able to attract funds from the capital markets without government support. The consumer is paramount and he should be served well with good quality electricity at reasonable rates. [18]

To ensure grid security and quality & reliability of power supply reasonable spinning reserve at national level has to be created in addition to enhancing the overall availability of installed capacity to 85%.[19]

Capacity of about 100,000 MW is planned to be set up during the 10th and 11th plans, ie between 2002 and 2012. This implies doubling the installed capacity and, incidentally, works out to adding about 430 MW every fortnight! Capacity addition plan for addition

[17] Fulekar M.H. and Dave J.M., 'Release and behavior of Cr, Mn, Ni and Pb in a fly-ash/soil/water environment: column experiment', IntJ. Of Environmental Studies, 4, 281-296 (1991)

[18] Bruvold, W.H., Ongerth, H.J., 'Taste quality of mineralized water', Journal of the American Water Works Association, 61: 170(1969).

[19] M.P. Sharma, Arun Kumar and Shalini Rajvanshi, 'Assessment of Tropic State of Lakes: A Case of Mansi Ganga Lake in India' ,Journal of Water, Energy & Environment, (Hydro Nepal), 6 (2010)

of 41,110 MW finalized for the Xth Plan period- the Central, State and Private sector's share is expected to be 51%, 16%, and 25% respectively. About 7% is expected to come from renewable sources and 2% from the Tala project in Bhutan. [Capacity Addition Program, Mission 2012, MoP].[20]

The Hydro Power initiative has also been launched by the Prime Minister in 2003, under which a capacity of 50,000 MW is to be added in the same period- 2002 to 2012. Outlay for power sector for the Xth Plan period has been enhanced to Rs 1,43,399 cr, an increase of approximately 214% over the IXth Plan outlay of Rs 45,591 crores. Advance action plan initiated for capacity identified for addition in the XIth Plan. In the last two Plan periods, barely half of the capacity addition planned was achieved. The optimistic expectations from the IPPs have not been fulfilled and in retrospect it appears that the approach of inviting investments on the basis of government guarantees was perhaps not the best way.

Hydro Generation

Hydroelectricity generation enhances India's energy security, is ideal for meeting the peak demand and is not linked to issues concerning fuel supply, especially the price volatility of imported fuels. Only about 20% of vast hydro potential of 150,000 MW in India has been tapped so far. [21]

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% compared to a growth rate of 11.6% in thermal generation. Owing to the decline in hydro development and prevailing peak power deficits, coal-fired thermal power units, which should generally be used for base load operation, were being used to meet peaking requirements. This leads to non-optimal utilisation of economic and perishable resources. [22]

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[20] NTPC Limited, 'Environmental Assessment Report: India: NTPC Capacity Expansion Financing II Tapovan–Vishnugad Hydroelectric Project and Loharinag–Pala Hydroelectric Project'. Prepared for Asian Development Bank.(2013)
[21] Macan, T.T., 'Freshwater Ecology', Longmans, London (1963).
[22] Moore, M.L., 'NALMS management guide for lakes and reservoirs', North American Lake Management Society Madison, WI, 53705-5443, USA (1989).

Countries like Norway, Canada have been utilising 60% and 44% of their hydro potential whereas India has lagged far behind. Considering the present adverse hydro thermal mix of 25:75, Hydroelectric power in India country needs priority attention for the full development of the feasible hydro potential.

Nuclear Power

In India, fourteen nuclear power plants are producing about 2800 Mega Watt constituting 2.2% in the overall capacity profile. Nuclear power is considered a reliable source of energy to meet base load demand. Nuclear power generation in India is going to get a big push with the Government putting in place an ambitious expansion programme to increase it to about 10,000 MW by the year 2012 and about 20,000 MW by the year 2020. In 'Vision 2020', it was deemed possible and necessary to have an installed Nuclear Power Capacity of 20,000 MW by the year 2020. Consequently the share of nuclear power will increase in the overall generation profile. [23]

To achieve this, Public sector investments are being stepped up, the Department of Atomic Energy is looking at using recycled fuel and is also examining the option of private sector partnership to see that not only targets are achieved but exceeded. Nuclear power plants are being set up at locations away from coal mines. Economics of generation will be, among others, important considerations while setting up nuclear plants. Already, companies like Reliance have announced their interest in setting up nuclear power plants if the sector is opened up for private participation.

Considering that India has vast thorium reserves, Nuclear Power Corporation of India Limited (NPCIL) is poised to play a leading role in future to meet the ever increasing energy demands. The Company is enhancing its initial target of 1300 MW capacity addition during X plan (2002-07) to 2520 MW. The installed capacity at the end of XIth Plan would be around 10280 MW and 20,000 MW by the year 2020.

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[23] Singh, D. and Sharma, R.C., 'Biodiversity, ecological status and conservation priority of the fish of Alaknanda, a parent stream of the River Ganges (India). Aquatic Conservation: Marine and Freshwater Ecosystems', TJOIL(2012)

For detailed & updated information on the Indian Power Sector, refer to the report - 'Overview of Power Sector in India'[24]

Captive Generation

The existing installed capacity of 25,000 MW of captive generation, offers a sizeable potential capacity which could be well harnessed for meeting requirements. This does not include captive units of less than 1 MW capacity in industry and the large numbers of DG Sets in operation as standby for domestic, commercial and agricultural users. Captive units in industries are used to supplement the power drawn from the grid and as stand by in case of power cuts. More than half of the existing captive power capacity was added in the 1980s. With the looming power shortages, similar spurt is expected in the future also.

Long term arrangements for supply of energy particularly during peak hours could also be useful in the mutual interest of the utilities and the captive generating stations. The captive generators are being encouraged to supply their surplus power to the grid.

The Electricity Act, 2003 is very liberal with respect to setting up of captive power plants and captive generation has been freed from all controls. The Act allows captive plants to be set up in group which is primarily aimed at enabling such small & medium industries as may not be in a position to set up plant of optimal size in a cost effective manner. This is not only for securing reliable, quality & cost effective power for the industry but also to facilitate creation of employment opportunities through speedy & efficient growth of industry.

Rural Electrification

Rural electrification is viewed as a prime mover for agricultural and agro- industrial development, employment generation and improvement in the quality of life of people in rural areas.

[24] Annual Report, 'Ministry of New and Renewable Energy Sources', 2005-06.

The distribution of electricity including rural electrification is under the jurisdiction of the State Governments who are considering various options for necessary institutional framework to be put in place not only to ensure creation of rural electrification infrastructure but also to operate and maintain supply system for securing reliable power supply to consumers. Electricity Act, 2003 provides the requisite framework for expediting electrification in rural areas with necessary empowerment. It permits operation of the standalone system in rural areas, independent of regulatory regime. It also provides distribution of electricity in rural areas, responsibility of operation & maintenance and collection of bills by utilities or by panchayats, local authorities, NGOs and other franchises.

Status

The status of village electrification is as follows:

Number of villages (according to 1991 census):	587,258
Number of villages Electrified:	495,298
Percentage of Villages Electrified:	84.3%
Balance villages to be electrified:	91,960
Potential of Energy of Pumps:	19,594,000
Number of Pumpsets Energised:	14,177,684
Percentage of Pumpsets Energised:	72.4%

Source: www.conserveindia.org

During the year 2003-2004, 4589 inhabited villages were electrified and 192,721 pumpsets/ tubewells were energised. Cumulatively 494,587 villages have been electrified and 14,002,634 electric irrigation pumpsets have been energised as on 31.3.2004. As regards the electrification of tribal villages, out of a total of 107,045 tribal villages in the country, 82,976 villages have been electrified as on 31.3.2004. Similarly, 301,019 Harijan Bastis have been electrified as on the same date.[25]

Transmission & Distribution Losses

The core problem with the power sector, as was identified in the mid- 90s, has been poor state of sub-transmission and distribution system of SEBs and other electricity utilities. The initiatives taken by the Central government and State governments to attract investments focused primarily on generation with limited success. [26]Distribution segment of power industry remained neglected for decades.

The plan outlay for the power sector has been heavily biased towards generation. While a balanced proportion is 1:1 (1 for generation, 1 for transmission & distribution), this was 3:1 in 1993 and has improved to 1.3: 1 in the ninth plan period (1997- 02). This shift has been due to the realization of the anomaly, and also due to the fact that the State is not investing much in generation now. In most parts of the country, distribution infrastructure suffers from inadequate transformation capacities, lack of redundancies, high technical losses, poor consumer services, absence of IT to address the issues of reliability and consumer concerns.

T&D losses merit concern and have been consistently very high. T&D losses for Indian utilities in aggregate increased from 17.5% in 1970/71 to 21.7% in 1985/86, and then levelled off to about 21% by 1990/91 and are presently in the range of 18% to 62% in various States. The aggregate technical & commercial (AT&C) losses are in the range of 50% of power generation. Out of the total generated power, about 55% is billed and only about 41% is realized.[27]

It is small wonder then that almost all the State Electricity Boards (SEBs) make losses and have accumulated losses of over Rs 26,000 crore. Most of the SEBs are cash strapped

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[25] Jha C. N. & Prasad J. K.., 'Fly ash: a resource materifsinceal for innovative building material - Indian perspective substitute and paint from coal ash" 2nd international conference on "fly ash disposal &utilization", New Delhi, India, (2000).
[26] Kumar Vimal and MathurMukesh, 'Clean environment through fly as utilization. Cleaner Technology', MOEF-CPCB, Govt. of India, 235-255, (2013)
[27] Kant K., Chakarvarti S.K., 'Environmental impact of coal utilization in thermal power plant', Journal of Punjab Academic of For. Med. &Toxi, 3, 15-18 (2003)

and are not even able to earn a minimum Rate of Return (RoR) of 3% on their net fixed assets in service after providing for depreciation and interest charges in accordance with Section 59 of the Electricity (Supply) Act, 1948. The gap between the average cost of supply has been constantly increasing. At present SEBs loose nearly 110 paise for every unit of electricity sold. This is despite charging a very high tariff to the industrial consumers. Their competitiveness in the globalized environment is seriously affected.

Renovation & Modernization

In order to bridge the gap between demand and supply, especially in the context of limited financial resources available, it has become imperative to look for other options which are not as capital intensive as new capacity addition and which could be implemented in a comparatively shorter time frame.

In this regard, optimum utilisation of existing installed capacity in India to maximise the generation through renovation, modernisation, uprating and life extension of existing power plants is considered to be the most cost effective option with lesser gestation period. SEBs/Utilities may review the priorities and go for renovation, modernisation and uprating of their existing plants and avail the opportunity of getting grants/loans through AG&SP and other incentives being provided by the Government thereby ensuring power generation at minimal cost.[28]

One of the major achievements of the power sector has been a significant increase in availability and plant load factor (PLF) of thermal power stations especially over the last few years The overall national average PLF has improved from 55% to 73% in last 20 years Renovation and modernization, with financial support of Government of India, for achieving higher efficiency levels is being pursued vigorously and all existing generation capacity is targeted to be brought to acceptable level of performance.[29]

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[28] Ignasi Querlt,XavierQuerol ,Angel Lopez-Solar ,Felicano Plana ,Use of coal fly ash for ceramics ;a case study for large Spanish power station, fuel,8 , 787-791, (1997)
[29] Fulekar M.H. and Dave J.M., 'Release and behavior of Cr, Mn, Ni and Pb in a fly-ash/soil/water environment: column experiment', IntJ. Of Environmental Studies, 4, 281-296 (1991)

Revised 10th and 11th Plan Programmes

The schemes identified by CEA under National Perspective Plan and not completed till the beginning of 10th plan have been reviewed in consultation with SEBs/ PSUs/ PFC and the revised 10th Plan programme has been finalised. As per 10th Plan Programme reviewed in consultation with the utilities a total of 72 schemes (11 nos. under Central Sector and 63 nos. under State Sector) have been identified having a total installed capacity of 8,082.45 MW to accrue a benefit of 2,446.87 MW at an estimated cost of Rs 2,712.237 crore.

As per 11th Plan programme reviewed with the utilities, a total of 31 schemes (2 nos. under Central Sector & 29 nos. in State Sector) have been identified having a total installed capacity of 4,681.00 MW to accrue a benefit of 4415.10 MW at an estimated cost of Rs 2,168.61 crore. [30]

Programme for the year 2003-04:

As per the revised Xth Plan programme, 11 schemes (3 in Central Sector & 8 in State Sector) to accrue a benefit of 170.35 MW having an installed capacity of 2737.95 MW at an estimated cost of Rs 199.865 crores were targeted for completion during the year 2003-04.

Achievement during the year 2003-04

4 (2 in Central Sector & 2 in State Sector) out of the 11 schemes targeted for the year 2003-04 with an installed capacity of 600.00 MW have been completed at an expenditure of about Rs 32.205 crores against the estimated cost of Rs 34.65 crores to accrue a benefit of 36.00 MW. Works on remaining 7 schemes are in advanced stages.

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[30] Keefer R.F., 'Coal ashes-industrial wastes or beneficial by-products. In: Keefer R.F., Sajwan K., editors, Trace Element in Coal and Coal Combustion Residues. Advances in Trace Substances Research, Florida': Lewis Publishers, CRC Press, 3–9 (1993)

Energy Conservation

Energy conservation has emerged as one of the central issues in the national economic agenda in recent years. There is a significant potential of the order of over 20% savings through energy efficiency and demand side management measures in different sectors, without forgoing any of the end-use benefits of energy. Society stands to gain from conservation and improved energy efficiency, both in terms of money saved by reducing energy costs in the short run as well as reducing investment needs for energy production in the long run.

Energy Conservation Act, 2001

Considering the vast potential of energy saving and benefits of energy efficiency, the GoI enacted the Energy Conservation Act, 2001, which has come into force with effect from March 2002. The Act provides necessary legal and institutional framework to enable the government to rapidly promote efficient use of energy and its conservation in different sectors of the economy.

For complete Act, refer to the report - 'Overview of Power Sector in India 2005- revised edition'[31]

The Ministry of Power has also created, under this Act, a central coordinating body called Bureau of Energy Efficiency, which will be responsible for promoting energy saving measures. Energy saving of 400 MW and other energy inputs totaling Rs 2300 cr has been achieved during last five years.

The total All India Installed Capacity of electric generating stations as on 31st March, 2013 was 2,23,343.60 MW and the demand was 1,35,453 MW.

Target for power generation is fixed on an annual basis. As against the power generation target of 930 BU for the year 2012-13, 911.65 BU has been achieved, which is 98% of

[31] Official Journal of the European Communities. 'Directive 2001/80/EC of the European Parliament and of the Council on limitation of emissions of certain pollutants into the air from large combustion plants' 23 October 2001

the target. The overall electricity generation in power utilities in the country as well as import from Bhutan since the beginning of 9th Plan is as under:

The total All India Installed Capacity of electric generating stations as on 31st March, 2013 was 2,23,343.60 MW and the demand was 1,35,453 MW.[32]

The following steps have been taken / are being taken by the Government to achieve the electricity generation target during 2013-14:

YEAR	GENERATION (BU)
2004-05	587.4
2005-06	617.5
2006-07	662.52
2007-08	704.5
2008-09	723.8
2009-10	771.6
2010-11	811.1
2011-12	876.9
2012-13	911.65

Source: www.conserveindia.org

BU: Billion Units

[32] Mishra U.C., 'Environmental impact of coal industry and thermal power plants in India', TJOIL, 72(1-2), 35-40 (2004)

Renovation and Modernization of old power plants. Efforts are being made to make coal and gas available for power sector.

Review of progress of power projects is being done at the highest level by the Minister of State for Power (Independent Charge), Secretary, Ministry of Power and Chairperson, Central Electricity Authority, to identify the constraint areas and facilitate their faster resolution, so that the projects are commissioned on time. [33]

Power sector has grown positively over the 11th Plan period. It registered a growth rate of 3.96% in 2012-13. The peak deficit in the year 2012-13 was 9% against the deficit of 10.6% in the year 2011-12. The decision to add generation capacity of 88,537 MW, import 82 Million Tonnes of coal, reduction in transmission and distribution losses etc. is expected to bridge the gap between peak demand and peak met. As per Planning Commission, capacity addition of 88,537 MW is planned from conventional sources for the 12th Five Year Plan on an all-India basis.

Steps taken to meet the power requirement in the country inter-alia are:

Rigorous monitoring of capacity addition of the on-going generation projects. Review meetings are taken by Ministry of Power regularly with CEA, equipment manufacturers, State Utilities/CPSUs/Project developers, etc. to identify the bottlenecks in capacity addition and resolve the issues.[34]

In view of the increasing requirement of capacity addition to meet the demand, the capacity building of main plant equipment has been carried out in the country with the formation of several joint ventures for manufacture of main plant equipments in the country. Thrust to make coal and gas available for power sector. Thrust is being given to power generation from renewable sources. As per MNRE, grid interactive renewable

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[33] Dr. Parag Diwan and Prof A.C Kher, 'Energy Law and Policy' UPES, Trivia Times 11(2012)

[34] Coal Atlas of India, Prepared and published by Central Mine Planning & Defense Institute (CMPDI), Ranchi-834008, 1993, on behalf of Coal India Limited, 10 Netaji Subhash Road, Kolkata 700001, India.

capacity addition likely during 12th Plan is about 30,000 MW. Steps taken by the Government to bridge the gap between demand and supply of power in the country which inter-alia include the following:-

- Planned Capacity addition of 88,537 MW during 12th Plan period (2012-2017).
- Rigorous monitoring of capacity addition of the on-going generation projects.
- Development of Ultra Mega Power Projects of 4,000 MW each.
- Augmentation of domestic manufacturing capacity of power equipment through Joint Ventures.
- Coordinated operation and maintenance of hydro, thermal, nuclear and gas bases power stations to optimally utilize the existing generation capacity.
- Thrust to import of coal by the power utilities to meet the shortfall in coal supplies to thermal power stations from indigenous sources.
- Renovation, modernization and life extension of old and inefficient generation units.
- Strengthening of inter-state and inter-regional transmission capacity for optimum utilization of available power.

With the aim to reduce the Aggregate Technical and Commercial Losses (AT&C) up to 15% in the country and improvement in power distribution sector, Government of India has launched the Restructured-Accelerated Power Development and Reforms Programme (R-APDRP) in July 2008. The focus of R-APDRP is on actual demonstrable performance by utilities in terms of sustained AT&C loss reduction.

Chapter 2: TYPES OF PROJECTS

India possesses one of the largest power generation capacities in the world (its current ranking is fifth) with an installed capacity of 156,000 MW which is about 4 percent of global power generation. The top four countries, viz., US, Japan, China and Russia together consume about 49 percent of the total power generated globally. [35]The average per capita consumption of electricity in India is estimated to be 704kWh during 2008-09. The power sector has emerged as major focus area for the government both central and state. However, it suffers from power shortages estimated at 14-15 per cent, with the figure higher in the northern and western regions.

India's generation capacity of 2,300 MW in 1950 expanded to over 116,500 MW including non-utilities at the end 2000-01. The total installed capacity of electric power generation further increased to 141,080 MW in 2007-08 (upto January 2008) compared to a capacity of 128,000 MW during the same period in 2006-07. The Eleventh Plan has targeted a capacity addition of 78,570 MW. The five years (2007-2012) may be the best of times for power equipment makers with the power sector on an expansion spree. With order-book growth expanding over the last three years, there is a good chance that this will continue. Close to 82% of the planned generation capacity for the Tenth Plan was either implemented or was in the process of being implemented. Even assuming a 70% implementation ratio for the Eleventh Plan, close to 55,000 MW will be added. Five ultra mega power projects, totaling 20,000 MW are coming up in 2008. In the transmission sector, for example, Power Grid Corporation is planning a capex of Rs 710 billion by 2010.

Earlier, the shortfalls in achieving the Plan targets of addition to power generation and up-gradation of transmission and distribution had adversely affected the electrical equipment industry. The peak shortage which was over 11% of the requirement in 2003-04 increased to 11.7% in 2004-05 and to over 12% in 2005-06. The shortage further rose

[35] Garg, A., Shukla P.R., *Emission Inventory of India*, Tata McGraw-Hill Publishing Company Limited, 2002

to about 14% in 2006-07. In the ten months of 2007-08 the peak shortage had risen to over 15% of the peak demand of 107,010 MW.[36]

The national grid envisage 200,000 MW transmission capacity and 37,700 MW of inter-regional power transfer capacity (current inter-regional power transfer capacity is 20,750 MW) to ensure smooth transfer of power from power –surplus to power-deficit regions. According to the Power Ministry, the power sector has tied up Rs 2,240 billion worth of investments to build power plants with 70,000 MW capacities in the next three years. The Indian government has set ambitious goals in the 11th plan for power sector owing to which the power sector is poised for significant expansion. In order to provide availability of over 1000 units of per capita electricity by year 2012, it has been estimated that need-based capacity addition of more than 100,000 MW would be required. This has resulted in massive addition plans being proposed in the sub-sectors of Generation Transmission and Distribution. Investment is also expected to flow into different segments of the value chain, covering the segments of power generation, transmission and distribution and allied sectors such as equipment, technology and services. The private sector is expected to play a more active role in investment and capital productivity. The government has undertaken a number of initiatives to facilitate private sector participation.[37] With some fast moves at launching fast track projects to augment supplies, the Indian industry needs to improve its competitiveness. The Indian market is growing and multinationals with newer technologies are now more active.[38]

Energy is required for everything that we do, and it is the next important thing apart from the food upon which the lives of nations depend. Lack of power could cause economies to cripple. The flourishing power generation industry is considered to be a sign of prosperity for any nation. Learn more about the types of power plants used to generate this energy. Energy is an important requirement for us. From running our air conditioners

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[36] Olivier, J.G.J.; Bouwman, A.F.; Berdowski, J.J.M.; Veldt, C.; Bloos, J.P.J.; Visschediik, A.J.H.; van der Maas, C.W.M.; Zandveld, P.Y.J. ,. 'Sectoral emission inventories of greenhouse gases for 1990 on a per country basis,Environmental Science & Policy TJOIL 2(2010).

[37] Chowdhury, S.; Chakraborty, S.; Bhattacharya, S.; Garg, A.; Mitra, A.P.; Mukherjee, I.; Chakraborty, N., 'An emission estimation of greenhouse gas emission from thermal power plants in India during 2002-03' Ministry of Environment and Forests, Government of India, New Delhi, (2004)

[38] Rees, O.W.; Shimp, N.F.; Beeler, C.W.; Kuhn, J.K.; Helfinstine, R.J., 'Sulfur Retention in Bituminous Coal Ash', Illinois State Geological Survey, Circular. 396 (1966).

to fueling our vehicles, our daily survival depends upon energy. Energy requirements have led countries to war and continues to be a bone of contention between many nations. Insufficient power (energy) supply is one of the main causes of crippling economies. Strong power generation industry indicates strong economic growth and prosperity for any nation. Energy comes in various forms. The most convenient of all of them is electrical energy. Not only is it easy to generate, but it can also be generated through a number of different ways with the help of different types of power plants. Although the word 'generated' is commonly used along with the term 'energy', it is a fact that energy cannot be generated or destroyed. We can just change the form of energy. At power plants too, energy that is available in a particular form is converted into another form.

Different Types of Power Plants

Nuclear Power Plants

Nuclear power plants work on the chemical process of fission. Nuclear reactors are used to generate electricity. Fission is a type of nuclear reaction in which, when the atoms of certain elements called nuclear fuels absorb free neutrons, they split into two or more small nuclei and some free neutrons. In the process, large amount of energy is released. The free neutrons further strike the atoms of other fissile materials, thus setting off a chain reaction. The energy released from this chain reaction is harnessed to generate electricity.[39]

Nuclear power plants have ways to control or stop these reactions when they seem to go out of control and become threatening. The nuclear fuel used are Uranium-235 or Plutonium-239. Every country is in the race of becoming capable of harnessing nuclear energy. It is so because the free energy released by nuclear material is millions times more than that contained in an equal amount of any other traditional fuel. However, what raises the concern about these reactions is that a lot of radioactive material is created in the process. These substances remain radioactive for long. This raises the problem of

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[39] Sathyanathan, V.T.; Mohammad, K.P., 'Prediction of un burnt carbon in tangentially fired boiler using Indian coals', Fuel (2004).

managing nuclear waste. Records show that there are about 435 working nuclear power plants in the world. You must have heard and read about the 2011 Fukushima nuclear accidents. Managing the 'used fuel' at the plants and reducing the chances of threats involve high designing skills, extensive research and use of advanced technology. Moreover, nuclear power stations should be able to sustain a terrorist attack (large fires or explosions), as power stations are preferred targets of terrorist attacks. Thus, the operating cost or cost of setting up a new nuclear plant is likely to shoot up rapidly not only due to increasing costs of fuels but also due to the advanced technology required.

Thermal Power Plants

These power plants generate electrical energy from thermal energy (heat). Since heat is generated by burning fossil fuels like coal, petroleum, or natural gas, these are also collectively referred to as the fossil fueled power plants. [40]Coal power plants were the earliest of the fossil power plants to have been built. Even today, coal is the most common fuel that is used by thermal power stations. The heat generated by burning the fossil fuels is used to turn rotating machinery, most commonly a steam turbine or a gas turbine that changes the thermal energy into mechanical energy. The rotating turbine is attached to an alternator that coverts the mechanical energy of the rotating turbine into electrical energy. Handling and disposal of ash plays an important role in maintaining the environmental balance. These days, thermal power stations that use biomass or biofuel to generate electricity are being constructed.[41]

Hydro Power Plants

These plants use the kinetic energy of flowing water to produce electrical energy. Hydro power plants store water in large reservoirs. Water in these reservoirs flow down the dam and rotate a turbine. As the blades of a turbine turn, so do the magnets inside the generator which is connected to the turbine. These magnets rotate past copper coils and

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[40] NATCOM, 'India's Initial National Communication (NATCOM) to the United Nations Framework Convention on Climate Change', Ministry of Environment and Forests, Government of India, (2004).

[41] Visuvasam, D.; Selvaraj, P.; Sekar, S., 'Influence of Coal Properties on Particulate emission control in Thermal Power Plants in India'. Proceedings in Second International Conference on Clean Coal Technologies for our Future (CCT 2005),Sardinia, Italy (2005).

with each rotation, electricity is produced. There are more than 2,000 hydro power plants in the US, making it the largest source of energy in the country. Despite their utility, their major drawback is that they are highly dependent on the hydrological cycle of the area where they are built. Less electricity is generated when the supply of water to the plant is insufficient. Some hydro power stations were shut down due to shortage of water.

Direct benefits of dams, reservoirs and hydro power plants include increased availability of water for drinking and for crops, improved irrigation, good employment opportunities and a better standard of living for the villagers in the surrounding area. Construction of dams and hydro power plants results in economic and social upliftment of the local people. Reservoirs also promote fish farming and eco-tourism in the area. But, at the same time, people have to surrender their lands, millions are displaced, as few villages, cities and towns are flooded due the dam. According to the available records, the Three Gorges Dam, built on the river 'Yangtze' in China is the world's largest hydro power project.

Solar Power Plants

Solar energy is one of the most abundant natural resources that is capable of providing more power than the current demand requires. Most of the solar power plants are concentrating solar power plants in which the rays of the sun are concentrated into a single beam using lenses and mirrors. The beam is then used to heat a working fluid that is used to generate power. Besides these, multi-megawatt photovoltaic plants have also been built in recent times. In these plants, Sun-rays are concentrated on photovoltaic surfaces which convert the Sun's energy into electrical energy using the photoelectric effect. Scientists are working on the idea of space-based solar power station. It involves collection of solar power in the solar panels fixed on a satellite in earth's orbit and its use on earth. More solar energy is available in the space than that is available on the surface of the earth. It is easier to collect solar energy in space. On the surface of the earth, various factors like day/night cycle, changing weather and seasons affect the process of energy collection. As the rays of the Sun pass through the gases present in the Earth's atmosphere, their intensity is reduced. I hope, scientists succeed in achieving their goals within a few decades. Other than the types of power plants that are mentioned above, there are geothermal energy power plants, wind turbines and renewable power plants that generate electricity for human consumption. Man has discovered various ways of generating electricity, but they are not sufficient as the need for electricity is constantly increasing. Therefore, scientists are still on the lookout for more ways of generating power. Although fission is the only way of producing energy in nuclear power plants, efforts are on to use nuclear fusion and radioactive decay for energy production. As far as conservation of energy is concerned, we should save electricity by taking stairs instead of using elevators whenever possible, switching off fans, televisions, music systems, lights, etc. when leaving the room, using timers and sensors, etc. This way, we can save the resources on the earth.[42]

[42] Alan D. Smith, ' Types of Power Plants' <http://www.buzzle.com/articles/types-of-power-plants.html> accessed 17 March 2014

Chapter 3: HYDRO POWER PLANT

Introduction

Hydropower is a renewable energy resource because it uses the Earth's water cycle to generate electricity. Water evaporates from the Earth's surface, forms clouds, precipitates back to earth, and flows toward the ocean. The movement of water as it flows downstream creates kinetic energy that can be converted into electricity. 2700 TWH is generated every year. Hydropower supplies at least 50% of electricity production in 66 countries and at least 90% in 24 countries. Out of the total power generation installed capacity in India of 1,76,990 MW (June, 2011), hydro power contributes about 21.5% i.e. 38,106 MW. A capacity addition of 78,700 MW is envisaged from different conventional sources during 2007-2012 (the 11th Plan), which includes 15,627 MW from large hydro projects. In addition to this, a capacity addition of 1400 MW was envisaged from small hydro up to 25 MW station capacity. The total hydroelectric power potential in the country is assessed at about 150,000 MW, equivalent to 84,000 MW at 60% load factor. The potential of small hydro power projects is estimated at about 15,000 MW.

Technology

A hydroelectric power plant consists of a high dam that is built across a large river to create a reservoir, and a station where the process of energy conversion to electricity takes place. The first step in the generation of energy in a hydropower plant is the collection of run-off of seasonal rain and snow in lakes, streams and rivers, during the hydrological cycle. The run-off flows to dams downstream. The water falls through a dam, into the hydropower plant and turns a large wheel called a turbine. The turbine converts the energy of falling water into mechanical energy to drive the generator After this process has taken place electricity is transferred to the communities through transmission lines and the water is released back into the lakes, streams or rivers. This is entirely not harmful, because no pollutants are added to the water while it flows through the hydropower plant.

Potential in India

India is blessed with immense amount of hydro-electric potential and ranks 5th in terms of exploitable hydro-potential on global scenario. As per assessment made by CEA, India is endowed with economically exploitable hydro-power potential to the tune of 1 48 700 MW of installed capacity. The basin wise assessed potential is as under :-

Basin/RiversProbable Installed Capacity (MW)

Indus Basin	33,832
Ganga Basin	20,711
Central Indian River system	4,152
Western Flowing Rivers of southern India	9,430
Eastern Flowing Rivers of southern India	14,511
Brahmaputra Basin	66,065
Total	1,48,701

Sl. No	States	Central Sector		State Sector		Private Sector		Total	
		No.	MW	No	MW	No.	MW	No.	MW
1.	Himachal Pradesh	2	816	7	892	6	749	15	2457
2.	Jammu & Kashmir	4	2450	4	1473	0	0	8	3923
3.	Uttarakhand	12	4374	7	1655	5	829	24	6858
4.	Punjab	0	0	1	168	1	75	2	243
5.	Madhya Pradesh	3	166	0	0	0	0	3	166
6.	Andhra Pradesh	0	0	3	1560	0	0	3	1560
7.	Kerala	0	0	6	373	0	0	6	373
8.	Karnataka	0	0	2	400	0	0	2	400
9.	West Bengal	1	120	2	66	0	0	3	186
10.	Sikkim	1	520	0	0	10	1935	11	2455
11.	Arunachal Pradesh	3	1610	0	0	23	7969#	26	9579
12	Assam	0	0	1	150	0	0	1	150
13	Manipur	2	1566	0	0	0	0	2	1566
14	Tamil Nadu	0	0	1	500	0	0	1	500
15.	Meghalaya	0	0	1	54	1	450	2	504
	TOTAL	28	11622	35	7291	46	12067	109	30920

Includes only 600 MW out of 2400 MW Siang Lower H. E. Project for capacity addition during 12th Plan.

Source: www.conserveindia.org

Projects Major

Hydropower generating units

NAME	STATE	CAPACITY (MW)
BHAKRA	PUNJAB	1100
NAGARJUNA	ANDHRA PRADESH	960
KOYNA	MAHARASHTRA	920
DEHAR	HIMACHAL PRADESH	990
SHARAVATHY	KARNATAKA	891
KALINADI	KARNATAKA	810
SRISAILAM	ANDHRA PRADESH	770

Top ten countries (in terms of capacity)

COUNTRY	POWER CAPACITY (MWh)	INSTALLED CAPACITY (MW)
TAJIKISTAN	527000	4000
CANADA	341312	66954
USA	319484	79511
BRAZIL	285603	57517
CHINA	204300	65000
RUSSIA	160500	44000
NORWAY	121824	27528
JAPAN	84500	27229
INDIA	82237	22083
FRANCE	77500	77500

Source CERC 2014

Barriers

The energy of running water has been exploited for very many years. However, traditional approaches have suffered disadvantages due to environmental factors. For example:

- Building a dam across a river floods the land that would otherwise be available for use, alters the landscape, affects the local community that would have lived and worked on the flooded land, alters the character of the river, and prevents the free movement of fish;
- Diverting a river affects the nature of the countryside and does not lend itself to use on a large scale.

- Permanent complete or partial blockage of a river for energy conversion is adversely affected by variations in flow.
- Building large-scale hydro power plants can be polluting and damaging to surrounding ecosystems. Changing the course of waterways can also have a detrimental effect on human communities, agriculture and ecosystems further downstream.
- Hydro projects can also be unreliable during prolonged droughts and dry seasons when rivers dry up or reduce in volume.

Maintenance of DAMS

The legislation, authorities, and references listed below are the more significant citations applicable to the maintenance and safety of dams.

A. Federal Land Policy and Management Act of 1976, as amended.

B. Federal Water Pollution Control Act, as amended 1972 and 1977.

C. Public Rangelands Improvement Act of 1978, as amended.

D. Soil Conservation and Domestic Allotment Act of 1972, as amended.

E. National Dam Inspection Program Act of 1972, as amended.

F. National Dam Safety Program (P.L. 104-303, Section 215)

G. Executive Order 11988—Floodplain Management, amended by Executive Order 12148—Federal Emergency Management.

H. Executive Order 11990—Protection of Wetlands, amended by Executive Order 12608—Elimination of Unnecessary Executive Orders and Technical Amendments to Others.

I. Executive Order 12088—Federal Compliance with Pollution Control Standards. Executive Order 13148 (Greening the Government Through Leadership in Environmental

Management) revokes Section 1-4 of EO 12088. Executive Order 12580 (Superfund Implementation) amends EO 12088 by renumbering Section 1-802 as Section 1-803, and adding a new Section 1-802.

J. Departmental Manual, Part 753 DM-1, Special Programs Dams Safety Program General Criteria, January 5, 1981, as amended April 14, 1982.

K. National Environmental Policy Act.

L. Federal Guidelines of Dam Safety, Federal Coordinating Council for Science Engineering and Technology, June 25, 1979.

M. FEMA 64, Federal Guidelines for Dam Safety Emergency Action Planning for Dam Owners, April 2004.

N. FEMA 93, Federal Guidelines for Dam Safety, April 2004

O. FEMA 94, Federal Guidelines for Selecting and Accommodating Inflow Design Floods for Dams.

P. FEMA 333, Federal Guidelines for Hazard Potential Classification System for Dams, April 1995.

Q. FEMA 1448, Glossary of Terms for Dam Safety

R. The National Dam Safety Program Act Implementation Plan

S. BLM Handbook H-9177-1, Dam Safety Inspection Report Guidelines Embankment Dams, March 27, 2006.

T. BLM Manual 9102, Facility Design

U. BLM Manual 9103, Facility Construction

V. BLM Manual 9104, Facility Maintenance

W. Any subsequent Federal or Departmental policies and guidelines.

Environmental Impacts of Hydropower Plants

The impact of hydroelectric power plant on the environment is varied and depends upon the size and type of the project. Although hydropower generation does not burn any fuel to produce power and hence does not emit greenhouse gases, there are definite negative effects that arise from the creation of reservoir and alteration of natural water flow. It is a fact that dams, inter-basin transfers and diversion of water for irrigation purposes have resulted in the fragmentation of 60% of the world's rivers. The physical environment is affected rather significantly by the construction of a hydroelectric power station. Both the river and ecosystem of the surrounding land area will be altered as soon as dam construction begins.

1. Impact of Size and Type of Hydropower Plant: It is difficult to correlate the damage caused by dams to their size or type, as the impacts depend on local conditions. Generally plants with smaller dams are considered less environmentally damaging than those with larger dams. Also, run-of-river (ROR) hydropower plants are generally less damaging than reservoir power plants, because it is not necessary to flood large areas upstream of the project for storage. Yet in some cases run of river impacts can also be severe due to river diversion over long stretches of the river.

2. Impact of River Diversion: While both ROR and reservoir types of hydropower dams may divert water, this is always the case with ROR plants, since they seek to increase kinetic energy with an increased head. The length of diversion can range from a few meters or less to kilometers (km). For example, the Teesta-V ROR dam in northeastern India diverts water for a 23 km long stretch of the river. Eventually the diverted water is returned to the river. Often downstream flows are reduced considerably or even completely stopped during certain periods of time with sudden intervals of high flows. Such drastic variability in water flow impacts the structure of aquatic ecosystems often leading to a loss of biodiversity. Also, under normal conditions, increased sediment transport from low to intermediate flows provides a warning to aquatic organisms that high flows may follow. Abrupt changes from low to high flows obliterate this cue, making it difficult for organisms to respond to impending environmental changes. A decrease in fish populations has been observed in dewatered reaches below diversions. After long periods of little to no flow some species may not be able to recover and go extinct.

3. Impact of the Reservoir:_Dams have major impacts on the physical, chemical and geo-morphological properties of a river. Environmental impacts of dams have largely been negative. Worldwide, at least 400,000 square kilometers have been flooded by reservoirs. Once the barrier is put in place, the free flow of water stops and water will begin to accumulate behind the dam in the new reservoir. This land may have been used for other things such as agriculture, forestry, and even residences, but it is now unusable. The loss of habitat may not seem severe but if this area was home to a threatened or endangered species, the dam construction could further threaten that species risk of extinction.

3.1 Sedimentation_Large dams with reservoirs significantly alter the timing, amount and pattern of river flow. This changes erosion patterns and the quantity and type of sediments transported by the river. Sedimentation rate is primarily related to the ratio of the size of the river to the flux of sediments. The reservoir that has been rapidly filling up with water immediately begins filling up with sediment as well. The trapping of sediments behind the dam is a major problem. Every year it is estimated that 0.5 to 1% of reservoir storage capacity is lost due to sedimentation. The engineering problem with sedimentation is that less power is generated as the reservoir's capacity shrinks.

3.2 Downstream Erosion:_Trapping of sediments at the dam also has downstream impacts by reducing the flux of sediments downstream which can lead to the gradual loss of soil fertility in floodplain soils. Clean water stripped of its sediment load is now flowing downstream of the dam. This clean water has more force and velocity then water carrying a high sediment load and thus erosion of the riverbed and banks becomes problematic. Since this is unnatural and a form of "forced erosion" it occurs at a much faster rate then natural river process erosion to which the local ecosystem would be able to adapt.

3.3 Impact on Local Climate: Another often-ignored environmental effect of the reservoir is the impact on the micro-climate level. Studies indicate that man-made lakes in tropical climates tend to reduce convection and thus limit cloud cover. Temperate regions are also impacted with "steam-fog" in the time period before freezing. Since water cools and warms slower then land, coastal regions tend to be much more moderate then land-locked regions in terms of temperature. Therefore, large dams have a slight moderating effect on the local climate.

3.4 Greenhouse Gas Emission from Dams: Freshwater reservoirs can emit substantial amounts of the greenhouse gases methane and carbon dioxide as organic matter submerged in a reservoir decays under anaerobic and aerobic conditions, respectively. Studies indicate that GHG emissions from hydropower reservoirs in boreal and temperate region are low relative to the emissions from fossil fuel power plants, but higher relative to life cycle emissions from wind and solar power.[43] Tropical reservoirs with high levels of organic matter and shallow reservoirs have higher emission levels. A recent compilation of greenhouse gas emissions from reservoirs found a correlation between the age of the reservoir and latitude. Younger reservoirs and those in low latitudes are the highest emitters. For example, of four Brazilian dams in the Amazon, showed that the GHG emissions factor of the electricity produced by those hydropower dams exceed those from a coal-fired power plant.

3.5 Dams Inducing Earthquakes: Finally, a least studied and most disputed physical impact of reservoirs is the possibility of inducing earthquakes. Many scientists believe that seismic activity can be attributed to the creation of dams and their adjacent storage reservoirs. They postulate that the added forces of the dam along inactive faults seem to free much stronger orogenic tensions. Early research indicates that the depth of the water column may be more important to inducing earthquakes rather than total volume of water in the reservoir. While more research is needed on this subject several disasters such as the Koyna Dam inIndiaseem to provide some truth to this theory. While these impacts

[43] Sathyanathan, V.T.; Mohammad, K.P., 'Prediction of un burnt carbon in tangentially fired boiler using Indian coals', Fuel. (2004)

can be quite severe often they do not receive the attention of the biological impacts that people tend to associate more with animals like fish.

3.6 Impact on Fisheries:_Dams and river diversion can impact freshwater, as well as marine fisheries. Estuarine and marine fisheries are dependent on estuaries and rivers as spawning grounds and the transport of nutrients from the river to the sea. Migratory fish are especially vulnerable to the impacts of dam construction. Dams can prevent migrating fish such as salmon and eel to reach their spawn grounds. A survey of 125 dams by the World Commission on Dams (WCD) reported that blocking the passage of migratory fish species has been identified as a major reason for freshwater species extinction in North America. Lower catch is a common side effect of dams and has been reported worldwide. There have been cases where fishery production below a dam has increased due to controlled discharge of the sediments.[44] Disadvantages of Hydroelectric Power Plants

In spite of the factors mentioned above, developing HEP does carry certain disadvantages:

- A variety of geological changes occur due to the construction of a dam on the river, especially in the downstream area.
- Various plant and animal ecosystems gets adversely affected due to their submergence in the water reservoir formed by the dam.
- The soil quality in downstream river declines.
- HEP plants are severely impacted by droughts. If water is not available, the plant would not be able to produce electricity.
- Fish population gets affected if fish cannot migrate to the spawning grounds upstream past impoundment dams, or if they cannot migrate downstream to the ocean.

However, such occurrences happen rarely and their impact is very low, as compared to the huge benefits arising out of a HEP project development.

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[44] Rees, O.W.; Shimp, N.F.; Beeler, C.W.; Kuhn, J.K.; Helfinstine, R.J., 'Sulfur Retention in Bituminous Coal Ash', Illinois State Geological Survey, Circular. 396(1996).

Impact of Hydroelectric Power Plants

Economic Advantage

Development of a HEP project is often deterred due to the substantial initial investment required. But this HEP project investment cost needs to be balanced against the longer project life and lower operation & maintenance costs, coupled with no consumption of fuel for energy production, vis-à-vis those of the TP plant. From an economic perspective, keeping in view the quality of the energy produced, the balance shows a clear advantage for hydropower. Moreover, from a development and growth perspective, the external benefits and costs associated with the projects need to be considered. If total costs for the lifetimes of the respective electricity generation options are considered, HEP appears to have the greatest advantage.

It was concluded at the 17th Congress of the World Energy Council in 1998 in Houston that development and use of appropriate renewable energies should be given clear priority, with the aim of restricting emissions resulting from the use of fossil fuels. It has been found to have longer plant life (of 100 years) and therefore, is a sustainable energy source.

Social Impact

Like any other economic activity, HEP project impacts the project area. These changes can be geographical and social like land use transformation, and displacement of people who were living in the reservoir area. However, these projects generate employment and further growth opportunities for the local population. New public services and infrastructure development, including schools, hospitals, roads, etc. come up in the area with the introduction of electricity to the rural/underdeveloped areas, enabling better growth of the nation.[45] But, the social effects of HEP schemes are variable and project-specific. However, with planned anticipation and subsequent addressing at the project planning stage, the adverse impacts can be efficiently tackled, and in some cases, evaded

[45] Olivier, J.G.J.; Bouwman, A.F.; Berdowski, J.J.M.; Veldt, C.; Bloos, J.P.J.; Visschediik, A.J.H.; van der Maas, C.W.M.; Zandveld, P.Y.J., 'Sectoral emission inventories of greenhouse gases for 1990 on a per country basis' Environmental Science & Policy' 2 (1999)

altogether. Implementation of an effective public participation programme from the early stages of a project becomes crucial. If a project is considered to be a development opportunity for the community, the project affected families (PAFs) will be able to enjoy a higher standard of living through associated infrastructure developments.

Case study of silent valley

Long before the Internet era, a remarkable people's movement saved a pristine moist evergreen forest in Kerala's Palakkad District from being destroyed by a hydroelectric project. The battle for the now famous Silent Valley raged for over ten years and involved thousands of people who did not even live in the vicinity of the area that was to be destroyed. Although the campaign did not have any centralized planning, it was highly effective.[46] The sustained pressure exerted on the government by citizens using every possible means available at the time – letters to the editors of newspapers, seminars, widespread awareness programmes, and finally petitions and appeals in court and other high offices – proved ultimately successful. In 1986 Silent Valley was declared a National Park, a striking testimony to the power of peoples' action. The lessons from this inspiring and hard-fought campaign are still relevant today. Here is a gist drawn from an article by the poet Sugatha Kumari in 'Silent Valley – Whispers of Reason'.

1970: the Kerala State Electricity Board (KSEB) proposes a hydroelectric dam across the Kunthipuzha River that runs through Silent Valley, that will submerge 8.3 sq km of untouched moist evergreen forest.

Arguments it makes for the Silent Valley Hydroelectric Project (SVPH):

•It will generate electricity for the state of Kerala with the installation of four units of 60 MW each. (The KSEB avers that the state's electricity requirements will not be met without this additional power).

•Irrigate an additional 100 sq km in the Mallapuram and Palghat districts.

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[46]CEA letter on PPP in distribution – experience of input based DF model in town from the chairperson of CEA, Letter No. DPD/ Franchisee/Bhiwandi/ 2008/ 489, dated 10-Jan-2008.

•Provide employment to several thousand people during the construction phase and boost the economy of the state.

1971 – 72: Steven Green, a scientist from the New York Zoological Society, conducts studies on primates, especially the lion-tailed macaque in Silent Valley. Green expresses concerns about the possible threats to the rare macaque from the project. Around the same time, herpetologist Rom Whitaker explores Silent Valley to study the snakes of the region. He writes a letter to the Bombay Natural History Society about the need to conserve the Valley. Reports like these alert other naturalists.

February 1973: The Planning Commission approves the project at a cost of about Rs 25 crores. However, due to lack of sufficient funds, implementation is delayed october 1976: National Committee on Environment Planning and Coordination (NCEPC) sets up a task force, chaired by Zafar Futehally, to study the ecological problems that could be precipitated by the project. Work on the project is suspended pending the task force's impact analysis. Task Force recommends that project be scrapped. However it provides a loophole that stipulates that, if abandoning the project is not possible, a series of safeguards should be implemented. Unsurprisingly, the Kerala government opts to proceed with the project by promising to implement all safeguards. State argues that the area submerged by the dam is only 1022 hectares, of which 150 ha is grasslands. Also argues that only 10 percent of the ecosystem will be damaged, while ecological safeguards will protect the rest.

However, several NGOs strongly oppose the project and urge the government to abandon it. Conservationists argue that:

•The entire lower valley will be submerged by the dam, destroying its biodiversity.

•The 10 percent loss projected by the government will actually be far worse.

•The workforce brought in for the construction of the project will reside in the area for several years and the destruction they cause – illegal wood felling, cattle grazing, poaching, encroaching – will destroy the Valley.

1977: Sathish Chandran Nair visits Silent Valley. With missionary zeal he starts a movement to create awareness in academic circles through talks and slide shows. V.S. Vijayan of the Kerala Forest Research Institute does a study on the impact of hydroelectric projects on the environment, and writes to the authorities not to begin the project till his report is submitted. He is admonished and his report is suppressed.

The message of the conservationists is taken to villages and cities all over Kerala. S Prabhakaran Nair tours the villages of north Malabar; Prof. John Jacob trains young nature lovers. Soon Nature Clubs spring up all over the state.[47]

Undeterred, the state government plunges ahead with the project.

The result is that the outcry against the Silent Valley Hydroelectric Project – which started as a localized movement through individual and small group protests – goes national and international.

The General Assembly of the IUCN urges the Government to conserve the undisturbed forest area. Many eminent people, including conservationists and corporate and political leaders, write to the Central Government requesting that no sanction be given to the project. These include Salim Ali, Madhav Gadgil, CV Radhakrishnan, MS Swaminathan, Subramaniam Swamy, Sitaram Kesari, Piloo Modi and Krishna Kant. Salim Ali writes that the project is 'shortsighted' and has 'limited objectives'. Institutions like the BNHS and Geological Survey of India ask that the area be declared a Natural Bioreserve.

However, Prime Minister Morarji Desai rejects all the appeals and recommends that the proposal begin with no delay.

June 1979: Kerala begins the project in earnest.

[47] Feedback Ventures Pvt. Ltd.; ―Final Report on Standardization of Distribution Franchisee Model‖ Report; Sep-2009

August 1979: N.V. Krishna Warrier of the Prakriti Samrakshana Samiti, Prof. Joseph John, and P. Gopalakrishnan Nair, an advocate, file a petition and get a stay order from the High Court of Kerala, stopping work on the project.[48]

Soon after, the Silent Valley Samrakshana Samiti and Kerala Sastra Sahitya Parishad start awareness campaigns with vigour. They hold protest meetings, rallies and debates all over the state, turning the campaign into a mass people's movement.

Famous writers from Kerala join the movement and contribute their skills: poems, plays, stories and articles, to convey the message to the ordinary citizen.

Meanwhile, at the Centre, Morarji Desai is replaced by Charan Singh as PM. He institutes a Central Committee to re-investigate the issue, headed by M.S. Swaminathan, much to the chagrin of the Chief Minister of Kerala. In a move reeking of money-backed counter-propaganda, the State Government sets up its own panel of 'environmentalists' and scientists who support the government's views.

January 1980: the High Court rejects the writ plea, saying that it is not for the courts to go into the merits of scientific arguments and that it is "satisfied that the matters have received attention before the State decided to launch the project". Work on the project begins again in earnest.

Meanwhile, a small group of campaigners meet the Kerala Governor and request her to issue a stay order against continuing work on the project until the Committee set up by the Centre gives its report. She agrees, and work is halted once again. On the streets, the awareness campaigns continue.

The role of the media: In the media too, the fight for Silent Valley marks a distinct curve. The leading Malayalam newspapers first carry positive columns on the hydroelectric project. By 1977, four years after the project is approved and environmentalists begin their opposition to it, the newspapers still largely carry only news of the government's efforts to start the project.[49] Editorial opinion, on the rare occasions that it is expressed,

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[48] World Energy Outlook 2009, International Energy Agency, France.

[49] Ajay Pandey, Sebastian Morris, Electricity Reforms and Regulations – A Critical review of last 10 years of Experience IIM-A-2009.

strongly support the project and 'development'. Some publications even take potshots at the lion-tailed macaque, which has become a symbol of the wildlife that the environmentalists are trying to protect in Silent Valley.

The Express, a local daily, is an exception. It carries editorials that constitute a deliberate and strong tilt towards saving Silent Valley; it also carries a feature with a measured argument explaining the importance of rainforests in layman's terms.

In 1979, a slight shift in newspaper reportage is noticeable. Along with support for the project, some newspapers raise concern for the ecological consequences of destroying the rainforest. Malayalam Manorama, a popular magazine, although inclined to view the project favourably, opens up its letters and features columns to environmental opinions.

At first, few national newspapers consider the environment a particularly interesting subject, and the Silent Valley battles that are raging in Kerala may well be in another continent. The political push and shove that the project endures eventually gets the newspapers to cover the opposition to the project. The Indian Express, with its many southern editions, is ideally placed to pick up the issue. It's Kochi editions regularly feature Silent Valley and its concerns – even lambasting the Morarji Desai government for approving the project.[50]

The Hindu regularly features editorials on the subject. In August 1979, the paper carries a full-page report on the flora and fauna of Silent Valley. The letters section of the paper attracts several eminent people, among them Rom Whitaker, M.K. Prasad, Madhav Gadgil. The eminent naturalist, M. Krishnan writes, "In my lifetime I have seen many fine wildlife habitats demolished for hydel projects. Silent Valley is more important than them all – the last authentic sizeable evergreen forests left."

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[50] Anoop Singh, *Power Sector Reforms in India: current issues and prospects*, Energy policy, vol.34, no.16, Nov 2006

More political twists and turns: Meanwhile, in Delhi, Charan Singh's term as Prime Minister is over in a short six months. He is replaced by Indira Gandhi. Luckily for the conservation movement, she takes an active personal interest in the Silent Valley project, as national and international pressure mounts.

January 1981: Bowing to unrelenting public pressure, Indira Gandhi declares that Silent Valley will be protected. However – when the fine print is read – it is learned that the area under the hydroelectric project is not covered under the protected area! When the people become aware of this 'little detail', hundreds of protest telegrams are sent to the Central Government. More pressure is heaped on the government by NGOs, reputed scientists and intellectuals, and ordinary citizens.

June 1983: the Centre re-examines the issue through a commission chaired by Prof. M.G.K. Menon.

November 1983: the Silent Valley Hydroelectric Project is called off.

1985: Prime Minister Rajiv Gandhi formally inaugurates Silent Valley National Park.

Chapter 4: THERMAL POWER PROJECT

Thermal power uses steam to spin turbines, which in turn feed electric generators. Most power plants in the world use thermal energy to operate. A thermal power plant is usually defined by the type of fuel used to heat the water and create steam. Coal, oil, and even solar and nuclear powers can be used to create the steam necessary to run a thermal plant.

Many thermal plants operate on a partially closed loop, using what is known as a Rankine cycle. Water is heated by fuel, such as coal or nuclear power, until it becomes steam. Steam is passed through a series of chambers that make it stronger, hotter, and more powerful. The steam reaches the turbines and spins them, then is pushed through to a cooling storage area where it can condense back into water. The water can then be reused to create steam, completing the loop. One type of thermal power plant that emits the heating step is a geothermal plant. This makes use of steam and naturally boiling water that rises from the earth in the form of geysers and hot springs. Geothermal sources can be unpredictable, and have somewhat limited use due to their presence only in certain places, such as alongside tectonic divides. Nevertheless, geothermal plants use less energy than many other varieties, making them more cost and time efficient. One of the major concerns with thermal power plant is the fuel used to generate steam from water. Common fuel sources include coal and other fossil fuels, which have several built-in problems. In addition to the dwindling resources available, fossil fuels are generally heavily pollutant and are believed by many scientists to be a major contributing factor in global warming. Solar thermal power have the benefit of being non-pollutant and also utilizing a completely renewable resource: sunlight. Using solar panels to absorb sun, lenses and mirrors then concentrate the heat to activate a steam generator. This technology is in its infancy in the early 21st century; efficiency and the variables of a moving sun continue to create problems in building a large capacity solar thermal power plant. Thermal power is a mighty tool in everyday life on the planet; many regions receive the bulk of their energy supply from thermal plants. Experts say the technology requires advances and refinements to meet growing energy requirements In addition, pressure to reduce fossil fuel consumption and create low pollution energy sources requires new ideas, plans, and experimentation to be brought to the field. [51]

Environmental issues in thermal power plant projects primarily
include the following:

- Air emissions
- Energy efficiency and Greenhouse Gas emissions
- Water consumption and aquatic habitat alteration
- Effluents
- Solid wastes
- Hazardous materials and oil
- Noise

Air Emissions

The primary emissions to air from the combustion of fossil fuels or biomass are sulfur dioxide (SO2), nitrogen oxides (NOX), particulate matter (PM), carbon monoxide (CO), and greenhouse gases, such as carbon dioxide (CO2). Depending on the fuel type and quality, mainly waste fuels or solid fuels, other substances such as heavy metals (i.e., mercury, arsenic, cadmium, vanadium, nickel, etc), halide compounds (including hydrogen fluoride), unburned hydrocarbons and other volatile organic compounds (VOCs) may be emitted in smaller quantities, but may have a significant influence on the environment due to their toxicity and/or persistence. Sulfur dioxide and nitrogen oxide are also implicated in long-range and trans-boundary acid deposition.

The amount **Air Emissions** The primary emissions to air from the combustion of fossil fuels or biomass are sulfur dioxide (SO2), nitrogen oxides (NOX), particulate matter (PM), carbon monoxide (CO), and greenhouse gases, such as carbon dioxide (CO2). Depending on the fuel type and quality, mainly waste fuels or solid fuels, other substances such as heavy metals (i.e., mercury, arsenic, cadmium, vanadium, nickel, etc), halide compounds (including hydrogen fluoride), unburned hydrocarbons and other volatile organic compounds (VOCs) may be emitted in smaller quantities, but may have a significant influence on the environment due to their toxicity and/or persistence. Sulfur

[51] Power Sector at a Glance ALL INDIA. *Available at* Powermin.nic.in. Accessed on 4th April 2014.

dioxide and nitrogen oxide are also implicated in long-range and trans-boundary acid deposition. The amount and nature of air emissions depends on factors such as the fuel (e.g., coal, fuel oil, natural gas, or biomass), the type and design of the combustion unit (e.g., reciprocating engines, combustion turbines, or boilers), operating practices, emission. Environmental Assessment Guidance for Thermal Power Projects The development of an environmental assessment (EA) for a thermal power project should take into account any government energy and/or environmental policy or strategy including strategic aspects such as energy efficiency improvements in existing power generation, transmission, and distribution systems, demand side management, project siting, fuel choice, technology choice, and environmental performance. New Facilities and Expansion of Existing Facilities An (EA) for new facilities and a combined EA and environmental audit for existing facilities should be carried out early in the project cycle in order to establish site-specific emissions requirements and other measures for a new or expanded thermal power plant. Table B-1 provides suggested key elements of the EA, the scope of which will depend on project specific circumstances. Tasks related to carrying out the quality impact analysis for the

EA should include:

• Collection of baseline data ranging from relatively simple qualitative information (for smaller projects) to more comprehensive quantitative data (for larger projects) on ambient concentrations of parameters and averaging time consistent with relevant host country air quality standards (e.g., parameters such as PM10, PM2.5, SO2 (for oil and coal-fired plants), NOX, and ground-level ozone; and averaging time such as 1-hour maximum, 24-hour maximum, annual average), within a defined airshed encompassing the proposed project;46

• Evaluation of the baseline airshed quality (e.g., degraded or non-degraded);

• Evaluation of baseline water quality, where relevant;

• Use of appropriate mathematical or physical air quality Ambient environmental quality in the airshed or water basin affected by the plant, together with approximate estimates of the contribution of the plant to total emissions loads of the main pollutants of concern

• The impact of the plant, under existing operating conditions and under alternative scenarios for rehabilitation, on ambient air and water quality affecting neighboring populations and sensitive ecosystems

• The likely costs of achieving alternative emissions standards or other environmental targets for the plant as a whole or for specific aspects of its operations

• Recommendations concerning a range of cost effective measures for improving the environmental performance of the plant within the framework of the rehabilitation project and any associated emissions standards or other requirements implied by the adoption of specific measures. These issues should be covered at a level of detail appropriate to the nature and scale of the proposed project. If the plant is located in an airshed or water basin that is polluted as a result of emissions from a range of sources, including the plant itself, comparisons should be made of the relative costs of improving ambient air or water quality by reducing emissions from the plant or by reducing emissions from other sources.[52]

An environmental assessment of the proposed rehabilitation should be carried out early in the process of preparing the project in order to allow an opportunity to evaluate alternative rehabilitation options before key design decisions are finalized. The assessment should include an environmental audit that examines the impacts of the existing plant's operations on nearby populations and ecosystems, supplemented by an EA that examines the changes in these impacts that would result under alternative specifications for the rehabilitation, and the estimated capital and operating costs associated with each option. Depending on the scale and nature of the rehabilitation, the audit/environmental assessment may be relatively narrow in.

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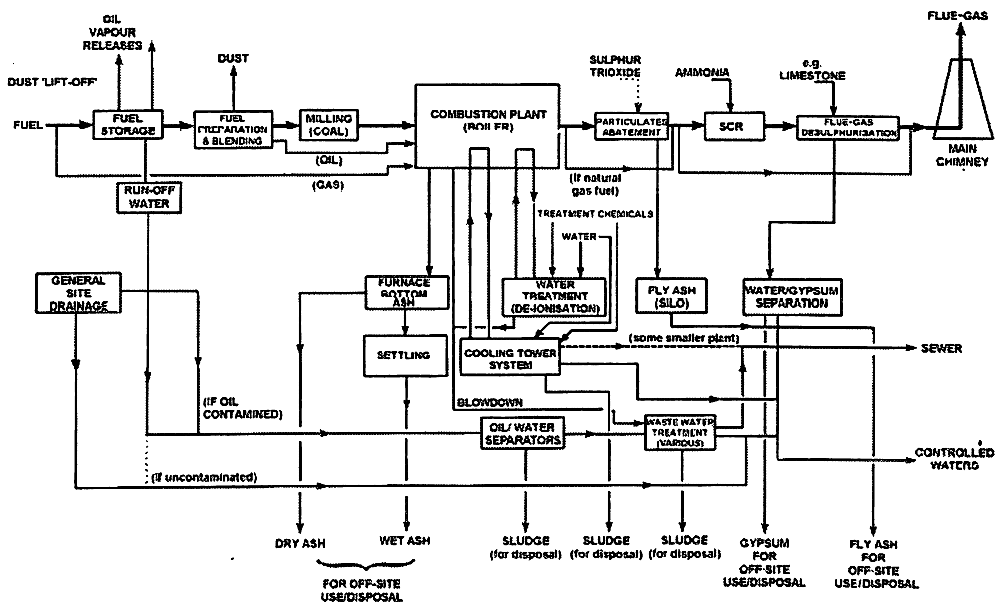
[52] Preetum Domah, Michael G.Pollitt, The Restructuring and Privatization of the Electricity Distribution and Supply Businesses in England and Wales, 123(2000).

Generalized Flow Diagram of a Thermal power plant[45] and Associated Operations



Source: EC 2006

Chapter 5: WIND AND SOLAR ENERGY GENERATION.

Introduction

Winds are caused by the uneven heating of the atmosphere by the sun, the irregularities of the earth's surface, and rotation of the earth. The earth's surface is made of different types of land and water. These surfaces absorb the sun's heat at different rates, giving rise to the differences in temperature and subsequently to winds. During the day, the air above the land heats up more quickly than the air over water. The warm air over the land expands and rises, and the heavier, cooler air rushes in to take its place, creating winds. At night, the winds are reversed because the air cools more rapidly over land than over water. In the same way, the large atmospheric winds that circle the earth are created because the land near the earth's equator is heated more by the sun than the land near the North and South Poles. Humans use this wind flow for many purposes: sailing boats, pumping water, grinding mills and also generating electricity. Wind turbines convert the kinetic energy of the moving wind into electricity.

Wind Energy for power generation

Wind Energy, like solar is a free energy resource. But is much intermittent than solar. Wind speeds may vary within minutes and affect the power generation and in cases of high speeds- may result in overloading of generator. Energy from the wind can be tapped using turbines. Setting up of these turbines needs little research before being established. Be it a small wind turbine on a house, a commercial wind farm or any offshore installation, all of them, at first, need the Wind Resource to be determined in the area of proposed site. The Wind Resource data is an estimation of average and peak wind speeds at a location based on various meteorological. The next step is to determine access to the transmission lines or nearest control centre where the power generated from the turbines can be conditioned, refined, stored or transmitted. It is also necessary to survey the impact of putting up wind turbines on the community and wildlife in the locality. If sufficient wind resources are found, the developer will secure land leases from property owners, obtain the necessary permits and financing; purchase and install wind turbines. The completed facility is often sold to an independent operator called an independent power producer (IPP) who generates electricity to sell to the local utility, although some utilities own and operate wind farms directly. Wind mills can be set up ranging scales of:

- On-shore grid connected Wind Turbine systems
- Off-shore Wind turbine systems
- Small Wind and Hybrid Energy Decentralized systems (Floating)[53]

Advantages

Excessive heating of earth due to burning of fossil fuels have forced people across the globe to generate power through wind. It is being used extensively in areas like USA, Denmark, Spain, India and Germany. Like any other source of power generation, wind energy has its own advantages and disadvantages.

1. Renewable Energy: Wind energy in itself is a source of renewable energy which means it can be produced again and again since it is available in plenty. It is cleanest form of renewable energy and is currently used many leading developed and developing nations to fulfill their demand for electricity.

2. Reduces Fossil Fuels Consumption: Dependence on the fossil fuels could be reduced to much extent if it is adopted on the much wider scale by all the countries across the globe. It could be answer to the ever increasing demand for petroleum and gas products. Apart from this, it can also help to curb harmful gas emissions which are the major source of global warming.

3. Less Air and Water Pollution: Wind energy doesn't pollute at all. It is that form of energy that will exist till the time sun exists. It does not destroy the environment or release toxic gases. Wind turbines are mostly found in coastal areas, open plain and gaps in mountains where the wind is reliable, strong and steady. An ideal location would have

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[53] Electricity Act 2003 – Comments (2003), *Also see* Godbole M., Economy and Political weekly, September 29,2003, Mumbai, India.

a near constant flow of non-turbulent wind throughout the year, with a minimum likelihood of sudden powerful bursts of wind.

4. Initial Cost: The cost of producing wind energy has come down steadily over the last few years. The main cost is the installation of wind turbines. Moreover the land used to install wind turbines can also be used for agriculture purpose. Also, when combine with solar power, it provides cheap, reliable, steady and great source of energy for the for developed and developing countries.

5. Create Many Jobs: Wind energy on the other hand has created many jobs for the local people. From installation of wind turbines to maintenance of the area where turbines are located, it has created wide range of opportunities for the people. Since most of the wind turbines are based in coastal and hilly areas, people living there are often seen in maintenance of wind turbines.

- Can be used for both distributed generation or grid interactive power generation using on-shore or off shore technologies.
- Ranges of power producing turbines are available. Micro-turbines are capable of producing 300W to 1MW and large wind turbines have typical size of 35kW-3MW.
- Wind turbine is suitable to install in remote rural area, water pumping and grinding mills
- Average capacity factor can be close or higher than 30%

Despite these advantages there few disadvantages too which makes wind turbines not suitable for some locations.

Disadvantages

- The total cost can be cheaper than solar system but more expensive than hydro.

- Electricity production depends on- wind speed, location, season and air temperature. Hence various monitoring systems are needed and may cost expensive.
- High percentage of the hardware cost (for large WT) is mostly spent on the tower designed to support the turbine

Technology

The range of wind speeds that are usable by a particular wind turbine for electricity generation is called productive wind speed. The power available from wind is proportional to cube of the wind's speed. So as the speed of the wind falls, the amount of energy that can be got from it falls very rapidly. On the other hand, as the wind speed rises, so the amount of energy in it rises very rapidly; very high wind speeds can overload a turbine. Productive wind speeds will range between 4 m/sec to 35 m/sec. The minimum prescribed speed for optimal performance of large scale wind farms is about 6 m/s. Wind power potential is mostly assessed assuming 1% of land availability for wind farms required @12 ha/MW in sites having wind power density exceeding 200 W/sq.m. at 50 m hub-height. The energy in the wind turns two or three propeller-like blades around a rotor. The rotor is connected to the main shaft, which spins a generator to create electricity. Wind turbines are mounted on a tower to capture the most energy. At 100 feet (30 meters) or more above ground, they can take advantage of faster and less turbulent wind. [54]Wind turbines can be used to produce electricity for a single home or building, or they can be connected to an electricity grid (shown here) for more widespread electricity distribution. Furthermore projects are going on exploring in Research Design and Development to achieve following goals:

- Continue cost reduction: improved site assessment, better modeling for aerodynamics, intelligent/recyclable materials, stand-alone and hybrid systems.

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[54] Tonci Bakovic,et al,*Regulation by Contract A New Way to Privatize Electricity Distribution?*, World Bank Working Paper 14, Sep-2003.

- Increase value and reduce uncertainties: forecasting power performance, improving standards and engineering integrity and storage techniques.
- Enable large-scale use: Load flow control and adaptive power quality
- Minimize environmental impacts: Noise impacts, Flora and Fauna, utilization of land resources and aesthetics integration India's Unique Proposition
- Geographic Location and Wind Potential: The potential is far from exhausted. It is estimated that with the current level of technology, the 'on-shore' potential for utilization of wind energy for electricity generation is of the order of 65,000 MW. India also is blessed with 7517km of coastline and its territorial waters extend up to 12 nautical miles into the sea. The unexploited resource availability has the potential to sustain the growth of wind energy sector in India in the years to come. Potential areas can be identified on Indian map using Wind Power Density map. C-WET, one of pioneering Wind Research organization in the country is leading in all such resource studies and has launched its Wind Resource map.

In a step towards identifying and properly exploiting these wind resources, MNRE has estimated state-wise wind power potential in the country.

- World Market Share: According to REN21- Global Status Report 2011 (GSR-2011), Indian company Suzlon was among top ten manufacturers of Wind Turbine manufacturer's in the world with world market share of 6.7%. Also major world companies are pouring into the fast evolving Wind Energy market in India: Vestas, GE Wind, Enercon and Gamesa have already opened up their establishments across various cities in India.
- Government Support and Policies: Several states have come up with renewable energy policies like Karnataka, Tamil Nadu and Andhra Pradesh. More details of and summary for such policies is available on this page.
- Installed Capacity: According to MNRE 's achievent report, The cumulative installed capacity of Grid Interactive Wind Energy in India by the end of September 2011 was 14989MW (of which 833MW was installed during 2011-

2012 against a target of 2400MW). Aerogenerators and hybrid systems contributed 1.20MW during 2011-12 to yield cumulative off-grid wind capacity of 15.55MW.

- India in the windy world: In 2008, India shared 6.58% of total wind energy installed capacity around the world, according to World Wind Energy Report-2008. According to GSR-2011, the world witnessed highest renewable energy installations through wind energy. Total installed capacity of wind energy reached 198GW by the end of 2010. India ranked third in the world in annual capacity additions and fifth in terms of total wind energy installed capacity. India has been able to fast pace its growth in wind energy installations and bring down costs of power production. The GSR 2011 reported on-shore wind power (1.5-3.5MW; Rotor diameter 60-100m) at 5-9 cents/kWh and off shore wind power (1.5-5MW; Rotor diameter 75-120m) at 10-20 cents/kWh. But India's onshore wind power cost reached 6-9cents/kWh in 2008 itself (Indian Renewable Energy Status Report-2010).[55]
- Clean Wind to overcome power shortage: Electricity losses in India during transmission and distribution have been extremely high over the years and this reached a worst proportion of about 24.7% during 2010-11. India is in a pressing need to tide over a peak power shortfall of 13% by reducing losses due to theft. Theft of electricity, common in most parts of urban India, amounts to 1.5% of India's GDP. Due to shortage of electricity, power cuts are common throughout India and this has adversely affected the country's economic growth. Hence a cheaper, non-polluting and environment friendly solution to power rural India is needed.
- Wind energy as job generator: Wind energy utilization creates many more jobs than centralized, non-renewable energy sources. Wind Energy companies have opened up huge career options. Also the ease and accessibility of manufacturing technology has given entrepreneurs with new business options to venture in. The wind sector worldwide has become a major job generator: Within only three

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[55] Lahiri R. N., Sinha A., Chowdhary S.P,*Privatization of power distribution utility in India through Restructuring and Reformation*‖, Power and Energy Society General,Meeting, IEEE, July,2010.

years, the wind sector worldwide almost doubled the number of jobs from 235,000 in 2005 to 440,000 in the year 2008. These highly skilled employees are contributing to the generation of 260 TWh of electricity.

Capacity Installed

A notable feature of the Indian programme has been the interest among private investors/developers in setting up of commercial wind power projects. Several companies have established themselves in wind technology manufacturing. The gross potential is 48,561 MW (source C-wet) and a total of about 14,158.00 MW of commercial projects have been established until March 31, 2011.

Solar Power Plants

Sun is the ultimate source of energy for each and every living thing on earth. Harnessing sun's unbound energy to the best of its ability is done in solar power plants. There are many ways to get the power from the sun through solar panels in solar power plants. There are direct as well as indirect ways to convert the sun's heat into power. Directly, the heat from sun is converted into electricity using photovoltaic. Indirectly, the sun's heat is converted into power by concentrating the heat of the sun to boil the water and then the steam from it is used for electricity generation. The construction of solar power plants is the best thing that is happening right now for the future generations. With each passing day, the consumption of power, which is produced by burning of the fossil fuels, is increasing at a very high rate. Fossil fuels are getting depleted at a much faster rate than they are being produced. If things keep on going the way they are right now, that time is not far away when there'll be no energy or power to consume. To prevent this dreadful day from coming into being, solar power plants are being set up around the globe. These solar power plants have proved to be and still are a boon to mankind. Sun's radiations are intermittent and to get a continuous supply of power various methods are adopted at the solar power plants. One of such ways taken on at the solar power plants is storage. The solar power is produced by concentrating the sun's radiations, with the help of mirrors and lenses, into a single beam and that beam is used to heat the water. The steam from the hot water is then used in a conventional power plant to generate electricity. This produced electricity is then stored so that it can be utilized when the sun is not there outside, shining in its full glory. Although the solar power plants are expensive to install, in spite of that, countries around the globe are opting for solar power plants instead of other power plants because solar energy is a renewable source of energy. This solar energy when combined with the other sources of energy such as the wind, biomass and hydro power, results in 100% renewable energy. This has been accomplished in a large combined power plant, which is bigger than any of the solar power plants, set up in Germany. Solar power plants are the best source of power supply not only for the humans but for the environment as well. Solar energy is very eco-friendly and it doesn't contribute towards global warming at all as the other fossil fuel power plants do. Solar power plants make the ideal utilization of sun's energy and are helping the future generations from being powerless. Solar power plants are a like a ray of hope for the human race to survive when all the fossil fuels will get exhausted and there'll be nothing left to produce power from anymore. Apart from the solar power plants, there are a lot of products which have become very popular overs the years like solar ingots, solar refrigerators, solar televisions, cells, air conditioners, lights, lanterns, lighting systems etc. [56]

Solar Power Plants in India

India is one of the nations across the world that receives the maximum solar insulation which makes it a highly potential contender of growing in solar power harnessing. Solar insulation is basically the intensity of solar energy that falls on a particular location on the earth's surface. This is recorded and thus decides how much power can be generated by this solar energy. In most nations, mainly developing nations, there are several remote areas that are not equipped with the proper electric infrastructure. Due to this reason, these nations keep surviving without the supply of electricity while in some villages and rural areas where electricity has reached, the power outages are so frequent that it becomes very difficult for people to live their lives. Despite of advancement in the modern science and technology, we have still not been able to provide a decent living to

[56] The Economic Times - Improving financial viability of distr. companies will spur investments, Jun 14, 2012 [28]

our countrymen, which is a big disappointment. This is where solar power can do wonders to light up the nook and cranny of the nations without any humongous capital being involved. So far, India is leading rest all nations that are playing major roles in harnessing solar power; however, still there is a lot to be done to spread the light to various dark corners. At present, whatever power is being produced by harnessing solar energy is being utilized to satiate energy requirements of the big cities. This is making it difficult to supply power to the parts that are living under stark darkness after sunset. For reaching out to these rural areas, it will require a helping hand of all the Indians who can afford to employ solar appliances at their homes, so that they power their own homes and do not depend upon government for their energy needs. This will also reduce the burden on the government by bringing down the energy dependence on foreign nations. The first commercial solar power plants were made during 1980s. They were 354 mega watt of concentrated solar power plants remain to be the largest solar power plants across the world which are located at California. Some of the other big names in solar power plants include Solnova Solar Power Plant and Andasol Solar Power Station, both of which at located in Spain. The Golmud Solar Park located in China also registers its name among the largest photovoltaic plants. In India, the government of Gujarat had agreed to build world's biggest solar power plant in India. Another major solar power plant India is soon to be erected in the Thar desert where approximately 35,000 square kilometer of land has been kept aside in order to build solar power plants in India. Solar power plants in India can help a great deal in the development process of the nation. Rural electrification being just one of the benefits of the solar power plants, there are many more benefits that one can reap out of installation of solar plants. Some of the major industries in India, including the paper industry, sugar and dairy industry can be integrated with the solar power plants. Solar energy can replace the steam turbines that are still put to use for power requirements. This shall also bring down the steam turbine capital investments and other power house infrastructures which shall help cut down the cost of energy generation with some amount of solar power plant cost involved. Several studies show that during high insulation times, one can so saving of more than 24 percent. The first ever solar power plant in India was of 50 kilo watt in capacity and was installed by MNES by employing the parabolic trough collector technology. This was installed in

Gurgaon in the year 1989. However, it only operated for about two years because of spares' deprivation. This solar power plant is likely to be revived in the times to come. Another solar power plant is in the pipeline to be installed at Mathania, Rajasthan. Proposed by government of Rajasthan, the plant is 140mega watt in capacity which involves 105 MW of conventional power and 35 MW of solar power. Besides, Rajasthan also housed a solar chimney technology based solar plant in the north western region. This project is to be accomplished in five stages. In addition to this, BHEL, a major power manufacturing company had also installed a solar dish run solar power plant during 1990s. A part of the payment for this solar project was paid by US and there were in total six dishes that were used for harnessing the power. Apart from Rajasthan, the other states that are ahead in the solar power harnessing are Gujarat and Andhra Pradesh.

The benefits of solar power plants in India are aplenty and cannot be overlooked for anything. Solar power plants can help speed up the process of development by several notches. With the help of power generated by these polar plants, we as a nation would not have to depend upon other nations for our energy requirements. So far, the energy produced comes from the fossil fuels and the coal mines. However, since India is not rich in both of these resources, we need to import these resources from the other nations that have rich reserves. Besides, since fossil fuels are limited in quantity and coal mines are not plenty either, these resources are only a handful and thus there demand always exceeds their supply. This further adds to the increased price of these resources, making the import a difficult thing for many nations. If India becomes self sufficient in terms of generation of these resources, with the help of installation of solar power plants, it would help us save a lot of money and time at the same time. In addition, excess energy produced can also be supplied to the other nations in return of the foreign currency. Thus, solar power is one of the golden resources that can really bring a change in the way India's economy while helping environment heal, for harnessing of solar energy does not emit any greenhouse gases.

Chapter 6 NUCLEAR POWER GENERATION

Nuclear Power in India

- India has a flourishing and largely indigenous nuclear power program and expects to have 14,600 MWe nuclear capacity on line by 2020. It aims to supply 25% of electricity from nuclear power by 2050.
- Because India is outside the Nuclear Non-Proliferation Treaty due to its weapons program, it was for 34 years largely excluded from trade in nuclear plant or materials, which has hampered its development of civil nuclear energy until 2009.
- Due to these trade bans and lack of indigenous uranium, India has uniquely been developing a nuclear fuel cycle to exploit its reserves of thorium.
- Now, foreign technology and fuel are expected to boost India's nuclear power plants considerably. All plants will have high indigenous engineering content.
- India has a vision of becoming a world leader in nuclear technology due to its expertise in fast reactors and thorium fuel cycle.

India's primary energy consumption more than doubled between 1990 and 2011 to nearly 25,000 PJ. India's dependence on imported energy resources and the inconsistent reform of the energy sector are challenges to satisfying rising demand.

Electricity demand in India is increasing rapidly, and the 1052 billion kilowatt hours gross produced in 2011 was more than triple the 1990 output, though still represented only some 750 kWh per capita for the year. With huge transmission losses – 222 TWh in 2011, this resulted in only about 774 billion kWh consumption. Gross generation comprised 836 TWh from fossil fuels, 33 TWh from nuclear, 131 TWh from hydro and 53 TWh from other renewables. Coal provides 68% of the electricity at present, but reserves are limited. Gas provides 15%, hydro 12%. The per capita electricity consumption figure is expected to double by 2020, with 6.3% annual growth, and reach 5000-6000 kWh by 2050, requiring about 8000 TWh/yr then. There is an acute demand for more and more reliable power supplies. One-third of the population is not connected to any grid. At mid-2012, 203 GWe was on line with 20.5 GWe having been added in 12 months. In September 2012 it had 211 GWe. The government's 12th five-year plan for 2012-17 is targeting the addition of 94 GWe over the period, costing $247 billion. Three quarters of this would be coal- or lignite-fired and only 3.4 GWe nuclear, including two imported 1000 MWe units planned at one site and two indigenous 700 MWe units at another. By 2032 total installed capacity of 700 GWe is planned to meet 7-9% GDP growth, and this was to include 63 GWe nuclear. The OECD's International Energy Agency predicts that India will need some $1600 billion investment in power generation, transmission and distribution to 2035.

India has five electricity grids – Northern, Eastern, North-Eastern, Southern and Western. All of them are interconnected to some extent, except the Southern grid. All are run by the state-owned Power Grid Corporation of India Ltd (PGCI), which operates more than 95,000 circuit km of transmission lines. In July 2012 the Northern grid failed with 35,669 MWe load in the early morning, and the following day it plus parts of two other grids failed again so that over 600 million people in 22 states were without power for up to a day[57]. A KPMG report in 2007 said that India needed to spend US$ 120-150 billion on power infrastructure over the next five years, including transmission and distribution (T&D)[58]. It said that T&D losses were some 30-40%, worth more than $6 billion per year. A 2012 report costs the losses as $12.6 billion per year. A 2012 report costs the losses as $12.6 billion per year. A 2010 estimate shows big differences among states, with some very high, and a national average of 27% T&D loss, well above the target 15% set in 2001 when the average figure was 34%. Installed transmission capacity is only about 13% of generation capacity.[59]

Nuclear power supplied 20 billion kWh (3.7%) of India's electricity in 2011 from 4.4 GWe (of 180 GWe total) capacity and after a dip in 2008-09 this is increasing as

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[57] The Economic Times - Improving financial viability of distr. companies will spur investments, Jun 14, 2012

58 Crisil Infrastructure Advisory in The Economic Times – May 7, 2012 [29]

[59] PwC India; Resurrecting the Sector; World Energy Council; Jan-2012 [24]

imported uranium becomes available and new plants come on line. Some 350 reactor-years of operation had been achieved by the end of 2011. India's fuel situation, with shortage of fossil fuels, is driving the nuclear investment for electricity, and 25% nuclear contribution is the ambition for 2050, when 1094 GWe of base-load capacity is expected to be required. Almost as much investment in the grid system as in power plants is necessary.

The target since about 2004 has been for nuclear power to provide 20 GWe by 2020, but in 2007 the Prime Minister referred to this as "modest" and capable of being "doubled with the opening up of international cooperation." However, it is evident that even the 20 GWe target would require substantial uranium imports.[60] In June 2009 NPCIL said it aimed for 60 GWe nuclear by 2032, including 40 GWe of PWR capacity and 7 GWe of new PHWR capacity, all fuelled by imported uranium. This 2032 target was reiterated late in 2010 and increased to 63 GWe in 2011.[61] But in December 2011 parliament was told that more realistic targets were 14,600 MWe by 2020-21 and 27,500 MWe by 2032, relative to present 4780 MWe and 10,080 MWe when reactors under construction were on line in 2017.

"the XII Plan proposals are being finalized which envisage start of work on eight indigenous 700 MW Pressurised Heavy Water Reactors (PHWRs), two 500 MW Fast Breeder Reactors (FBRs), one 300 MW Advanced Heavy Water Reactor (AHWR) and eight Light Water Reactors of 1000 MW or higher capacity with foreign technical cooperation. These nuclear power reactors are expected to be completed progressively in the XIII and XIV Plans."[62]

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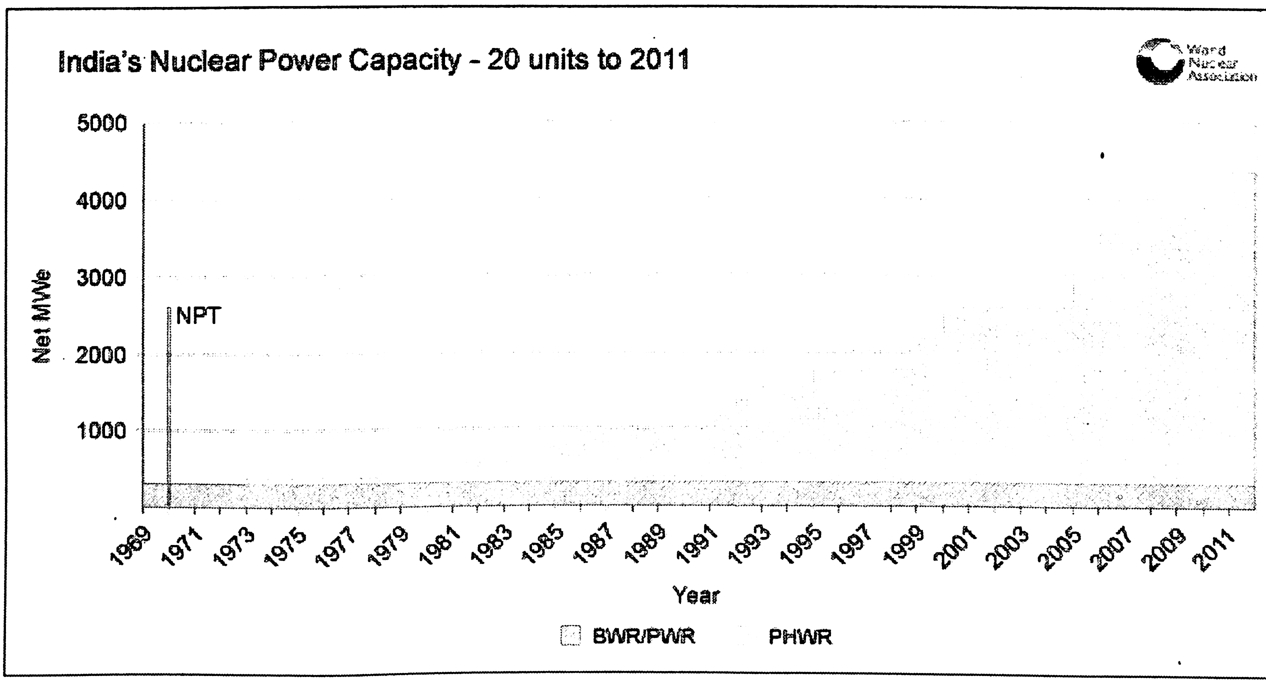
[60] Sec. 121 of EA-2003 mandates SERCs to undergo periodic tariff revisions. APTEL mandates SERCs to initiate suo-moto proceedings within one month after scheduled tariff revision filing. Only GERC took suo moto action based on the APTEL judgment.

[61] World Energy Outlook 2011, Report 21.

[62] Part III, Sec IV of CEA on Meter regulation applied to all level of Interface, consumer and Energy Audit Metering.

The 16 PHWRS and LWRs are expected to cost $40 billion. The eight 700 MWe PHWRs would be built at Kaiga in Karnataka, Gorakhpur in Haryana's Fatehabad District, Banswada in Rajasthan, and Chutka in Madhya Pradesh.[63]

After liability legislation started to deter foreign reactor vendors, early in 2102 the government said it wanted to see coal production increase by 150 Mt/yr (from 440 Mt/yr) to support 60 GWe new coal-fired capacity to be built by 2015. This would involve Rs 56 billion new investment in rail infrastructure.



Source www.nuclearpowersustainability.com

The Nuclear Power Corporation of India Ltd (NPCIL) is responsible for design, construction, commissioning and operation of thermal nuclear power plants. At the start of 2010 it said it had enough cash on hand for 10,000 MWe of new plant. Its funding model is 70% equity and 30% debt financing. However, it is aiming to involve other public sector and private corporations in future nuclear power expansion, notably National Thermal Power Corporation (NTPC) – see subsection below. NTPC is very

[63] Available at http://powermin.nic.in/whats_new/national_electricity_policy.htm, Access on April 18, 2014

much larger than NPCIL and sees itself as the main power producer. NTPC is largely government-owned. The 1962 Atomic Energy Act prohibits private control of nuclear power generation, though it allows minority investment. As of late 2010 the government had no intention of changing this to allow greater private equity in nuclear plants.

India's operating nuclear power reactors:

Reactor	State	Type	MWe net, each	Commercial operation	Safeguards status
Tarapur 1&2	Maharashtra	BWR	150	1969	Item-specific
Kaiga 1&2	Karnataka	PHWR	202	1999-2000	
Kaiga 3&4	Karnataka	PHWR	202	2007, (due 2012)	
Kakrapar 1&2	Gujarat	PHWR	202	1993-95	December 2010 under new agreement
Madras 1&2 (MAPS)	Tamil Nadu	PHWR	202	1984-86	
Narora 1&2	Uttar Pradesh	PHWR	202	1991-92	In 2014 under new agreement
Rajasthan 1	Rajasthan	PHWR	90	1973	Item-specific
Rajasthan 2	Rajasthan	PHWR	187	1981	Item-specific
Rajasthan 3&4	Rajasthan	PHWR	202	1999-2000	Early 2010 under new agreement
Rajasthan 5&6	Rajasthan	PHWR	202	Feb & April	Oct 2009 under new

Reactor	State	Type	MWe net, each	Commercial operation	Safeguards status
				2010	agreement
Tarapur 3&4	Maharashtra	PHWR	490	2006, 05	
Kudankulam 1	Tamil Nadu	PWR	917	(11/2013)	Item-specific
Total (21)			**5302 MWe**		

Source: www.nuclearpowersustainibility.com

Nuclear reactors deployed in India

The two **Tarapur**150 MWe Boiling Water Reactors (BWRs) built by GE on a turnkey contract before the advent of the Nuclear Non-Proliferation Treaty were originally 200 MWe. They were down-rated due to recurrent problems but have run well since. They have been using imported enriched uranium and are under International Atomic Energy Agency (IAEA) safeguards. However, late in 2004 Russia deferred to the Nuclear Suppliers' Group and declined to supply further uranium for them. They underwent six months refurbishment over 2005-06, and in March 2006 Russia agreed to resume fuel supply. In December 2008 a $700 million contract with Rosatom was announced for continued uranium supply to them.

The two small Canadian (Candu) PHWRs at **Rajasthan** nuclear power plant started up in 1972 & 1980, and are also under safeguards. Rajasthan 1 was down-rated early in its life and has operated very little since 2002 due to ongoing problems and has been shut down since 2004 as the government considers its future. Rajasthan 2 was restarted in September 2009 after major refurbishment, and running on imported uranium at full rated power.[64]

[64] World Energy Outlook 2009, International Energy Agency, France.

The **220 MWe PHWRs**(202 MWe net) were indigenously designed and constructed by NPCIL, based on a Canadian design. The only accident to an Indian nuclear plant was due to a turbine hall fire in 1993 at Narora, which resulted in a 17-houı total station blackout. There was no core damage or radiological impact and it was rated 3 on the INES scale – a 'serious incident'.

The **Madras**(MAPS) reactors were refurbished in 2002-03 and 2004-05 and their capacity restored to 220 MWe gross (from 170). Much of the core of each reactor was replaced, and the lifespans extended to 2033/36.

Kakrapar unit 1 was fully refurbished and upgraded in 2009-10, after 16 years operation, as was **Narora** 2, with cooling channel (calandria tube) replacement.

Following the Fukushima accident in March 2011, four NPCIL taskforces evaluated the situation in India and in an interim report in July made recommendations for safety improvements of the Tarapur BWRs and each PHWR type. The report of a high-level committee appointed by the Atomic Energy Regulatory Board (AERB) was submitted at the end of August 2011, saying that the Tarapur and Madras plants needed some supplementary provisions to cope with major disasters. The two Tarapur BWRs have already been upgraded to ensure continuous cooling of the reactor during prolonged station blackouts and to provide nitrogen injection to containment structures, but further work is recommended. Madras needs enhanced flood defences in case of tsunamis higher than that in 2004. The prototype fast breeder reactor (PFR) under construction next door at Kalpakkam has defences which are already sufficiently high, following some flooding of the site in 2004.

The **Tarapur** 3&4 reactors of 540 MWe gross (490 MWe net) were developed indigenously from the 220 MWe (gross) model PHWR and were built by NPCIL. The first – Tarapur 4 – was connected to the grid in June 2005 and started commercial operation in September. Tarapur 4's criticality came five years after pouring first concrete and seven months ahead of schedule. Its twin – unit 3 – was about a year behind it and was connected to the grid in June 2006 with commercial operation in August, five months ahead of schedule. Tarapur 3 & 4 cost about $1200/kW, and are competitive with imported coal.

Future indigenous PHWR reactors will be 700 MWe gross (640 MWe net). The first four are being built at **Kakrapar and Rajasthan**. They are due on line by 2017 after 60 months construction from first concrete to criticality. Cost is quoted at about Rs 12,000 crore (120 billion rupees) each, or $1700/kW. Up to 40% of the fuel they use will be slightly enriched uranium (SEU) – about 1.1% U-235, to achieve higher fuel burn-up – about 21,000 MWd/t instead of one third of this. Initially this fuel will be imported as SEU.

Kudankulam 1&2: Russia's Atomstroyexport is supplying the country's first large nuclear power plant, comprising two VVER-1000 (V-412) reactors, under a Russian-financed US$ 3 billion contract. A long-term credit facility covers about half the cost of the plant. The AES-92 units at Kudankulam in Tamil Nadu state have been built by NPCIL and also commissioned and operated by NPCIL under IAEA safeguards. The turbines are made by Leningrad Metal Works. Unlike other Atomstroyexport projects such as in Iran, there have been only about 80 Russian supervisory staff on the job. Construction started in March 2002.

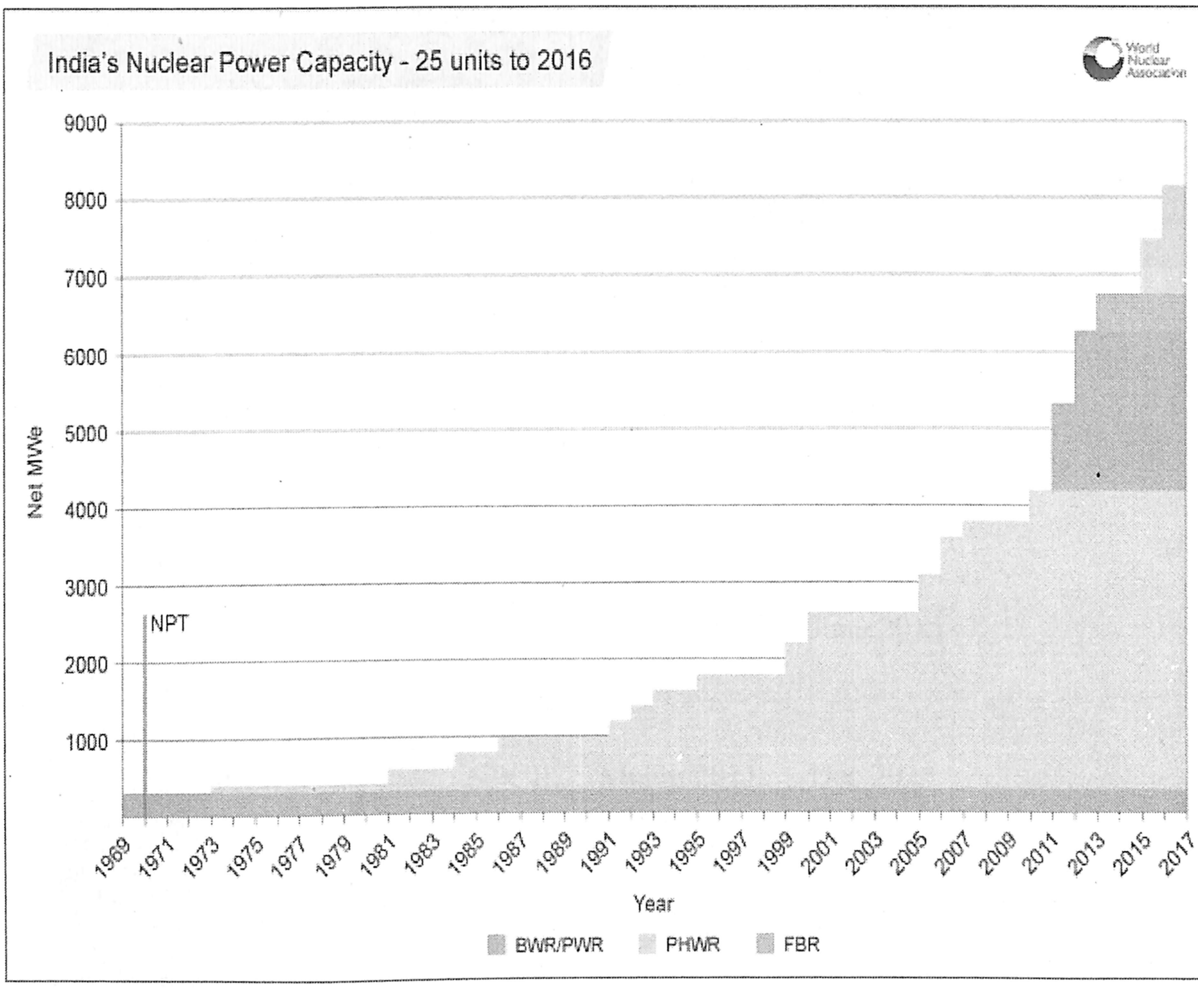
Russia is supplying all the enriched fuel through the life of the plant, though India will reprocess it and keep the plutonium. The first unit was due to start supplying power in March 2008 and go into commercial operation late in 2008, but this schedule has slipped by five years. In the latter part of 2011 and into 2012 completion and fuel loading was delayed by public protests, but in March 2012 the state government approved the plant's commissioning and said it would deal with any obstruction. Fuel loading was in September, and unit 1 started up in mid-July 2013, with unit 2 expected to do so early in 2014. Unit 1 was connected to the grid in October 2013 and is expected in commercial operation at full power early in 2014, with unit 2 following in October 2014. Each is 917 MWe net.

The original agreement in 1988 specified return of used fuel to Russia, but a 1998 supplemental agreement allowed India to retain and reprocess it.

While the first core load of fuel was delivered early in 2008 there have been delays in supply of some equipment and documentation. Control system documentation was delivered late, and when reviewed by NPCIL it showed up the need for significant refining and even reworking some aspects. The design basis flood level is 5.44m, and the turbine hall floor is 8.1m above mean sea level. The 2004 tsunami was under 3m.

A small desalination plant is associated with the Kudankulam plant to produce 426 m^3/hr for it using four-stage multi-vacuum compression (MVC) technology. Another reverse osmosis (RO) plant is in operation to supply local township needs.

Kaiga 3 started up in February, was connected to the grid in April and went into commercial operation in May 2007. Unit 4 started up in November 2010 and was grid-connected in January 2011, but is about 30 months behind original schedule due to shortage of uranium. The Kaiga units are not under UN safeguards, so cannot use imported uranium. **Rajasthan** 5 started up in November 2009, using imported Russian fuel, and in December it was connected to the northern grid. RAPP 6 started up in January 2010 and was grid connected at the end of March. Both are now in commercial operation.



Source: nuclearpowersustainibility.com

Under plans for the India-specific safeguards to be administered by the IAEA in relation to the civil-military separation plan, eight further reactors were to be safeguarded (beyond Tarapur 1&2, Rajasthan 1&2, and Kudankulam 1&2): Rajasthan 3&4 from 2010, Rajasthan 5&6 from 2008, Kakrapar 1&2 by 2012 and Narora 1&2 by 2014.

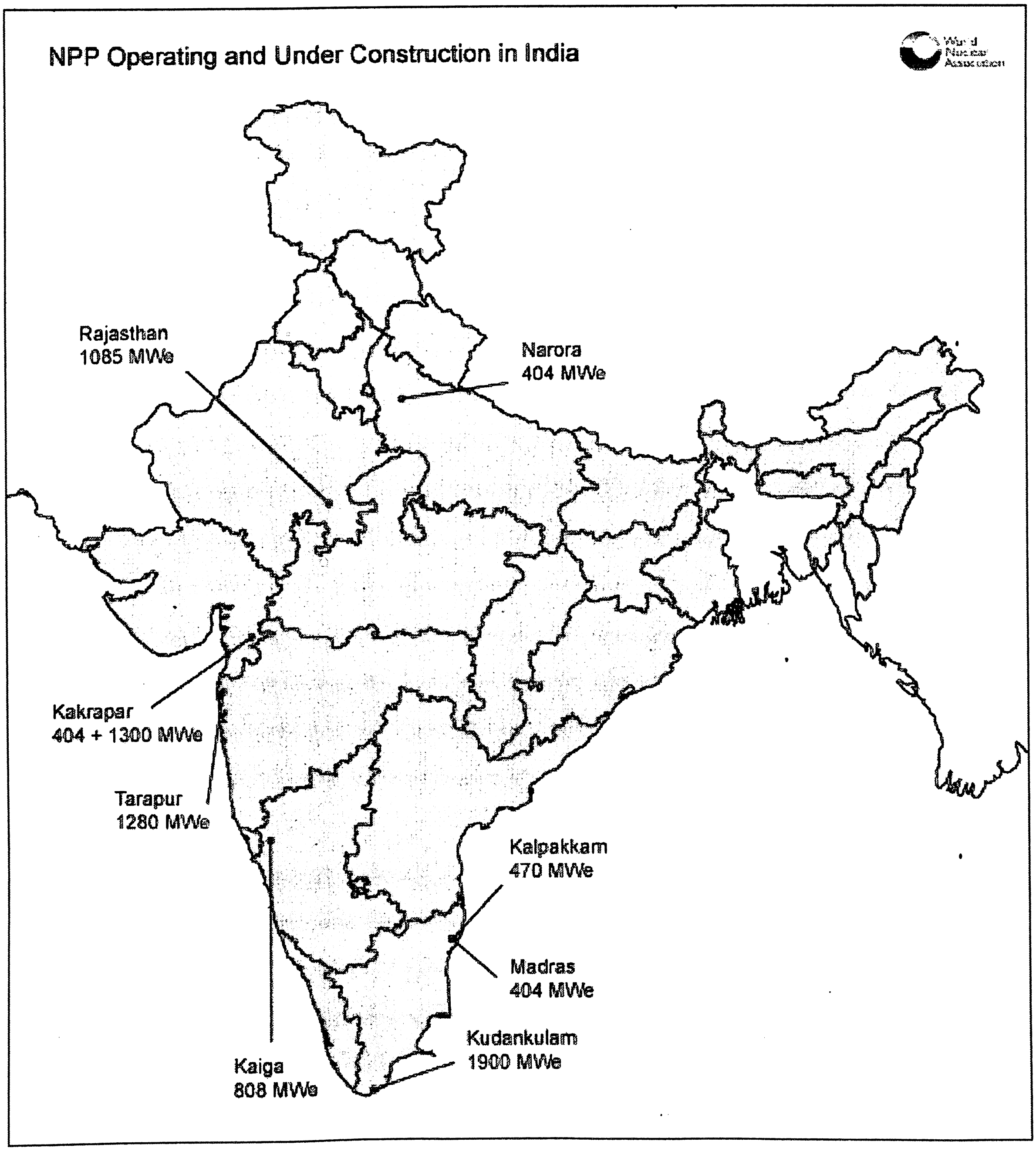
India's nuclear power reactors under construction:

Reactor	Type	MWe gross, net, each	Project control	Construction start	Commercial operation due	Safeguards status

Reactor	Type	MWe gross, net, each	Project control	Construction start	Commercial operation due	Safeguards status
Kudankulam 2	PWR (VVER)	1000, 917	NPCIL	July 2002	3/2014	item-specific
Kalpakkam PFBR	FBR	500, 470	Bhavini	Oct 2004	(9/2014 start-up) 2015	-
Kakrapar 3	PHWR	700, 630	NPCIL	Nov 2010	June 2015	
Kakrapar 4	PHWR	700, 630	NPCIL	March 2011	Dec 2015	
Rajasthan 7	PHWR	700, 630	NPCIL	July 2011	June 2016	
Rajasthan 8	PHWR	700, 630	NPCIL	Sept 2011	Dec 2016	
Total (6)		4300 MWe gross				

Rajasthan/RAPS also known as Rawatbhata

Source: www.nuclearpowersustainibility.com



Source: nuclearpowersustainibility.com

In mid-2008 Indian nuclear power plants were running at about half of capacity due to a chronic shortage of fuel. Average load factor for India's power reactors dipped below 60% over 2006-2010, reaching only 40% in 2008. Some easing after 2008 was due to the new Turamdih mill in Jharkhand state coming on line (the mine there was already operating). Political opposition has delayed new mines in Jharkhand, Meghalaya and Andhra Pradesh.[65]

A 500 MWe prototype **fast breeder reactor** (PFBR) is under construction at Kalpakkam near Madras by BHAVINI (Bharatiya Nabhikiya Vidyut Nigam Ltd), a government enterprise set up under DAE to focus on FBRs. It was expected to start up about the end of 2010 and produce power in 2011, but this schedule is delayed significantly. Construction was reported 94% complete in February 2013. Four further oxide-fuel fast reactors are envisaged but slightly redesigned by the Indira Gandhi Centre to reduce capital cost. One pair will be at Kalpakkam, two more elsewhere. (See also section below.)

Mithi Virdi in Gujarat's Bhavnagar distirct will host up to six Westinghouse AP1000 units built in three satages. NPCIL says it has initiated pre-project activities here, with groundbreaking in 2012. A preliminary environmental assessment for the whole project was completed in January 2013. State and local government and coastal zone clearances have been obtained. Westinghouse signed an agreement with NPCIL in June 2012 to launch negotiations for an early works agreement which was expected in a few months. A preliminary commercial contract between NPCIL and Westinghouse was signed in September 2013 along with an agreement to carry out a two-year preliminary safety analysis for the project. NPCIL said that it “must lay emphasis on strong public acceptance outreach and project planning." The first stage of two units is due on line in 2019-20, the others to 2024.

Kovvada in Andhra Pradesh's northern coastal Srikakulam district will host six GE Hitachi ESBWR units. GE Hitachi said in June 2012 that it expected soon to complete an early works agreement with NPCIL to set terms for obtaining approval from the Government for the project. Site preparation is under way, and a preliminary environmental assessment is being prepared. In February 2014 NPCIL said it hoped to pour first concrete by early 2015 for the first 1594 MWe reactor. Compensation for land acquisition was being organised.

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[65] Models: A to F is referred in RGGVY guidelines as advisory models in DF Implementation.

Haripur in West Bengal: to host four or six further Russian VVER-1200 units, making 4800 MWe. NPCIL says it has initiated pre-project activities here, with groundbreaking planned for 2012. However, strong local opposition led the West Bengal government to reject the proposal in August 2011, and change of site to Orissa state has been suggested.

Gorakhpur in the Fatehabad district of Haryana is a project with four indigenous 700 MWe PHWR units and the AEC had approved the state's proposal for the 2800 MWe Gorakhpur Haryana Anu Vidyut Pariyojna nuclear power plant. The inland northern state of Haryana is one of the country's most industrialized and has a demand of 8900 MWe, but currently generates less than 2000 MWe and imports 4000 MWe. The plant may be paid for by the state government or the Haryana Power Generation Corp. NPCIL has initiated pre-project activities here near the villages of Kumharia and Gorakhpur, and the official groundbreaking was in January 2014. A final environmental assessment for the project was approved in December 2013. Construction is due to begin in June 2015, with the first unit on line in 2021 after 63 months construction. Cost of the first two units is put at INR 210 or 235 billion ($3.4 or 3.8 billion).

Bargi or Chuttka in inland Madhya Pradesh is also designated for two indigenous 700 MWe PHWR units. NPCIL says it has initiated pre-project activities here, with groundbreaking planned for 2012. A preliminary environmental assessment is being prepared.

NTPC Plans

India's largest power company, National Thermal Power Corporation (NTPC) in 2007 proposed building a 2000 MWe nuclear power plant to be in operation by 2017. It would be the utility's first nuclear plant and also the first conventional nuclear plant not built by the government-owned NPCIL. This proposal became a joint venture set up in April 2010 with NPCIL holding 51%, and possibly extending to multiple projects utilising local and imported technology. One of the sites earmarked for a pair of 700 MWe PHWR units in Haryana or Madhya Pradesh may be allocated to the joint venture. NTPC said it aimed by 2014 to have demonstrated progress in "setting up nuclear power generation capacity", and that the initial "planned nuclear portfolio of 2000 MWe by 2017" may be greater. However in 2012 it indicated a downgrading of its nuclear plans. NTPC, now 89.5% government-owned, planned to increase its total installed capacity from 30 GWe in about 2007 to 50 GWe by 2012 (72% of it coal) and 75 GWe by 2017. It is also forming joint ventures in heavy engineering. NTPC is reported to be establishing a joint venture with NPCIL and BHEL to sell India's largely indigenous 220 MWe heavy water power reactor units abroad, possibly in contra deals involving uranium supply from countries such as Namibia and Mongolia

Radioactive Waste Management in India

In October 2013 BARC stressed the role of accelerator-driven subcritical molten salt reactor systems (ADS) burning minor actinides arising from partitioning of PHWR and LWR Purex output. These working in tandem would address waste issues more effectively and safely than using critical fast reactors to burn minor actinides. Pyroprocessing would treat these wastes.

Radioactive wastes from the nuclear reactors and reprocessing plants are treated and stored at each site. Waste immobilisation plants (WIP) are in operation at Tarapur and Trombay and another vitrification plant was commissioned by BARC in 2013 at Kalpakkam for wastes from reprocessing Madras (MAPS) used fuel. The WIPs use borosilicate glass, as in Europe.

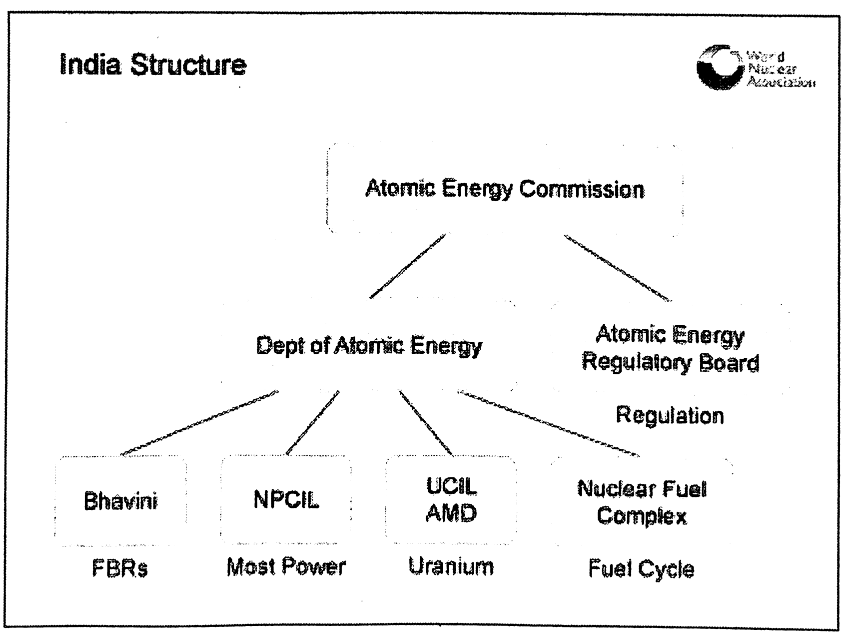
Research on final disposal of high-level and long-lived wastes in a geological repository is in progress at BARC.

Regulation and safety

The Atomic Energy Commission (AEC) was established in 1948 under the Atomic Energy Act as a policy body. Then in 1954 the Department of Atomic Energy (DAE) was set up to encompass research, technology development and commercial reactor operation. The current Atomic Energy Act is 1962, and it permits only government-owned enterprises to be involved in nuclear power.

The DAE includes NPCIL, Uranium Corporation of India Ltd (UCIL, mining and processing), Atomic Minerals Directorate for Exploration and Research (AMD, exploration), Electronics Corporation of India Ltd (reactor control and instrumentation) and BHAVINI (for setting up fast reactors). The DAE also controls the Heavy Water Board for production of heavy water and the Nuclear Fuel Complex for fuel and component manufacture.

The **Atomic Energy Regulatory Board (AERB)** was formed in 1983 and comes under the AEC but is independent of DAE. It is responsible for the regulation and licensing of all nuclear facilities, and their safety and carries authority conferred by the Atomic Energy Act for radiation safety and by the Factories Act for industrial safety in nuclear plants. However, it is not an independent statutory authority, and its 1995 report on a safety assessment of DAE's plants and facilities was reportedly shelved by the AEC. In April 2011 the government announced that it would legislate to set up a new independent and autonomous Nuclear Regulatory Authority of India that will subsume the AERB, and that previous safety assessments of Indian plants would be made public.



In August 2012 a parliamentary report from the Comptroller and Auditor General (CAG) on the AERB pointed out serious organisational flaws and numerous failings relative to international norms. The most fundamental issue highlighted by the report was the unsatisfactory legal status and authority of the AERB. Despite India's international commitments, awareness of best practice and internal expert recommendations, the report said, "the legal status of AERB continued to be that of an authority subordinate to the central government, with powers delegated to it by the latter." The CAG report emphasized the need to make the regulator independent of industry and government and insulated from commercial or political interference. The AERB had failed to prepare an overall nuclear radiation safety planning policy as required in 1983, and had failed to set up radiation safety directorates in 35 administrative areas to ensure the safe use of radiation in medical and industrial facilities, as required by a 2001 Supreme Court order. It had undertaken only 15% of the recommended level of inspections at industrial radiography and radiotherapy units, relative to IAEA norms, and had not achieved cost recovery from licensees. There was no detailed inventory of radioactive sources to help ensure safe disposal, and no "proper mechanism" to check the safe disposal of radioactive wastes.

This was largely anticipated and in September 2011 a bill to set up new stronger and more independent national nuclear regulatory authorities to oversee radiation and nuclear safety was introduced to India's lower house, the Lok Sabha. The Nuclear Safety Regulatory Authority Bill was drawn up in response to events at Fukushima and aims to establish several new regulatory bodies. A new senior **Council of Nuclear Safety (CNS)** chaired by the prime minister will oversee and review policies on radiation safety, nuclear safety and other connected matters. It will include various government ministers, with the cabinet secretary and head of the Indian Atomic Energy Commission, plus government-nominated "eminent experts". The second major body to be established is the **Nuclear Safety Regulatory Authority (NSRA)** and will be responsible for ensuring radiation safety and nuclear safety in all civilian sector activities. The NSRA will take over the functions of the existing AERB. The government expects to introduce the bill in a 2013 session of parliament. The AEC is preparing to invite the International Atomic Energy Agency's (IAEA) Integrated Regulatory Review Service (IRRS) to examine the new regulatory system, which will get statutory status after the passage of the Nuclear Safety Regulatory Authority (NSRA) Bill by Parliament. In 2012 an IAEA Operational

Safety Review Team (OSART) reviewed the Rajasthan nuclear power plant, notably units 3&4, and reported favourably.[66]

Environmental Impact of Nuclear Energy

While suspended particulate matter (SPM), CO_2, SOx, and NOx, emissions and waste disposal are dominant in the context of generating energy from fossil fuels, nuclear power is associated primarily with risks of radioactive release. Environmental impacts identifiable at various stages of the nuclear fuel cycle are: mining (accidents, release of radon gas and radioactive dust from Uranium mines and mills), radioactive seepage from waste and land degradation, processing (accidents), transport (accidents, risk of proliferation), and electricity generation (risk of catastrophic accidents, low and high level radioactive wastes).

Additionally, decommissioning of nuclear plants entails the disposal of radioactive wastes. While significant technological development has been made in the area of radioactive waste disposal and decommissioning, they are yet to be proven at large enough scale to satisfactorily resolve economic issues. However, despite these risks, global data suggests that of all the conventional energy options, nuclear energy has posed the least risks in terms of mortality per billion megawatt hours of generation.

[66] Policy Group Quarterly, *Bhiwandi Electricity Distribution Franchisee Model: A Resolute step in Distribution Reforms*, IDFC, No. 04/June 2009

Chapter 7: Conclusion

Energy systems have problems relating to the dynamic management of renewable and nonrenewable resources and also have issues of externalities. Demand for energy is increasing due to:

- Population growth.
- Increase in standard of living.

Energy problems in the urban sector.

In India's urban sector, there is a growing demand for electric power and gasoline.

Problems with power demand:

- Main source of power is coal.
- Coal plants are of low technical efficiency.
- Much of energy sector is publicly held and subsidized.

Energy efficiency is the proportion of a fuel converted to energy

- Fuel efficiency varies between fuel types; it is low in Indian coal.
- Modern plants have higher technical efficiency in converting heat to electricity.

Energy efficiency can be improved by:

- Washing coal before use.
- Using imported coal with higher energy and low ash content.
- Modernization of plants.

Other Related Issues:

• The use of low quality coal with low efficiency plants also contributes to air pollution problems and global warming- increasing gases.

• The energy supply problem is also associated with local and global environmental quality problems.

The rest of the world which will be affected by global warming gases produced by India may be ready to subsidize some of the conversion to more efficient and cleaner energy production. Economic use of alternative sources of electric power. Hydro-electric, gas, and even nuclear power should be studied.

Energy use in the urban sector of India is much below the developing world. Electricity systems have to be expanded to improve access and reliability so the quantity of electricity may expand; policy should aim at improving efficiency in energy generation and use. Improved efficiency in electricity use means improved efficiency of appliances. It can be achieved by:

• Reducing subsidies to electricity.

• Reducing taxation in electric appliances.

Electric power generation can be improved by reducing convergence losses. That may be a result of privatization and can reduce regulation. Firms will invest in developing infrastructure for energy generation as long as it is profitable.

Demand for Gasoline

Increases in the standard of living and population will lead to increase in demand for gasoline. This can be mitigated by:

• Improved public transportation.

• Reduced need for car.

• Improved energy use for vehicles.

Renewable Energy

In recent years, various policy-driven instruments characterised by ambitious targets have been used in order to enhance renewable energy uptake. But despite a multitude of renewable energy policies and financing mechanisms, actual implementation is lagging. Funds have not been delivered; projects have been commissioned but not finally deployed; penalties and enforcement of penalties are both traditionally weak. We have the following recommendations in this regard:

- Simply setting ambitious renewable energy targets without adequate implementation and firm institutional enforcement will not work. Stronger mechanisms/penalties to enforce the implementation of targets have to be developed.

- National Solar Mission and State-specific solar policies have successfully contributed to meeting or achieving a surplus of the RPO percentage for solar energy in individual states. States with a high solar potential should further develop state policies and set explicit solar targets.

- High installation costs and long gestation periods due to land acquisition and approval procedures for renewable power installations discourage financial investments. Financial instruments such as Viability Gap Funding and the Partial Risk Guarantee Fund that provide immediate support for project developers and reduce the initial costs and risk should therefore be prioritized.

- Exhaustible resources of fossil fuel and volatile market prices contribute to energy insecurity in India. Since subsidies to the energy sector in India are unlikely to abate, fossil fuel subsidy reforms are required in addition to policy transition in order to usher in energy alternatives, which are not only sustainable but also assist in improving India's fiscal balance.

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