History of Electric Power in India (1890 – 1990)

By Sandhya Madan, Swetha Manimuthu, Dr. S. Thiruvengadam.

ABSTRACT:

This paper gives an overview of the origins and development of hydroelectric and thermal power systems in India. Most of the early power generating stations, which were developed when India was a colony of the British, were hydro-electric in nature. These pre-independence generating stations fed loads in the urban areas and electrification of the villages was done mostly after 1947. The Electricity Supply Act of 1948 saw the emergence of State Electricity Boards (SEBs). The SEBs led to the rise of Regional Electricity Boards and efforts are being made to integrate the various regional grids into a single national grid. The latter half of the century saw inroads being made into other forms of energy, including nuclear and wind. These aspects have also been dealt with in the paper.

1-4244-1344-3/07/$25.00 ©2007 IEEE

ACKNOWLEDGEMENTS:

We would like to express our gratitude to Tamil Nadu Electricity Board for having let us use their library and archives. We would also like to thank our college, Sri Venkateswara College of Engineering, Chennai, India, for providing us with an opportunity to work on this paper.

1. PRE-INDEPENDANCE PERIOD:

Electricity was introduced in India by the British during the colonial period. They electrified the major cities, office centres and ports. PW Fluery & Co. used light bulbs to demonstrate electricity on the streets of Calcutta in 1879. Kilburn and Co., which later became Calcutta Electricity Supply Co., electrified Harrison Road (renamed MG Road) in Calcutta in 1889. This was the first street to have electric light bulbs in India.

The Electricity Act of India was framed in 1910. It allowed private companies to generate and supply electricity. Most of the early power stations in India were owned and operated by private companies. The first government installation was in Aruvankadu, Nilgiris. Some of the major companies were the Damodar Valley Corporation (DVC), Calcutta Electric Supply Corporation Ltd. (CESC),

Electricity was not very famous with the locals then. Advertisements in the newspapers and pamphlets on blotting papers were used to promote the use of electricity for lighting and heating purposes. The gas industry proved to be the major rival to the growth of electricity in India. The consumers of electricity apart from public utilities were mostly industries, banks, clubs and very few private residences. By the early 1900s, trams replaced horse driven carriages, ceiling fans replaced hand held punkahs(hand fans) and gas lights were becoming obsolete. This ensured the success of CESC.

Early Electricity advertisement

Electric power was introduced in India 10 years after it was introduced in London and 17 years after that in New York. It was charged at one rupee per unit, which was comparable to the price in London.

2. EARLY POWER SYSTEMS:

2.1 DARJEELING POWER STATION:

The first hydel generating station, Sidrabong Power station, was set up in Darjeeling with a capacity of 130kW. It generated power at 83.3 cycles per second. This power station was commissioned in 1896 to supply power to the Darjeeling tea plantations. The governors of the turbine were damaged due to floods in 1898 and had to be replaced. It used Gunther Impulse turbines. As demand grew, new units were added by 1905. By 1933, it had an installed capacity of 1000kW and it supplied power to West Bengal.

2.2 CALCUTTA ELECTRICITY SUPPLY COMPANY- EMAMBAGH STATION:

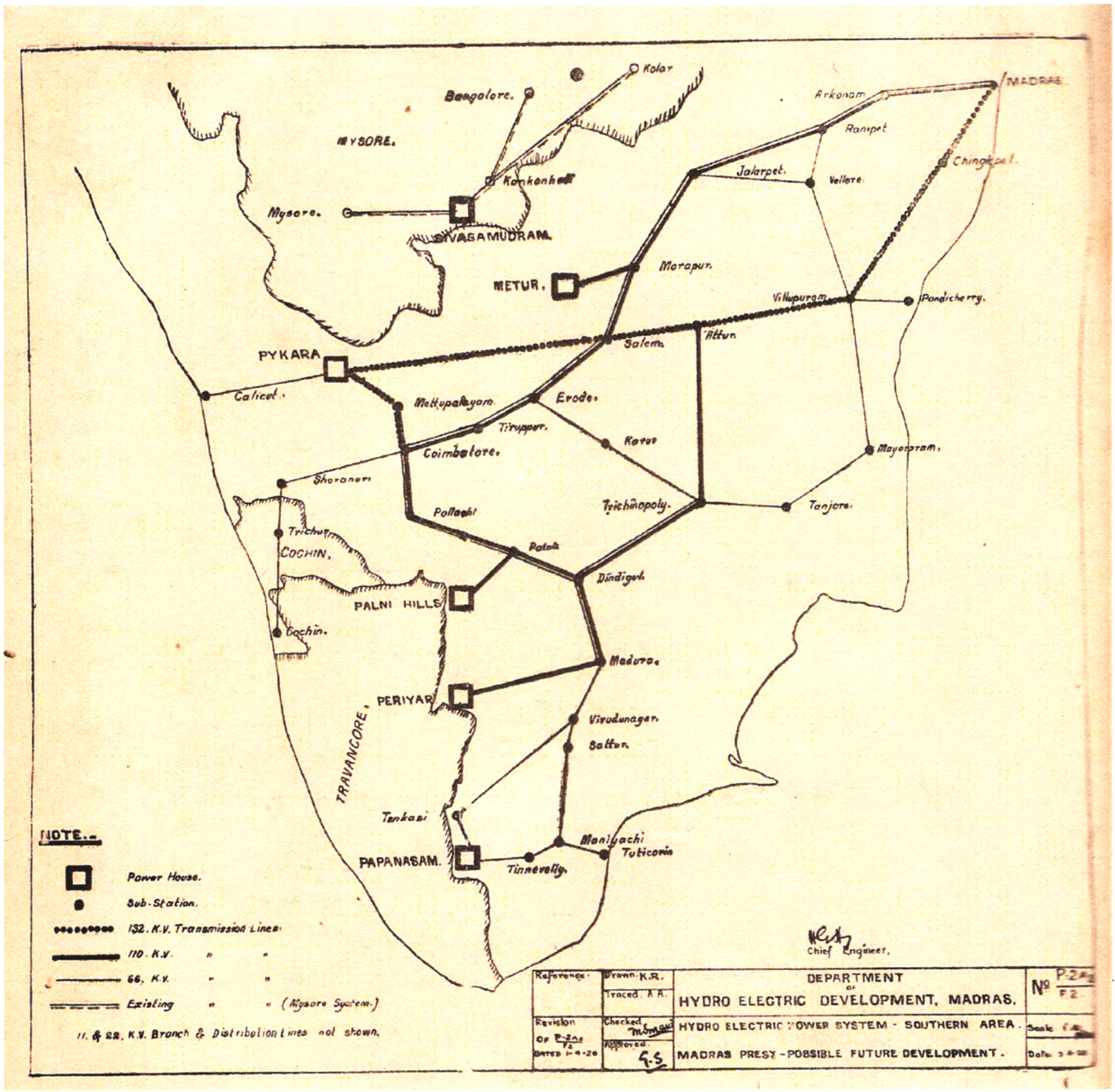
The Emambagh Power Station was the first thermal power station in India. It was commissioned by the Calcutta Electricity Supply Co. It supplied commercial loads in and around Calcutta from 1899. The boilers had a capacity of 500 hp with provision to have the capacity increased to 800 hp. The capacity of this plant was later upgraded by installations at Howrah (165kW), Alipore (700kW) and Ultadanga (1200kW). The Ultadanga station set up in 1910 had an AC installation which supplied power to the jute industry. To meet the growing demand, underground cables were laid by tunneling the Hoogly in 1929. The tunnels connected the Southern generating stations and the Botanical gardens in Calcutta.

2.3 SIVASAMUDRAM POWER STATION:

In the southern region, the major installation was the Sivasamudram Power Station. It was commissioned under the Cauvery Power Scheme (1902), by the Mysore government, mainly to supply power to the Kolar gold mines. In addition to the gold mines, it supplied power to Bangalore and the Madras Presidency. The initial capacity was 4500kW. The capacity was upgraded by later installations and by the eighth installation the capacity was around 56,000h.p. It used impulse turbines coupled to GE alternators. The power station generated power at 25Hz. It delivered power to the gold mines at 75kV and to Bangalore and Mysore at 35kV, which was later stepped up to 75kV. The transformer station had four transformer banks each with transformers of 450kVA capacity. Tirrill Regulators, installed near the Bench board, was used for the regulation of voltage. Thyrite arresters and oxide film arresters were used in the lightning arrester stations.

2.4 METTUR POWER STATION:

The power from Sivasamudram was received in the Mettur receiving station to be stepped down and converted to 50Hz before being sent to Madras. A generating plant was set up near the Mettur dam with a capacity of 33,00hp in 1925. The Mettur Generating Station supplied power to Madras, Erode and Moyar.



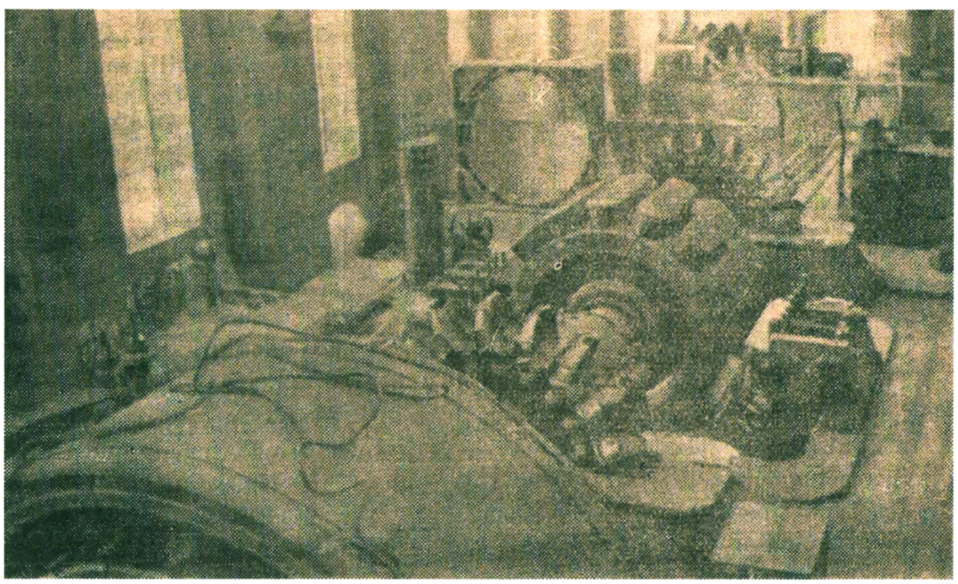
Water Power development in Southern India (1933)
(Indian Water Power Plants, Shiv Narayan)

2.5 TATA TRIO OF WATER PLANTS:

The Tata hydro-electric power supply companies harnessed the rainfall on the Bhore Ghat between Bombay and Pune for electrification of the Bombay Presidency. Tata Hydro-electric Power Supply Co., the first of these companies, utilized the monsoon precipitation collected in three lakes. It was formed in 1911 and had a capacity of 48,000 kW. The power station was located at Khopoli. Andhra Valley Power Supply Co., established in 1916, could generate up to 48,000 kW. Its power station was located in Bhivpuri.

The largest member of the trio, called the Tata Power Co., was built in Bhira in 1927 and had a generating capacity of 87,500 kW. It was also called the Nila – Mula River Project. It had head-works at Mulshi and was located away from the railway line, near the coast.

The Khopoli and Bhivpuri power plants were electrically tied both at the generating end and the receiving end. The Tata Power Co.'s generating station in Bhira was linked to the Khopoli station making the three concerns work in close co-operation sharing the load in Bombay. The power supply to Bombay from both the Bhivpuri Power Station and the Bhira Power Station was received at Dharavi Receiving Station, connected electrically to the Tata Hydro Co.'s Receiving Station at Parel in Bombay, which received electrical power from Khopoli as well. The Dharavi station had three 100 kVA transformers for stepping down the transmission voltage. There were 4 synchronous condensers with 12 poles, running at 500 rpm. Their poles were fitted with short circuit bars to enable them to run as induction motors at 7000 V. Each condenser had its own exciter. Voltage regulation was achieved by Tirrill Regulators. Protection was achieved by using static dischargers at 22 kV side and oxide-film arresters on the 100 kV side.



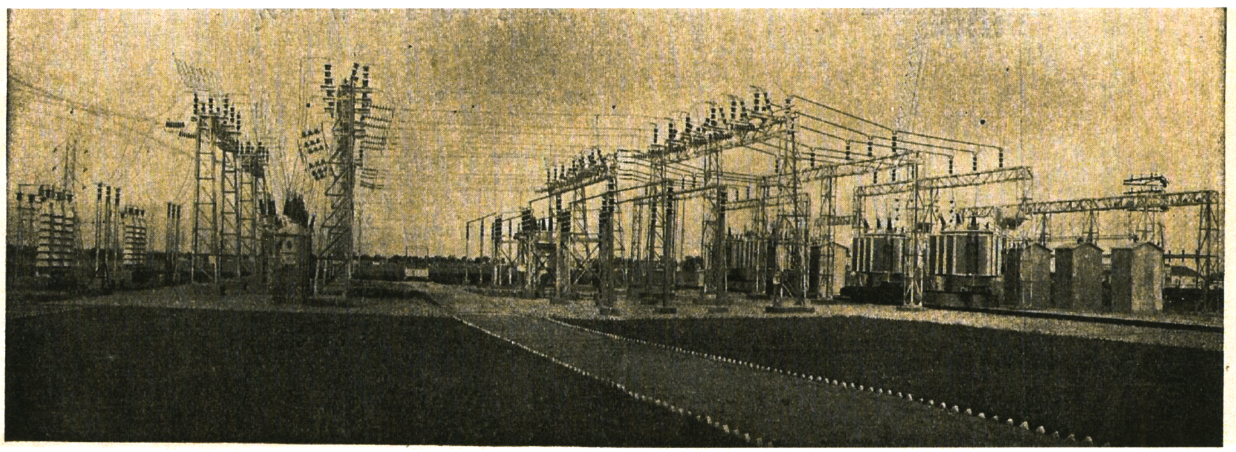
Generating Unit at Tata Power Plant, Bhira.
(Indian Water Power Plants, Shiv Narayan)

2.6 POWER STATIONS IN NORTHERN INDIA (JAMMU AND KASHMIR):

Jammu and Kashmir, the northern most state of India, had two major generating stations, the Jammu power plant and the Mohora water power plant. The Jammu Power Plant, built on the river Chenab, was commissioned for use in 1909. The Mohora Station, built on the river Jhelum, also became functional in the year 1909 and supplied power at 30000 V and 25 cycles per second through duplicate H.T. lines. The voltage could be stepped up to 60 kV if the load increased considerably. The frequency was doubled to twice the line frequency at stations supplying large lighting loads. The principal load was Srinagar.

2.7 PYKARA POWER STATION:

The Pykara power station of the Nilgiris was set up in 1933 with an installed capacity of 6.65MW. The power for the construction of the power station was obtained from the Glen – Morgan Scheme (1929) which had a capacity of 15000hp. The Pykara power station supplied power to the towns in southern India. It had three Escher Wyss Impulse turbines coupled to Metro – Vick alternators. The capacity of this power station was 6250kW at ordinary power factor. Local power requirements in Ooty and Conoor were supplied using a 250 kVA, 11000/400 V transformer. The receiving station in Coimbatore receives power from H.T. transmission lines at 22 kV. Power was dispatched to Erode and Trichy at 66 kV. The tailrace of the Pykara power station was harnessed by the Moyar Power Scheme located downstream the Pykara River.



Receiving Station, Coimbatore.
(Indian Water Power Plants, Shiv Narayan)

3. POST-INDEPENDENCE DEVELOPMENTS IN ELECTRIC POWER:

3.1 SEBs AND DEVELOPMENTS UNDER THE FIVE YEAR PLANS:

The evolution of the power sector in India began in 1948, when the Electricity Supply Act was passed. This marked the beginning of functioning of State Electricity Boards (SEBs). These SEBs were autonomous in that they could step up the generation capacity as well as transmission and distribution in their respective states. The Act also gave the Boards the autonomy for optimal utilization of resources in their states. Under this act, the Central Electricity Authority was formed for operating the generating facilities at the Central level.

The CEA was given the task of management of various electricity boards and power systems at the national level. Most states played a major role in post-independence power development. The Act also allowed the privatization of distribution and generation of electricity in the specified areas. This included the continuation of the services of The Calcutta Electric Supply Company, The Bombay Suburban Electric Supply Company, The Delhi Electric Supply Company, The Ahmedabad Electric Supply Company and many others.

In 1950, a system of Five Year plans for the economic development of the country was envisaged. This was the beginning of planned development of electric power. On 31.12.1950, the total installed capacity was only 1713MW, more that half the capacity being supplied by thermal power plants. The private sector then controlled 63% of generation while the rest was under public sector. In about 48 years the installed capacity has increased almost 52 times.

During the first Five Year Plan, Electricity Boards had been set up in the states of Andhra Pradesh, Karnataka, Tamil Nadu and Kerala in the south, Haryana, Himachal Pradesh, Jammu & Kashmir, Punjab, Rajasthan and Uttar Pradesh in the North, Gujarat, Madhya Pradesh and Maharashtra in the west and Bihar, Orissa and West Bengal in the East. West Bengal State Electricity Board had the distinction of being the first Electricity Board to be set up in 01.05.1956.

The per capita consumption in 1950 was 15KWh, about 23 times lesser than the per capita consumption in 1997-98. Moreover, before the introduction of five-year plans, the size of each generating unit was 15MW, which has increased to 500MW today...During the early 1960's, it was decided to divide the country into 5 regions, making the planning process regionally self-sufficient. The power systems would be planned in such a way that each region would perform as a single grid. These regional grids are, Southern, Northern, North-Eastern, Western and Eastern. These were set up with a view of linking the contiguous state grids into national grids.

3.2 CENTRAL SECTOR GENERATING AGENCIES:

The SEBs, although responsible for the development of power generation and distribution systems, were not able to meet the growing electricity demands, which were characterized by frequent power cuts. To improve the efficiency, central sector generating agencies were established in the mid-seventies. After the Fifth Five-Year Plan (1974-79), the Government of India was involved in supplementing the efforts of the State Government in transmission of electricity. This led to the setting up of central sector generating agencies that would help develop coal and hydroelectric resources in the country.

The Electricity Supply Act was amended in 1976 leading to the establishment of NTPC (National Thermal Power Corporation), NHPC (National Hydro-Electric Power Corporation), and NPCIL (Nuclear Power Corporation of India Limited.

These were generating utilities that were responsible for operating the facilities for transmission to client SEBs. In 1989, the National Power Transmission Corporation was set up for construction, operation and maintenance of grids between various states.

3.3 MID 1970s – EMERGENCE OF HYDROELECTRIC POWER:

By the mid 1970s, the higher grade coal resources, that have high calorific value had started dwindling and the dependence was on lower grade coal. This caused problems as components of generating units such as boilers and other coal handling plants had been designed for high grade coal resources. Due to these technical and managerial problems, in the 1970s and 80s, the utilization of coal-based power plants declined. Moreover, 200MW and 210MW coal-based generating units had been introduced, which faced initial problems. During the subsequent Five-Year Plans, the Department of Power and the CEA began a comprehensive project to modernize the old generating stations in various states so that they could function with the relatively lower grade coal resources. This period also saw the stabilization of 200 and 210 MW units. By the end of the eighth plan, the Plant Load Factor of thermal power plants had increased to 64.4% from 42% during the early seventies.

3.4 DEVELOPMENT OF HIGH VOLTAGE TRANSMISSION:

High voltage transmission facilities were developed in India even in the early stages, before independence, as hydroelectric power plants were often located away from the load centers. The first 220kV line was commissioned in 1950. This line would be used for supplying power from Bhakra power complex. ..In the 1960s, it was decided to have a transmission voltage of 400kV. Accordingly, the first 400kV line was commissioned in December 1977. By 1985, 11,000 circuit-km of 400kV lines were constructed. These lines were designed and constructed indigenously, making the country self-sufficient in the field of transmission equipment.

3.5 INDIA’S TRYST WITH NUCLEAR POWER:

The first nuclear reactor facility commissioned to be set up at Tarapur, Maharashtra in October 1964. It was to have two Boiling-Water Reactor (BWR) units with a capacity of 160MW each. It was completed in 1969. The units attained criticality in February 1969 and it began generating power for commercial use in October 1969. The Tarapur Reactor was the only facility that used BWR. This plant was constructed by L&T and Gammon India. It was built in collaboration with General Electric Co. of USA. Subsequent plants that were commissioned, till date, use the PHWR or Pressurized Heavy Water Reactor.

In the 1960s and 70s three more nuclear power plants were commissioned. They were to be constructed at Kota in Rajasthan, Kalpakkam in Tamil Nadu and

Narora in Uttar Pradesh. ..The Kota facility when commissioned in 1964, was to have one unit of 100MW. This unit attained criticality in 1972 while commercial operation started in December 1973. Construction of the second unit began in 1968, to have a capacity of 200MW. This unit began supplying power by 1981. The construction of units at Kalpakkam, near Chennai in South India, began by the early 70s. They had two units of 220MW each and were of the PHWR type. It was completed by the early 80s and by March 1986, both units were functional. The Narora power plants were completed by 1989 and also had two units of 220MW each. Around this time other projects were started at Kakrapara in Gujrat and Karwar in Karnataka.

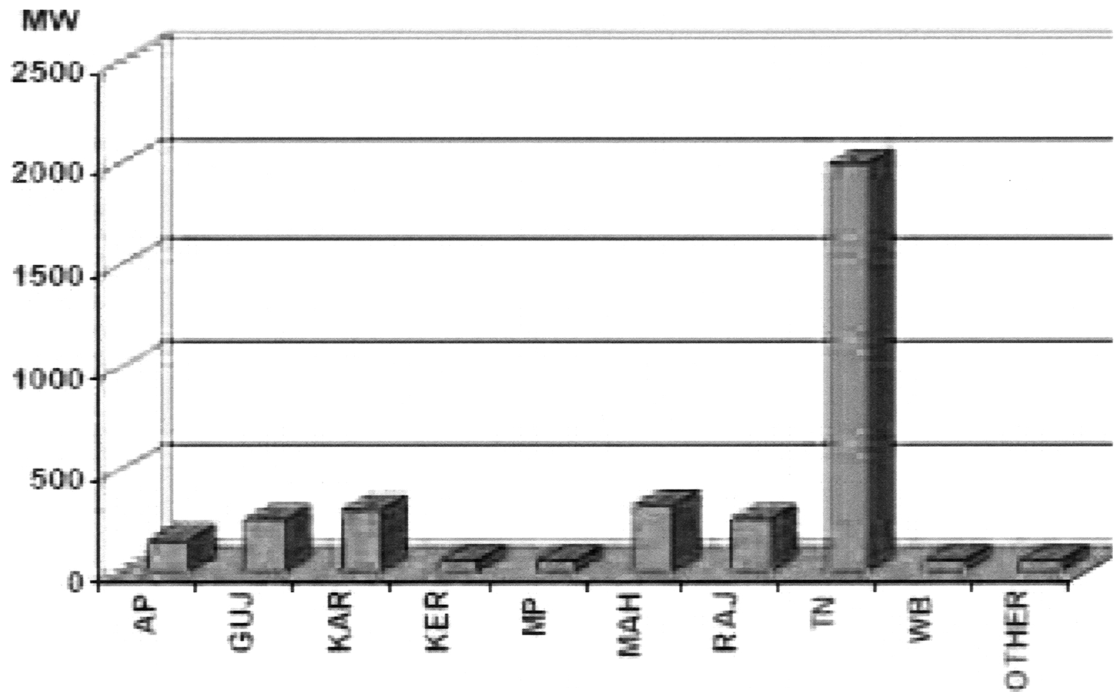
The spent uranium fuel from PHWR can be used to obtain Plutonium which is the fuel for the second stage for reactors. This process is called fuel reprocessing which involves obtaining fissile material from the used fuel. During that time, no collaborations were formed for exchange of information on fuel reprocessing and this technology was developed indigenously. Accordingly, a plant was commissioned at Trombay, near Bombay, that would have an output of 30 tonnes per annum. A second plant was set up for the same purpose at Tarapur in the early 1980s and a third plant at Kalpakkam in the mid 80s. In August 1988, it was decided to upgrade the facility at Kota, Rajasthan, by adding two more units of 220MW each. These units began operation by 2000.

All the plants in India are environmentally safe and no “nuclear accident”, as defined by the IAEA has occurred. These plants are also seismically sound. The tariffs of electricity supplied by these plants are comparable to those supplied by conventional methods.

4. WIND ENERGY IN INDIA:

Wind energy in India was first used in the 1950s mainly for agriculture and irrigation purposes as a cheaper alternative to diesel pumpsets. However, the development of wind power as a feasible alternative for generation of electricity was not given much impetus then. By the 1970s, the country was facing an energy crisis by indiscriminate development. The government looked towards renewable alternatives and the Commission for Additional Sources of Energy was set up in 1981 (CASE). This was during the sixth Five-Year Plan. Under this Plan, Water Pumping Demonstration Programme was introduced. In 1982, the Department of Non Conventional Energy Sources (DNES) was formed. During the subsequent plan, 2800 wind pumps were installed and began operation. At the state level, GEDA or Gujarat Energy Development Agency was set up to provide focus on renewable energy in the state. It was estimated that over its entire lifetime, a wind energy project would cost about Rs. 1.17 for each kWh.

In 1985, a programme for mapping wind energy at various locations in India was taken up. This would monitor wind energy at 600 locations in 25 states. The programme for development of wind energy was successful in Tamil Nadu, which led to a boom in wind energy technology in the state. The sites of the various windfarms in the state were accessible and the TNEB (Tamil Nadu Electricity Board) grid network passed through most of these sites making it easier to link the windfarms to the main grid.



Installed Capacity of Wind Energy in India (Ministry of Non-Conventional Energy Sources)

After the initial boom, however, there was a decline in usage of wind energy in the state due to lack of maintenance of wind turbines and failure of rotor blades. Moreover, there were no dedicated substations at these sites, causing poor generation and loss of revenue.

By 1990, the total installed capacity was 300MW, while the gross potential in the country is 45,000MW. Wind power projects have contributed 8.8 billion units to the various state grids. C-WET, Center for Wind Energy Technology, has been set up in Chennai, Tamil Nadu as an institution for standardization of wind equipment, testing, research and development of wind energy technology. .

5. HVDC LINES:

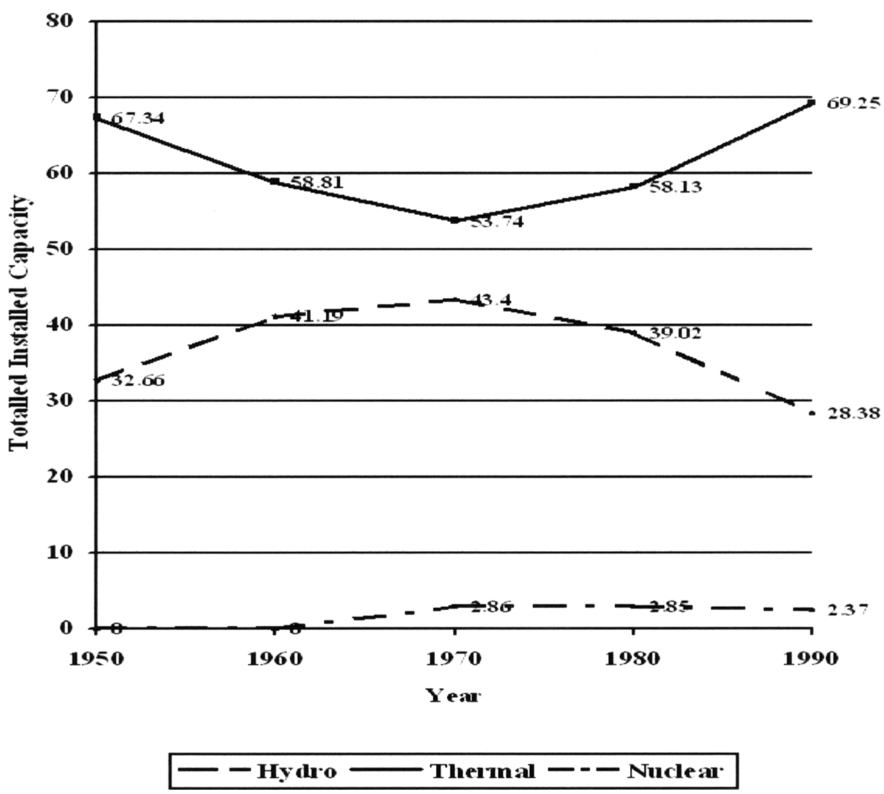
In 1989, the NPTC, National Power Transmission Corporation was set up. This is the largest transmission utility in the world. It was set up for construction and maintenance of grids between states and the five regions. This was one of the major steps taken to connect the entire country into a single regional grid. This utility was later renamed PGCIL, or POWERGRID Corporation of India Limited and also covered the distribution sector. To control the power flow between power systems, separated by large distances, HVDC lines were commissioned. Moreover, it was decided that both AC and DC lines would link various parts of the Indian grid.

The first HVDC back-to-back project was commissioned in Vindhyachal in 1989. It had a capacity of 500MW, connecting the Northern and Western grids. It was a bipolar line with an AC voltage of 400kV on both sides. The other High Voltage DC line commissioned in India was the Rihand – Delhi line. It would transmit power from Rihand to the Western part of the Northern grid. This 500kV link would supplement the 400kV AC line that supplied power to Delhi and the surrounding areas. Both the Vindhyachal and the Rihand-Delhi links were constructed by ABB.

The second longest HVDC line in India runs 1450kms from Orissa in the Eastern grid to Bangalore in the south. More specifically, it supplies power from Talcher to Kolar near Bangalore. This line was constructed by Siemens.

6. CONCLUSIONS:

The transmission loss in India was 20% in the 1980s, which also includes power theft. Efforts have been made to reduce these losses. Under the efforts taken to integrate the various regional grids, the Northern and North-Eastern grids are currently running in parallel. By the year 2011, PGCIL hopes to achieve its aim of a single national grid to reduce power deficits. India is self-sufficient in technical expertise in the field of power systems and has helped other nations like Nepal to set up their hydroelectric power plants.



Percentage contribution of power from Hydro, Thermal and Nuclear Sources from 1950 to 1990.

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