Towards Sustainable Power for Maharashtra

Electricity Blueprint

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Abbreviations and Acronyms

ABT	Availability Based Tariff
Ag DSM	Agricultural Demand Side Management
Ag LM	Agricultural Load Management
APDRP	Accelerated Power Development & Reform Program
AT&C Loss	Accelerated Technical and Commercial Loss
BAU	Business as Usual
BEE	Bureau of Energy Efficiency
BEST	Bombay Electricity and Suburban Transport
BSES	Brihanmumbai Suburban Electric Supply
BTL	Boiler Tube Leakage
CAG	Comptroller and Auditor General
CAGR	Compounded Annual Growth Rate
CEA	Central Electricity Authority
CFL	Compact Fluorescent Lamp
CHP	Combined Heat and Power Generation
CIL	Coal India Ltd
CPP	Captive Power Producers
CTU	Central Transmission Utility
DPC	Dabhol Power Company
DSM	Demand Side Management
EA 2003	Electricity Act 2003
ECBC	Energy Conservation Building Code
EHV	Extra High Voltage
ERC Act	Electricity Regulatory Commissions Act 1998
FSA	Fuel Supply Agreement
FYP	Five Year Plan
GAIL	Gas Authority of India Ltd
GCV	Gross Calorific Value
GoI	Government of India
GoM	Government of Maharashtra
HT	High Tension
HVAC	High Voltage Alternate Current
HVDC	High Voltage Direct current
IEA	International Energy Agency
IERM	Integrated Energy Resource Management

IPP	Independent Power Producers
ISGTF	India Smart Grid Task Force
JNNSM	Jawaharlal Nehru National Solar Mission
LE	Life Extension
LED	Light Emitting Diode
LM	Load Management
LNG	Liquefied Natural Gas
LoI	Letter of Intent
LT	Low Tension
MCCIA	Mahratta Chamber of Commerce Industries and Agriculture
MEDA	Maharashtra Energy Development Agency
MERC	Maharashtra Electricity Regulatory Commission
MIS	Management Information Systems
MNRE	Ministry of New and Renewable Energy
MoEF	Ministry of Environment and Forests
MoU	Memorandum of Understanding
MSEB	Maharashtra State Electricity Board
MSEDCL	Maharashtra State Electricity Distribution Company Ltd
MSETCL	Maharashtra State Electricity Transmission Company Ltd
MSGPCL	Maharashtra State Power Generation Company Ltd
Mu DSM	Municipal Demand Side Management
NGO	Non-Governmental Organization
NHPC	National Hydro Power Corporation
NPC	National Planning Commission
NPCIL	Nuclear Power Corporation of India Limited
NTPC	National Thermal Power Corporation
O&M	Operation and Maintenance
OECD	Organization for Economic Co-operation and Development
PAP	Project affected people
PFC	Power Finance Corporation
PLF	Plant Load Factor
PPA	Power Purchase Agreement
PVs	Photovoltaics
R&R	Rehabilitation and resettlement
R&M	Renovation and Modernization
REC	Rural Electrification Corporation
REL	Reliance Energy Limited

RGGVY	Rajiv Gandhi Grameen Vidyutikaran Yojana
RGPPL	Ratnagiri Gas and Power Private Limited
RLNG	Re-gasified Liquefied Natural Gas
SAWS	San Antonio Water System
SEB	State Electricity Board
SERC	State Electricity Regulatory Commission
SEZ	Special Economic Zone
SHP	Small Hydro Project
SLDC	State Load Despatch Centre
SPCC	Specific Coal Consumption
STP	Sewage Treatment plants
STU	State Transmission Utility
T&D	Transmission and Distribution
TAPS	Tarapur Atomic Power Station
TPC	Tata Power Corporation
UNFPA	United Nations Population Fund

Units

Ckt. Km.	Circuit kilometers
kCal/kg	kilo calories per kilogram
kCal/kWh	kilo calories per kilowatt hour
kg/kWh	kilogram per kilowatt hour
kW	Kilo Watt
kWh	Kilo Watt Hour
ml/kWh	mililitre per kilowatt hour
MTOE	Million tons of oil equivalent
MU	Million Units
MVA	Mega Volt Ampere
MW	Mega Watt
Rs.	Rupees

Overview

India Power Scenario

Power (energy) is one of the major inputs for economic development of a country. Increased economic activities have led to higher demand of energy resources. It is a crucial input not only for industrial development but also for socioeconomic progress.

Energy is essential for power generation, lighting, cooking, transportation, agriculture, industry, etc. This policy will mainly deal with energy use for power generation and cooking in Maharashtra. Most of the rural places do not have access to electricity and usually cook using traditional fuels. Inadequate ventilation leads to an increase in incidences of respiratory diseases among women and children. Innovative and advanced technologies need to be developed for these two fields. Monitoring mechanism needs to be introduced in order to ensure that regulatory processes are followed.

Indian Power Sector has progressed a great deal since independence. A network of institutions was set up at the state and central levels. The State Electricity Boards (SEBs) created at the state level were semi - autonomous bodies according to the law and owned by state government. They were entrusted with the responsibilities of electricity generation and its supply in the state, while remaining within the broad legal and policy frameworks designed by the state and central governments. At national level, an autonomous institution called the Central Electricity Authority (CEA) was created to provide techno-economic expertise and advice to the SEBs. The Central Electricity Authority was the supreme authority in crucial techno-economic matters such as sanctioning of new power projects as well as inter-state electricity transfer and exchanges.

The energy sector is one of the most capital-intensive sectors. In the post-independence period, because private industry was not adequately developed to raise such a huge capital, it was argued (even by the private sector) that government should take up the responsibility of developing this sector. The sector was thus developed and expanded by providing capital from the budgets of central and state governments. For many years, about one fourth to one fifth of the total plan allocation from the central and state governments' budgets was directed to the electricity sector.

The energy sector was consistently and generously funded in the Five-Year Plan budgets. By 2001, the State Electricity Boards had built an extensive network electrifying 85% of Indian villages, and increased installed capacity from minimum levels at independence – barely enough generation to provide minimal power to 20% of the population at the time – to 100,000 MW. However, in spite of this growth, investments made by the state governments have been unable to meet the energy needs of the population and the country has experienced significant capacity shortfalls an inequitable distribution of electricity. Some of the capacity constraints were due to the fact that the SEBs had consistently fallen short of the infrastructure targets in the Five year Plans. Had all the capacity targets been reached since the First Plan in 1950, total capacity addition would have been 84,000 MW in 1990, yet only 65,000 MW were installed at that time. Energy sector has gone through major transformations over the years, through unbundling of the electricity companies into separate generation, transmission and distribution companies and introduction of Acts and Policies. A brief history of the Indian Power sector is cited below.

Pre – independence

Utility scale electricity production in India began relatively early as compared to other developing countries, as it was a British colony. Most of the installed capacity was located in West Bengal and Bombay states which were under strong British influence and contained major urban and industrial areas. The first instance of generation of electricity in India dates back to 1879 in Kolkata (then Calcutta).

In 1897, the Government of Bengal granted an exclusive 21-year license to the Calcutta Electricity Supply Corporation to supply electricity to Calcutta. Mumbai (then Bombay) was the second city to get electricity and as time progressed, private companies set up power supply systems in major urban areas under franchises, which allowed them a reasonable rate of return.

The key driver for electricity growth was demand by industries, tramways, commercial enterprises and domestic use. To meet this demand coal fired and hydroelectric plants were installed. During this period, electricity undertaking was a private sector held under British holding companies that provided management as well finance. Most of the earlier private companies in the power sector cease to exist today as they were amalgamated into state-owned enterprises; however, a few of them continue to exist as private players.

Post – independence

After independence, the Indian Government created the National Planning Commission (NPC) and began its full-scale experiment of national-level economic planning with objectives of domestic self-sufficiency, rapid increase in the standard of living of Indian people, decreasing economic inequality and poverty and instituting a socialistic pattern of society. Electricity was viewed as a crucial instrument for social development and a rigid control by the government was considered essential for meeting the objectives. Private companies providing electricity was considered unacceptable, as they would focus on areas with greatest demand – cities and urban areas – and neglect rural areas due to meager return on their investments. This was considered inequitable so the government aimed its policies to provide cheap electricity to villages and rural areas, which would help increase electricity access and demand for irrigation and village-based small scale industries.

By the 1970s public owned sector dominated in the first two decades. In the earlier decades, the state sector was the principal; however the central sector soon began to play an important role. New centrally owned public sector corporations were established *viz.* National Thermal Power Corporation (NTPC) established in 1975, National Hydro Power Corporation (NHPC) in 1975 and Nuclear Power Corporation of India Limited (NPCIL) in 1987] to increase the capacity, aimed at supplementing generation activities of the State Electricity Boards (SEBs) and existing public sector companies.

The energy scene of the early 1970s was marked by power shortages and frequent power plant breakdowns. Hydroelectric plants were suffering from low generation, as water resources depended heavily on erratic monsoons. In the early 1970s, growth in generation from hydroelectricity reduced significantly because of poor monsoons, with only a 4% increase during the Fourth Plan (1969-1974). Other reasons, in addition to monsoons, included long construction times, delays in civil works, delays in delivery of power plant equipment, higher-than-expected capital costs and inadequate addition of transmission and distribution infrastructure. Further growth of hydroelectricity was stalled due to resistance from local groups against construction of large hydroelectric projects as they led to large-scale displacement and biodiversity losses.

Generation of electricity from nuclear sources had just begun with the commissioning of the Tarapur Atomic Power Station near Bombay in the year 1969. However, this nascent development was superseded by the international sanctions imposed on India because of its 1974 nuclear weapons test. The oil shocks of 1973 and 1978 marginalized the use of oil for power generation. The 1970s energy crisis was mostly due to failure of hydroelectricity and coal shortages, unlike some of the OECD countries. Nonetheless the oil crisis made the use of indigenous coal and hydroelectricity relatively cheaper and forced the government to emphasize coal usage in many energy-intensive sectors including electricity generation.

The SEBs established as autonomous commercial entities started facing several difficulties. The major problem was political interference which began to destroy financial viability of SEBs. They were not free to distribute power on a commercial basis and politicians keen to exploit the rural voting blocks, gave farmers practically free electricity for the irrigation pump sets. In the name of alleviating poverty and improving food security, flat rate tariffs based on electricity connections rather than metered consumption became the norm in rural areas of many states. This resulted in the increase in the share of agricultural electricity consumption. Thus there was inequality in the tariff rates and domestic consumers in most of the states also had lower tariffs than the actual cost of supply. To make up these losses, the SEBs set higher tariffs for industrial and commercial consumers. This led to the industries generating captive power on their premises and opting out of the grid. The share of industrial consumption in the overall electricity consumption reduced, further declining the SEBs financial situation.

In the financial crisis of 1991 a new power policy was passed in October which officially opened the power sector to private investors, the first time ever since independence. The Electricity (Supply) Act, 1948 was amended to allow private companies own power plants and generate electricity as Independent Power Producers (IPPs). The IPPs were offered lucrative incentives and by about mid-1995, about 189 projects with a total capacity of 75 GW were proposed. But most of these projects were based on expensive liquefied natural gas, natural gas or naptha rather than using the inexpensive poor quality Indian coal.

Another major breakthrough was the Electricity Act 2003 which created a new paradigm for the development of power sector in the country as it abolished the monopoly of the State Electricity Boards created through the Electricity (Supply) Act, 1948. The Act intends to separate generation from transmission and distribution, with the hope that generation will be subject to market competition. Industry could setup captive generation anywhere and has open access to the existing electricity transmission infrastructure, as long as it pays wheeling charges. Thus it created a new competitive framework for the development of the power sector in the country with focus on the consumers and safeguarding of their interests by independent Regulatory Commissions.

Today, India is a major energy producer as well as consumer. It ranks as the world's 7th largest energy producer accounting for about 2.49% of the world's total annual energy production. It is also the world's fifth largest energy consumer, accounting for about 3.45% of the world's total annual energy consumption in 2004. India experiences an electricity deficit of 9.2% and a peak shortage of 11%[1]; 23.97% of electricity was lost in transmission and distribution (T&D) while aggregate technical and commercial (AT&C) losses were 26.15%[2]. Above all, over 499 million are estimated to have no access to electricity (IEA 2007). As on July 2011, 13.22 crore out of 19.16 crore (70%) households have access to electricity. 320 million are estimated to have no access to electricity[3]. The 11th FYP calls for 80 GW of new electric power to be built between 2007 and 2012 a figure which includes 14 GW from renewable energy (CEA 2008).

Historical Background of Legislative Initiatives[4]

The central and state governments in India have carried out many legislative and regulatory reforms since mid-1990s which involve establishment of independent electricity regulatory commissions and increased participation of private sector in generation and distribution of electricity. As a consequence of these reforms in the electric power sector and in the overall economy, productivity of electricity use has increased since 1991. Despite these reforms, and the large generation capacity, electricity shortages are endemic throughout the country.

Pre Economic Reform Phase (before 1991)

Pre independence era (up to 1947)

In the pre-independence era, electricity was decentralized. It was generated and supplied locally by private entrepreneurs, enterprising municipalities and provincial governments. The hydroelectric project of Tata in Khandala supplied power to Mumbai (then Bombay), and

[1] Government of India, Ministry of Power, Central Electricity Authority, Highlights of Power sector, August 2012
[2] Government of India, Ministry of Power, Central Electricity Authority, Highlights of Power sector, August 2012
[3] Government of India, Planning Commission, Report of the Working Group on Power for Twelfth Plan (2012-2017)
[4] Economic and Political Weekly – Special Articles: S L Rao: The Political Economy of Power; Vol. - XXXVII No. 33, August 17, 2002

Mettur dam on Cauvery River supplied power to the Madras Presidency. But the emphasis was on supply to large urban concentrations, and there was little coordination or cooperation between the different suppliers. The first legislation was passed in 1877, which provided for protection of person and property from injury and risks, attendant to the supply and use of electricity for lighting and other purposes. This was repealed and replaced by the **Indian Electricity Act 1903**, a tentative measure to be amended with experience. The legislation of 1887 and 1903 that provided for private power and minimal regulation, evolved into a more comprehensive **Indian Electricity Act, 1910** which regulated generation, supply and use of electricity and dealt with licensing, regulation and safety, giving considerable authority to the provincial governments.

Salient Features of the Indian Electricity Act, 1910

- Provided basic framework for electric supply industry in India.
- Growth of the sector through licensees.
- Licenses allotted by State Government for supply of electricity in a specified area.
- Legal framework for laying down of wires and other works.
- Provisions laying down relationship between licensee and consumer.

[5]

Post-independence era (1947-1990)

At the time of independence, electricity generation and supply was concentrated in the hands of private electricity suppliers and largely in urban areas. It was necessary to promote overall growth and development across the country. Hence, the **Electricity (Supply) Act, 1948**, that was based on the broad lines of the Electricity (Supply) Act, 1926 in force in the United Kingdom, was introduced. It was enacted "*to facilitate the establishment of regional coordination in the development of electricity transcending the geographical limits of local bodies*". It provided "*for the rationalization of the production and supply of electricity and generally for taking measures conducive to the electrical development of the Provinces of India*". It enabled the creation of state electricity boards for promoting the coordinated development of generation, supply and distribution in the Provinces and in other areas of the country. It enabled the creation of state electricity boards for promoting the coordinated development of generation, supply and distribution in the Provinces and in other areas of the country. It was amended subsequently and significant additions and changes were introduced. Central Electric Authority (CEA) was established to develop a national power policy and coordinate electricity planning over the country at the central level.

[5] http://www.powermin.nic.in/indian_electricity_scenario/pdf/Historical%20Back%20Ground.pdf

Salient features of the Electricity (Supply) Act, 1948

- Mandated creation of SEBs.
- Need for the State to step in (through SEBs) to extend electrification (so far limited to cities) across the countrv.

The Industrial Policy Resolution of 1956 reserved generation and distribution of electricity exclusively for states. The existing private licensees were however allowed to continue. This led to the gradual domination of electricity sector by government enterprises. Regional Electricity Boards were formed in 1964 to promote regional coordination and operation of power supply.

In 1976, amendments were made which enabled state and central governments to set up generation companies, which resulted in establishment of NTPC, NHPC, North Eastern Electric Power Corporation Ltd. (NEEPCO), Mysore (now Karnataka) Power Corporation, and consulting firm WAPCOS. Joint sector projects between states and central government were also made possible, with Damodar Valley Corporation (DVC), Neyveli Lignite Corporation Ltd. (NLC), etc.

Main amendments to the Indian Electricity Supply Act

- Amendment in 1975 to enable generation in Central sector.
- Amendment to bring in commercial viability in the functioning of SEBs – Section 59 amended to make the earning of a minimum return of 3% on fixed assets a statutory requirement (*w.e.f* 1.4.1985).
- Amendment in 1991 to open generation to private sector and establishment of RLDCs.
- Amendment in 1998 to provide for private sector participation in transmission, and also provision relating to Transmission Utilities.

Post Economic Reform Phase (after 1991)

Till 1991, the power sector was mainly under the government ownership under various state and central government owned utilities. However the Indian Power sector had reached a dead end by the 1980s. The total losses of the SEBs without subsidy had crossed Rs. 3000 crore. The sector was facing peak shortages in various parts of the country and severe financial burden was imposed on the state governments because of the performance of the SEBs[6].

By amendments in 1991, generation was opened to private investment, including foreign investment. Legislation governing the electricity sector was amended in October 1991 allowing private investor to generate power and sell it to the grid. The policy permitted 100 percent foreign-owned companies to set up power project, without any export obligations. Attractive returns were provided in the policy. Since the policy was based on negotiations leading to tariff

[6] Government of India, Planning Commission, Power and Energy Division, Annual Report on the working of State Power Utilities and Electricity Departments, 2011-12

finalization, the initial projects led to high tariffs. Besides, the poor financial position of the SEBs which are the monopoly purchasers of power, led the central and state governments to offer many artificial comforts to the new investors. Regional Load Dispatch Centers were also established at the same time to operate the power system in a region, ensure regional grid security and to integrate with power systems of other regions and areas. Tariffs in cases of interregional movements and transmission charges were to be determined by the central government on the advice of the CEA.

Further amendments in 1998 opened transmission to private investment, subject to the approval of Central Transmission Utility (CTU).

It was realized that in spite of giving a free hand to foreign investors through the 1991 amendment, not many generation projects could come up, and that unless the sector was restructured & unbundled, investment would not be made in this sector.

The Electricity Regulatory Commissions Act, 1998, enabled the creation of electricity regulatory commissions at the centre and the states. The MERC was established in 1999 under this Act. Such commissions had already been set up in Orissa and Haryana in 1996 and 1998 respectively under state legislations. The primary functions of CERC is to regulate the tariffs of Central Public Sector Undertakings generating companies, tariffs of power generated and supplied inter-state, interstate tariffs for transmission services, regulation of inter-state transmission and issue of licenses to private investors in interstate transmission. The SERCs determine tariffs to be charged to customers, the tariffs and functioning of intrastate transmission including the operation of the SLDC. The enactment of the ERC Act, 1998 was only a partial step towards reforms.

The Electricity Regulatory Commission (ERC) Act, 1998

- Provision for setting up of Central / State Electricity Regulatory Commission with powers to determine tariffs.
- Constitution of SERC optional for States.
- Distancing of Government from tariff determination.

Other than this, three major steps were taken by the government to improve the performance of the power sector. The first was initiation of Accelerated Power Development Program (APDP) in 2000-01 which focused on giving a composite loan/grant to for improving the infrastructure of electric utilities. The name of the scheme was changed to Accelerated Power Development & Reform Program (APDRP) in 2003-03 and the funding was made extremely liberal.

The second step was establishment of Expert Committee for making recommendations for one-time settlement of outstanding dues of all SEBs towards central public sector undertakings and for suggesting a strategy for capital restructuring of the SEBs. The committee recommended that 50% of the surcharge/interest on delayed payments be waived. The rest of the dues along with full principal amount aggregating to about Rs. 33,600 crores be secured through bonds issued by the respective state governments.

The third initiative taken was to sign Memorandum of Understanding (MOU) with State governments in order to accelerate the process of reforms. The state governments were encouraged to set up their own electricity regulatory commissions, undertake 100 percent metering, conduct energy audits at 11 KV level, impose minimum agricultural tariff, pay subsidies on time, etc. In return, the Central government promised to increase the share of the State concerned from central generating stations, upgrade the inter-state transmission lines through APDRP funding, extend help for the State's rural electrification program and provide other financial benefits. By 2005, the Central Government had signed MOUs with all of India's 28 states[7].

Salient features of the Electricity Act, 2003

- No license is required for Generation and captive generation has been freely permitted. Hydro projects exceeding the capital cost notified by Central Government however, need concurrence of the Central Electricity Authority.
- No license required for generation and distribution in notified rural areas.
- Transmission Utility at the Central as well as State level, to be a Government company – with responsibility for planned and coordinated development of transmission network. Provision for private licensees in transmission.
- Trading, a distinct activity recognized with the safeguard of the Regulatory Commissions being authorized to fix ceilings on trading margins, if necessary.
- Open access in distribution with provision for surcharge for taking care of current level of cross subsidy with the surcharge being gradually phased out.
- Distribution licensees would be free to undertake generation and trading.
- The State Governments are required to re-organize the SEBs. However, they may continue the SEB as State Transmission Utilities and licensees for such time the State and Central Government agree.
- Setting up of the State Electricity Regulatory Commission made mandatory.
- An Appellate Tribunal to hear appeals against the decision of the CERC and SERCs.
- Metering of all electricity supplied made mandatory.
- Provisions relating to theft of electricity made more stringent.
- For rural and remote areas standalone systems for generation and distribution permitted.
- Thrust to complete rural electrification and provide for management of rural distribution by Panchayats, cooperative societies, non-government organizations, franchises, etc.

[7] Government of India, Planning Commission, Power and Energy Division, Annual Report on the working of State Power Utilities and Electricity Departments, 2011-12

The Electricity Act 2003 repealed all the existing electricity laws, such as, the Indian Electricity Act 1910, the Electricity Supply Act 1948, etc. but saved various reform acts of some of the states which were already in operation. This Act made it mandatory for all SEBs to unbundle into separate generation, transmission and distribution entities, so as to make them vertically more efficient than vertically integrated utilities. There are several other sections in the Act which talk about open access, quality of supply, standards of performance, etc.

Reforms have played a crucial role in each segment of the power sector. In the generation segment, de-licensing of thermal and captive power generation and generation in rural areas has allowed private players to invest in power generation. The government made distribution a separate segment to improve the segment's performance.

After the establishment of regulatory commissions, several regulations have been passed; the most important ones being Availability–Based Tariff Order (2002), Terms and Conditions of Tariff (2004), Multi-Year Tariff (MYT) Norms (2004), Electricity Grid Code (2006), and Open Access in Inter-State Transmission (2008).

Availability–Based Tariff Order - Generator and beneficiary set up PPAs on the basis of which generators feed power to the grid and beneficiary draws the power. If buyer overdraws power it has to pay Unscheduled Interchange (UI) charges and if generator overfeeds to the grid it will have to pay UI charges. It has improved the quality of power supply dramatically, brought the much-needed commercial discipline among the generators and utilities, and laid the foundation of a power market. The ABT regime also encourage inter-state trading and merit order dispatch[8]

Terms and conditions of tariff – These were Introduced in 2004. Norms were laid down to determine tariff for generation, transmission and distribution.

Multi-Year Tariff was introduced to reduce regulatory risk and incentivize efficient performance of utility. It was set up for a fix number of years called control period. In this period fixed charges remain unchanged while energy charges change.

In 2006 the ***Electricity Grid Codes*** laid down technical rules covering all the utilities connected through grid or using inter-state transmission system. These codes ensure efficient functioning of power system. CERC is the regulatory body that monitors these codes at the central level while SERC monitors it at state level.

National Electricity Policy (NEP)[9] - Under the provisions of section 3(1) of the Electricity Act, 2003, the Central Government is required to prepare the National Electricity Policy for development of power system based on optimal utilization of resources. The Policy was

[8] International Journal of Regulation and Governance, Khosla Sunil K, Plummer Judith: How price reform revolutionized the operational discipline of India's power sector, 2005

[9] Government of India, Ministry of Power, National Electricity Policy, February 2005

prepared in consultation with States, Central Electricity Authority and other stakeholders. It aims at accelerated development of power sector, providing supply of electricity to all areas and protecting interests of consumers and other stakeholders keeping in view availability of energy resources, technology available to exploit these resources, economics of generation using different resources, and energy security issues.

Objectives of NEP

- Access to Electricity
- Available for all households in next five years.
- Availability of Power Demand to be fully met by 2012. Energy and peaking shortages to be overcome and spinning reserve to be available.
- Supply of Reliable and Quality Power of specified standards in an efficient manner and at reasonable rates.
- Per capita availability of electricity to be increased to over 1000 units by 2012.
- Minimum lifeline consumption of 1 unit/household/day as a merit good by year 2012.
- Financial Turnaround and Commercial Viability of Electricity Sector.
- Protection of consumer interests.

National Tariff Policy

Objectives of NTP

- Ensure availability of electricity to consumers at reasonable and competitive rates;
- Ensure financial viability of the sector and attract investments;
- Promote transparency, consistency and predictability in regulatory approaches across jurisdictions and minimize perceptions of regulatory risks;
- Promote competition, efficiency in operations and improvement in quality of supply.

Installed Capacity in India

The current installed capacity as on **August 31, 2012** was **2,07,006 MW**, of which 39,291 MW was from hydropower; 1,37,936 MW from thermal power generation, 4780 MW from nuclear and 24,998 MW from renewable sources[10]. Other than this captive generating capacity of 34,444 MW was also connected to the grid[11]. As can be seen from the graph, the Indian Power sector is dominated by coal, which is a domestically abundant resource.

Thermal capacity comprises coal (117,833 MW – 85.4%), gas (18,903 MW – 13.7%) and (1120 MW – less than 1%) diesel based capacity. Of the various sources of power generation, coal based installed capacity dominates with 66.6% of the total installed capacity.

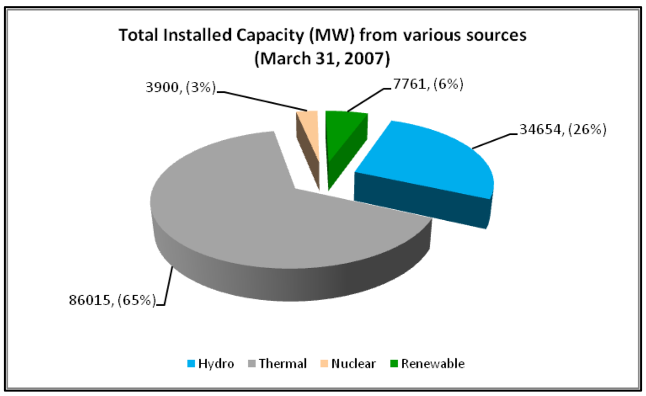


Figure 1 –Installed Capacity (MW) in India (March 31, 2007)

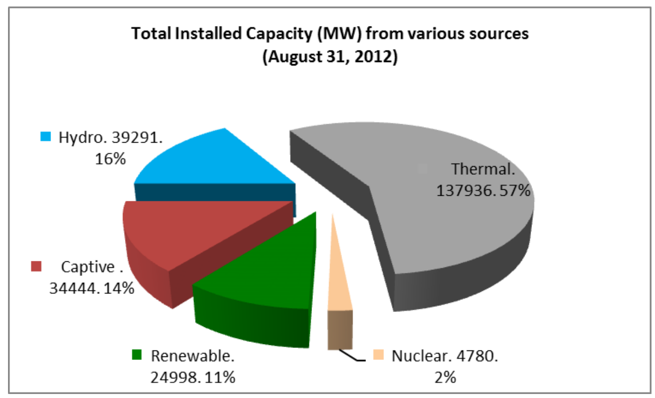


Figure 2 –Installed Capacity (MW) in India (August 31, 2011)

Capacity addition in the 10th Plan

The cumulative capacity at the end of the **10th plan** was **1,32,329 MW** which included 34,654 MW from hydro; 86,015 MW from thermal (coal, lignite, gas, oil & diesel); 3,900 MW from nuclear power plants and 6,191 MW from renewable energy sources (small hydro projects, biomass gas, biomass power, urban and industrial waste power & wind energy)[12]. This capacity comprises central, state and private sectors. Coal based power plants dominate electricity generation as use of coal offers a number of advantages *viz.* it is often the most economical fuel, especially when compared with natural gas or oil; coal used for power generation is often produced domestically, which enhances energy security; and coal conversion technologies are well-established with a long manufacturing and operational history.

[10] Government of India, Ministry of Power, Central Electricity Authority, Monthly Reports, August 2012
[11] Government of India, Ministry of Power, Central Electricity Authority, Monthly Review of Power Sector Reports
[12] Government of India, Planning Commission, Report of the Working Group on Power for Eleventh Plan (2007-2012), February 2007: Table 1.4

Capacity addition of 21,080 MW was achieved during the 10th Plan. Capacity expansion had fallen short of targets; both in the 9th and 10th Five-year plans the capacity additions were just about half the targets. The capacity addition targeted and achieved in the 10th is tabulated below[13].

Table 1 – Installed Capacity Addition during the 10th Plan

Type/ Sector	Target				Achievement			
	Central	State	Private	Total	Central	State	Private	Total
Thermal	12790	6676	5951	25417	6590	3554	1971	12114
Hydro	7842	5381	1170	14393	4495	2691	700	7886
Nuclear	1300	0	0	1300	1080	0	0	1080
Total	21932	12057	7121	41110	12165	6245	2671	21080

The Central sector was leading the charge of capacity addition accounting for 54% of new capacity addition, followed by state sector (29%) and private sector (17%). None of the sectors achieved the set target. Of the target set, Central sector achieved 55%, state sector 52% while private sector achieved 38%.

Taking into consideration the target set for capacity addition based on source of power generation, hydro power comprised 35%; thermal power 62% and the target set for nuclear power was 3%.

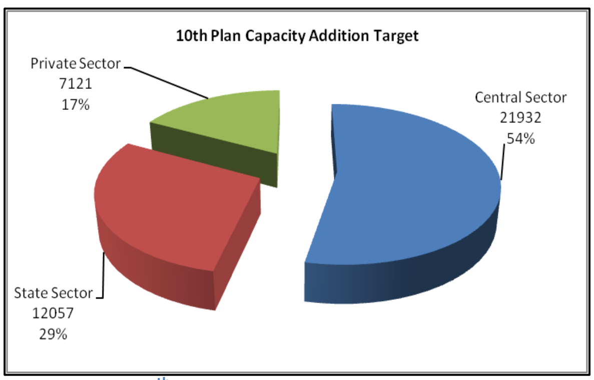


Figure 3 – 10th Plan Capacity addition target for various sectors

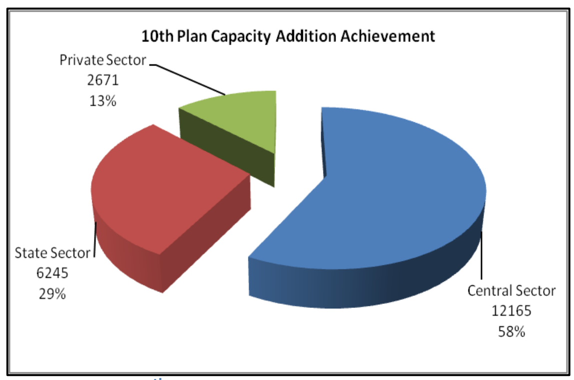


Figure 4 – 10th Plan Capacity addition achievement by various sectors

[13] http://planningcommission.nic.in/plans/planrel/fiveyr/11th/11_v3/11v3_ch10.pdf

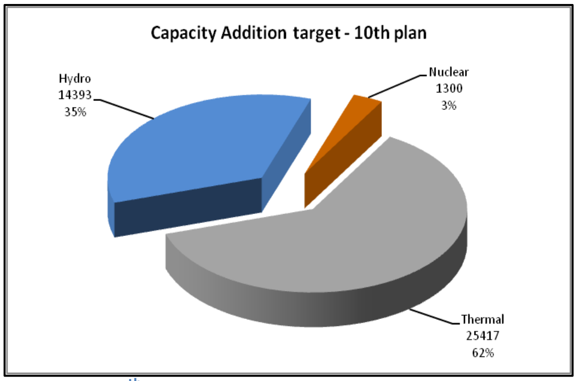


Figure 5 – 10th Plan Capacity Addition Target (Source wise)

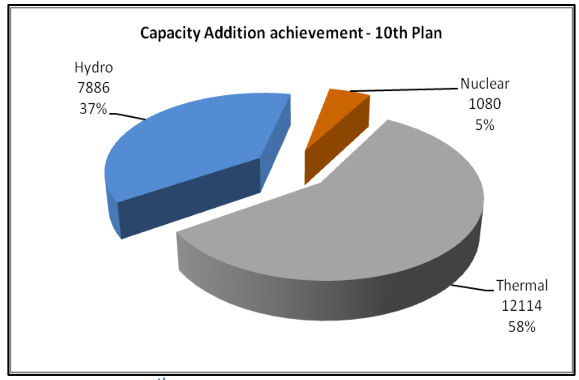


Figure 6 - 10th Plan Capacity Addition Achievement (Source wise)

Capacity Addition Target in 11th Plan

The government has set a target of **78,700 MW** capacity addition during **11th 5-year plan**. It is unlikely that this target can be reached in the 11th Five-year plan (2007 -12)[14].

Table 2- 11th Plan capacity addition target - Sector wise (MW)

Type/ Sector	Central	State	Private	Total
Thermal	24840	23301	11552	**59693**
Hydro	8654	3482	3491	**15627**
Nuclear	3380	0	0	**3380**
Total	**36874**	**26783**	**15043**	**78700**

The central sector in the 11th plan too will be leading the charge in capacity additions with accounting for as much as 47%, followed by state sector (34%) and the private sector (19%), though the target set for central sector was reduced by 7% and that of state and private sectors were increased by 5% and 2% respectively in comparison to the 10th plan.

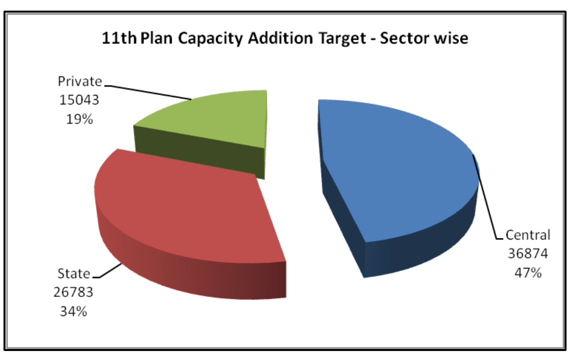


Figure 7 – 11th Plan Capacity Addition Target: Sector wise

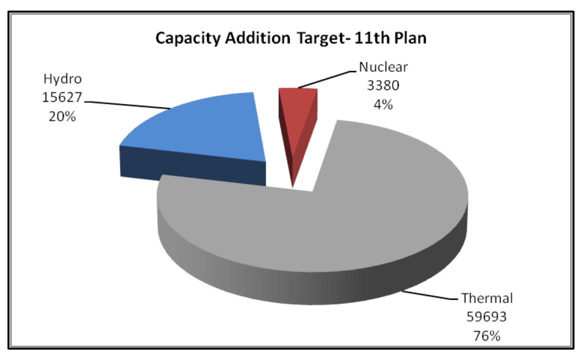


Figure 8 – 11th Plan Capacity Addition Target: Source wise

[14] Government of India, Planning Commission, Report of the Working Group on Power for Eleventh Plan (2007-2012), February 2007

The target set for thermal power capacity addition is 76% whereas for hydro and nuclear it is 20% and 4% respectively. A capacity addition of 34,462 MW has been achieved during the first four years of the 11th Plan. Year wise details of the targeted and actual capacity addition during 11th Plan up to 31.03.2011 is given below. Actual achievement during the 11th Five Year Plan has been 54,963 MW[15] as against the targeted 78700 MW.

Table 3 - All India target and actual capacity addition during 11th plan upto 31.3.2011 (MW)

Year	Type		Target	Achievement
2007-08	Hydro		2,372	2,423
	Thermal		9,007	6,620
		Coal	7,880	5,620
		Lignite	0	0
		Gas	1,127	1,000
	Nuclear		660	220
	Total		12,039	9,263
2008-09	Hydro		1,097	969
	Thermal		5,773	2,485
		Coal	3,820	2,010
		Lignite	200	0
		Gas	1,753	475
	Nuclear		660	0
	Total		7,530	3,454
2009-10	Hydro		845	39
	Thermal		13,002	9,106
		Coal	9,105	6,655
		Lignite	1375	335
		Gas	2,522	2,116
	Nuclear		660	440
	Total		14,507	9,585
2010-11	Hydro		1,346	690
	Thermal		17,793	11,251
		Coal	14,000	9,725
		Lignite	1,185	635
		Gas	2,608	891
	Nuclear		1,220	220
	Total		20,359	12161
Grand Total (Up to 31st March 2011)				34,462

[15] Government of India, Planning Commission, Power and Energy Division, Annual Report on the working of State Power Utilities and Electricity Departments, 2011-12; Government of India, Ministry of Power, Central Electricity Authority, Operational Performance of Generating Stations, 2011-12

Growth of India's Installed Capacity since 6th Plan Period

Growth of installed capacity since the 6th plan is graphically presented in the below. The average growth in installed capacity of thermal and nuclear power since 6th plan was 35%, for hydropower it was 22% and 1372% for renewable energy.

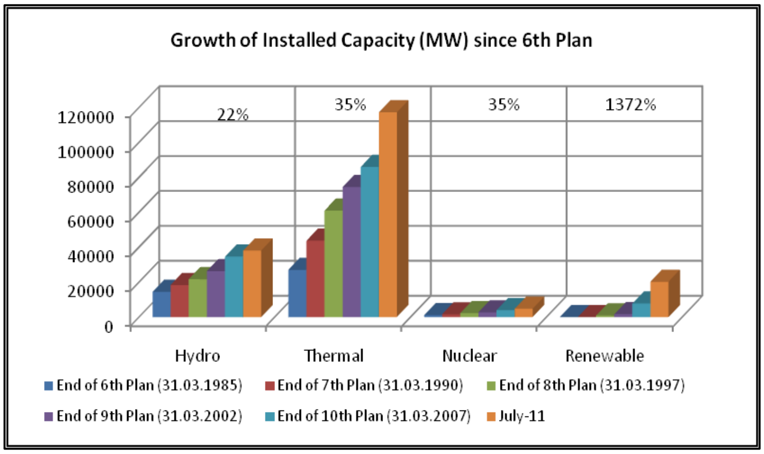


Figure 9: Growth of Installed Capacity (MW) from 6th Plan till July 2011

Thermal power comprises of coal, gas and diesel based capacity which showed average growth of 31%, 127% and 73% respectively from the end of 6th plan till July 2011. Large increase in growth in gas based installed capacity was registered in the 7th and 8th plan periods. From the end of the 10th plan till July 2011, coal based installed capacity registered 38% growth while gas based capacity showed 29% growth.

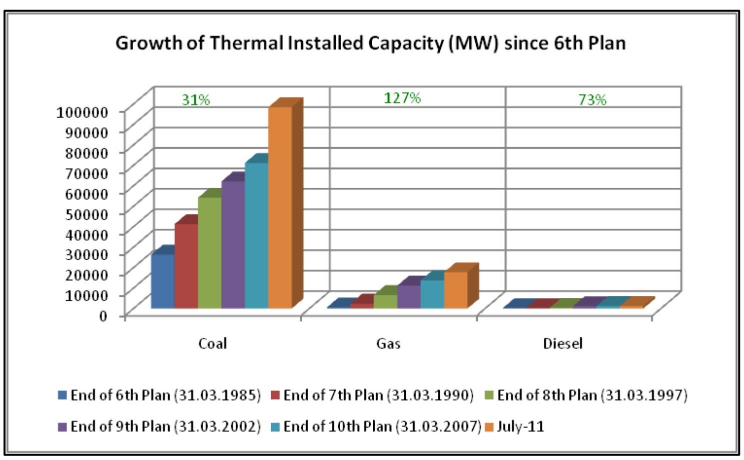


Figure 10 – Growth of Thermal Installed Capacity since 6th Plan

India Power Supply Position

The table below depicts energy requirement from 2007-08 to 2010-11[16]. Over the years, power requirement is increasing. Though power shortfalls have reduced, the gap between demand and supply is yet to be bridged. Demand always outstrips availability.

Table 4 - Power supply position (2007-08 to 2010-11)

Year	Peak (MW)				Energy (MU)			
	Peak Demand (MW)	Peak Met (MW)	Peak Deficit/ Surplus (MW)	Peak Deficit/ Surplus (%)	Energy Require-ment (MU)	Energy Avail-ability (MU)	Energy Deficit/ Surplus (MU)	Energy Deficit/ Surplus (%)
2007-08	108866	90793	-18073	-16.6	739343	666007	-73336	-9.9
2008-09	109809	96785	-13024	-11.9	777039	691038	-86001	-11.1
2009-10	119,166	104,009	-15,157	-12.7	830,594	746,644	-83,950	-10.1
2010-11	125,077	112,167	-12,910	-10.3	862,125	789,013	-73,112	-8.5

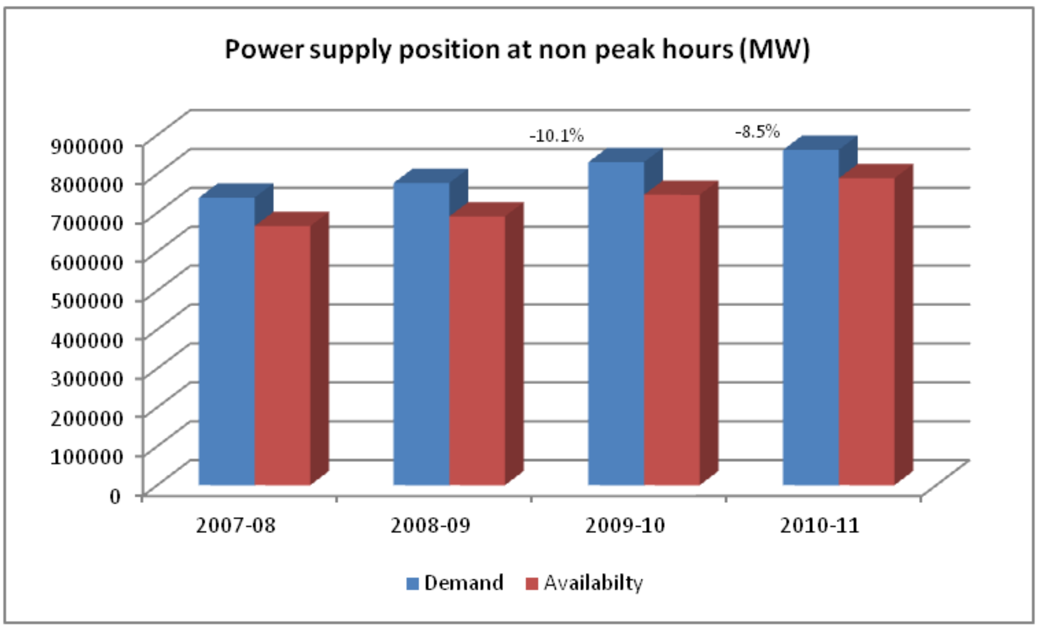


Figure 11 – Power supply position (2007-08 to 2010-11)

[16] Government of India, Planning Commission, Report of the Working Group on Power for Eleventh Plan (2007-2012)

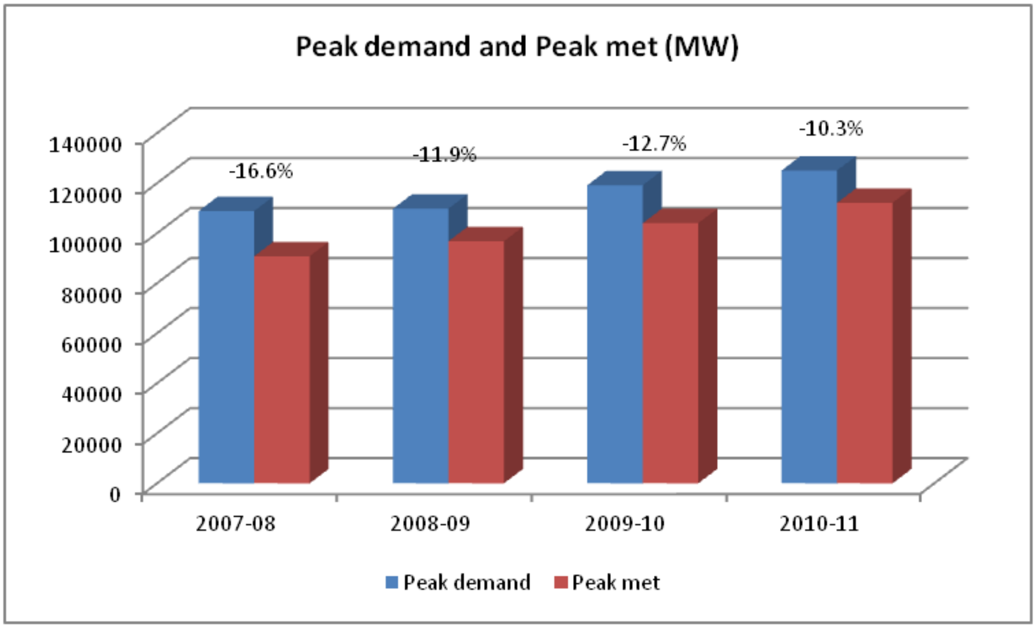


Figure 12- Peak demand and peak met (2007-08 to 2010-11)

The tables below provide information on the power requirement and availability for India from April to August 2012. In this time period there was shortage of 8.5% (35,409 MU). In August 2012 there was a power shortage of 9.1%[17]. Power shortages hamper economic development of the country.

Table 5-Power supply position -India (August 2012)

August 2012				April to August 2012			
Requirement (MU)	Availability (MU)	Surplus/deficit		Requirement (MU)	Availability (MU)	Surplus/deficit	
		MU	%			MU	%
82815	75306	-7509	-9.1	418431	383022	-35409	-8.5

Peak demand and Peak met

Table 3 indicates peak demand for the period between April and August 2012. Demand was highest in June 2012 (135,453 MU) resulting in 12,159 MU of power shortfall, a 9% deficit.

Table 6-Peak demand and peak met (August 2012)

August 2012				April to August 2012			
Requirement (MU)	Availability (MU)	Surplus/deficit		Requirement (MU)	Availability (MU)	Surplus/deficit	
		MU	%			MU	%
128250	115822	-12368	-9.6	135453	123294	-12159	-9.0

[17] Government of India, Ministry of Power, Central Electricity Authority, Monthly Reports, August 2012

Maharashtra Power Scenario

Maharashtra is the second largest state in India both in terms of population and geographical area (3.08 lakh sq. km.). Total population of the state is 11.2 crore (precisely 11,23,72,972 Census 2011) with 45.2% people residing in urban areas and 54.8% in rural areas. The population density is 365 per sq.km[18].

Maharashtra state was created in 1960. In the subsequent years, Maharashtra State Electricity Board (MSEB) made significant progress as compared to the other SEBs. This was achieved in spite of not including the industrial mega-city like Mumbai in MSEBs service area. The annual turnover of MSEB in 2000-01 amounted to Rs. 12,500 crores, which was highest among all SEBs, and equivalent to the annual budget of some medium-sized states in India.

Electricity supply grid of Maharashtra is a part of the Western region electricity grid in the country and shares electricity with the neighboring Gujarat, Madhya Pradesh, Chhattisgarh, Goa, Daman & Diu and Dadra Nagar Haveli.

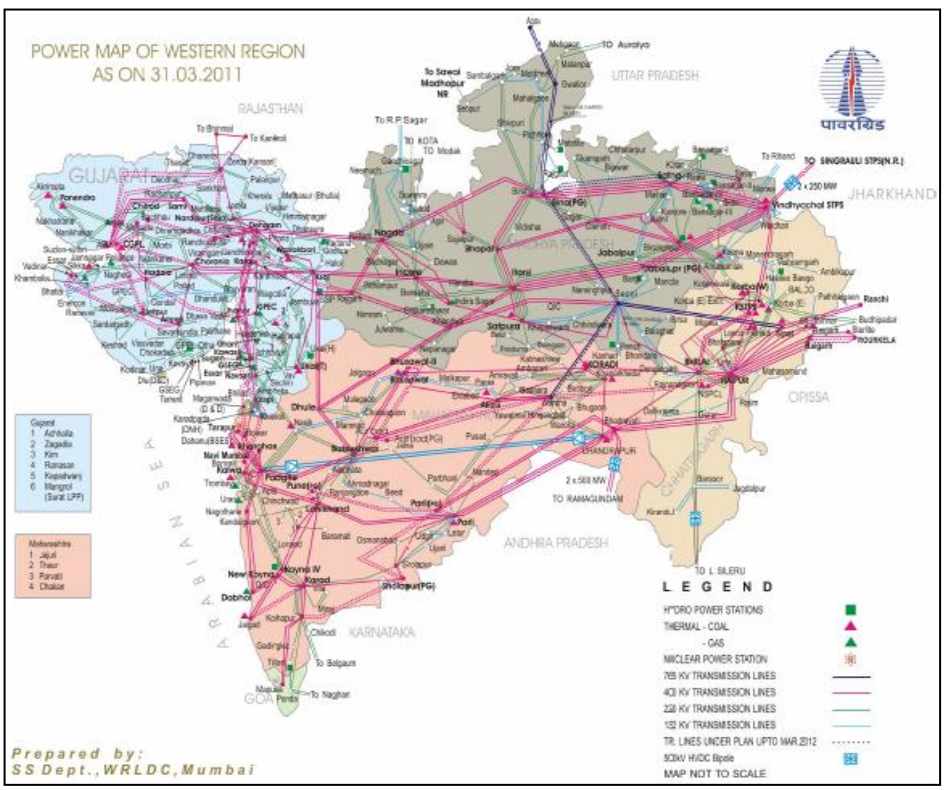


Figure 13 - Western grid: Maharashtra, Gujarat, Madhya Pradesh, Chhattisgarh, Goa, Daman & Diu Dadra Nagar Haveli[19]

[18] Government of Maharashtra, Department of Planning, Directorate of Economics and Statistics: Economic Survey of Maharashtra 2011-12, Ch.9 Infrastructure; Government of India, Ministry of Home Affairs, Census of India, 2011

[19] Government of India, Power System Operation Corporation Ltd, Western Region Load Despatch Centre, Annual Report 2010-11

Maharashtra State Electricity Board (MSEB) is a state-owned electricity utility established in June 20, 1960 with generation, transmission and distribution functions, operating within the state of Maharashtra. MSEB is the largest and only state-owned electricity provider in Maharashtra with around 186 lakh consumers. According to provisions of the Electricity Act 2003, the state government restructured MSEB and formed separate companies for generation, transmission and distribution. GoM unbundled MSEB into four companies' w.e.f. 6th June 2006 into *MSEB Holding Company Ltd, Maharashtra State Power Generation Company Ltd (MSPGCL), Maharashtra State Electricity Transmission Company Ltd (MSETCL)* and *Maharashtra State Electricity Distribution Company Ltd (MSEDCL).* The holding company is chaired by the State Energy Minister. The state established Maharashtra Electricity Regulatory Commission (MERC) in 1999 under the Central Electricity Regulatory Act 1998.

M.S.E.B. Holding Co .Ltd – This Company produces, distributes, and transmits electricity through its subsidiaries MSPGCL, MSETCL and MSEDCL.

Maharashtra State Power Generation Company Ltd (MSPGCL) –The main functions of MSPGCL, also known as "MahaGenCo" is to establish, operate and maintain generating stations, tie-lines, substations and dedicated transmission lines and supply electricity to licensees and consumers. The total installed capacity of MahaGenCo is 9996 MW, which includes thermal, gas and hydropower generating stations.

Maharashtra State Electricity Transmission Company Ltd (MSETCL) – The main function is to develop the intra state transmission system as well as ensure safety and stability of the grid.

MSETCL has 559 EHV substations with transformation capacity of 89,178 MVA and transmission circuit of 39,871 circuit km.

Table 7- Transmission system network of MSETCL (as on 31.3.2012)[20]

Voltage level	EHV Substations	Transformation Capacity (MVA)	EHV Lines (ckt. km)
500 kV HVDC	2	3582	1504
400 kV	22	18180	7405
220 kV	171	39383	13209
132 kV	260	21633	12073
110 kV	34	2674	1724
100 kV	36	2587	686
66 kV	34	1139	3270
Total	**559**	**89178**	**39871**

[20] http://www.mahatransco.in/

Maharashtra State Electricity Distribution Company Ltd (MSEDCL) – It is one of the largest public sector company engaged in power distribution and serves 193 lakh consumers in Maharashtra State, excluding the city of Mumbai.

Table 8 - Total No. of Consumers of MSEDCL[21]

Category of consumers	No. of consumers (in Lakh)
Domestic	143.00
Commercial	13.79
Industrial	3.63
Agriculture	31.7
Others	10.00
Total	202.12

Maharashtra's power system is bifurcated into that of Mumbai "served Tata Power Companies (TPC) and Reliance Energy Limited (REL - erstwhile BSES Ltd.) and Bombay Electricity and Suburban Transport (BEST), a state government undertaking" and the rest of the state served by MSEDCL.

The operations of Tata Power and Reliance include power generation, transmission and distribution, while BEST is a distribution utility with no generation of its own and receives electricity from Tata Power.

Tata Power has 1200 circuit km transmission network and a 935 km HT and LT cable distribution network connecting 17 major receiving stations and over 85 sub-stations in its Mumbai License area[22].

Mula Pravara Electric Cooperative Society (MPECS) was the only rural electric cooperative distribution utility in the state established in 1969. It served nearly 183 villages spread over five talukas in Ahmednagar district catering to 1.45 lakh customers. It also had its own network to supply electricity to the consumers in its area of operation. It was awarded a 20 year license in 1971, which was renewed in 1991 up to 2011. According to MSEDCL, MPECS since 1977 had defaulted in payment of regular bills to erstwhile MSEB, and it continued with its habit. The accumulated arrears of MPECS had amounted to Rs. 2316 crore in March 2012[23]. After the Maharashtra Electricity Regulatory Commission's order dated January 27, 2011, MSEDCL has started distribution of electricity in the area which was previously within the territorial jurisdiction of Mula Pravara Electricity Cooperative Society from February 1, 2011.

[21] http://www.mahadiscom.in/aboutus/mahadiscom-Company_profile.pdf
http://www.mahadiscom.in/aboutus/abt-us-01.shtm
[22] http://www.tatapower.com/services/transmission.aspx
[23] Reply to RTI from MSEDCL

Installed Capacity

The total installed capacity in Maharashtra from the power generating stations of the state, Centre and private sectors is 26,838 MW. This includes 11,956 MW of MSPGCL (State) and 8600 MW of private sector (Tata, Reliance, JSW, Wardha Power Company Ltd as well as Renewable Energy projects incentivized by Ministry of New and Renewable Energy) and 6282 MW from Central sector[24]. Of the total power installed capacity of the central power generating stations, Maharashtra gets a share of 4282 MW *i.e.* 68% from the central power generating stations located in the state is allocated for use in Maharashtra (As of August 31, 2012)[25]. Coal power plants dominate the power sector in the state.

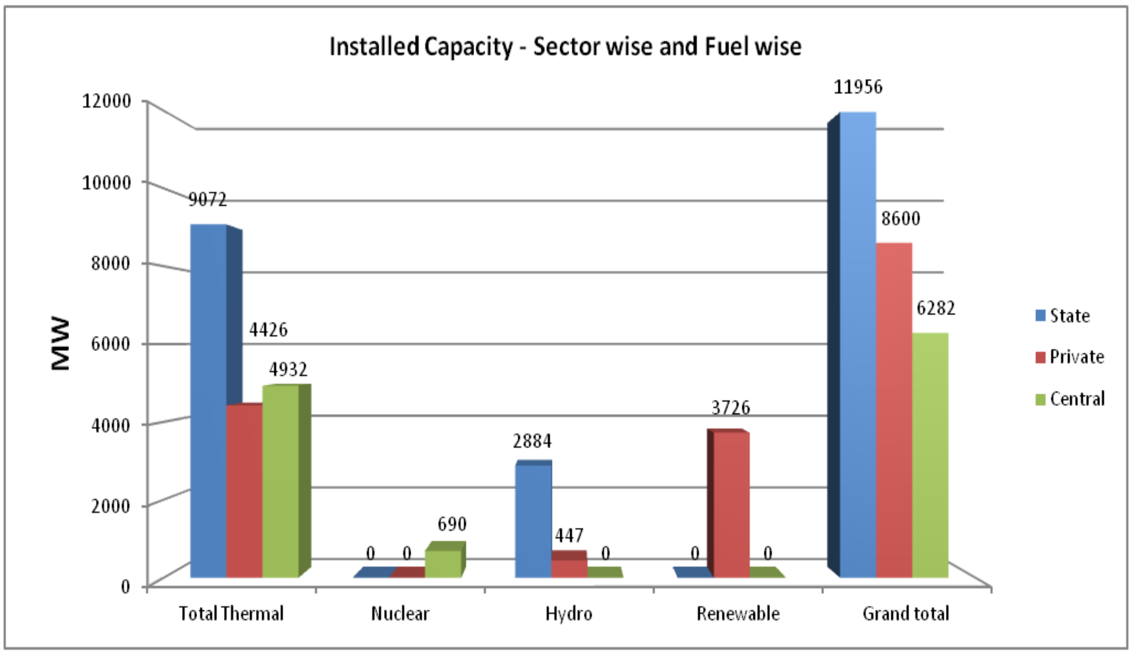


Figure 14 - Installed Capacity in Maharashtra from State, Private and Central Sectors

Table 9 – Installed Capacities of Power Utilities in Maharashtra State

	Coal	Gas	Diesel	Total Thermal	Nuclear	Hydro	Renewable	Grand total
State	8400	672	0.00	9072	0.00	2884	0.00	11956
Private	4246	180	0.00	4426	0.00	447	3726	8600
Central	2968	2624	0.00	4932	690	0.00	0.00	6282
Sub Total	**15614**	**3476**	**0.00**	**19090**	**690**	**3331**	**3726**	**26838**

[24] Government of India, Ministry of Power, Central Electricity Authority, Monthly Reports, Installed capacity (in MW) of Power Utilities in States/UTS located in Western Region including allocated shares in joint & Central sector utilities http://www.cea.nic.in/reports/monthly/inst_capacity/aug12.pdf

[25] Government of India, Ministry of Power, Central Electricity Authority, Allocation of Power from Central generating Stations, August 31, 2010 http://www.cea.nic.in/reports/monthly/gm_div_rep/power_alloc_wr.pdf

Of the total installed capacity, the state comprises 44.5%; central power generating stations comprise 23.4% of the installed capacity while private power generating stations comprise 32.1%.

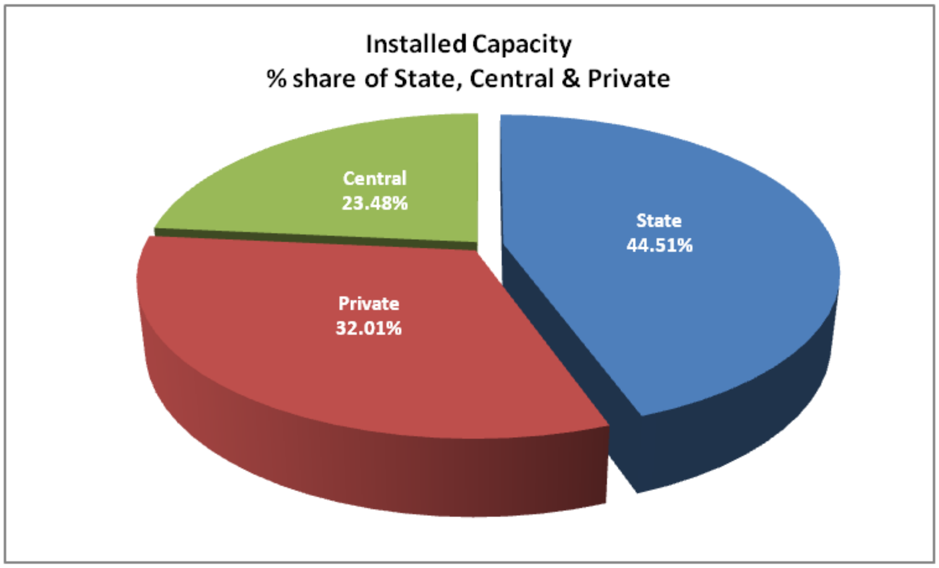


Figure 15 - % Share (State, Private and Central Utilities) of installed capacity

Installed capacity available for use in Maharashtra

Total installed capacity available for use in Maharashtra is 23,506.09 MW, of which 20,897.09 MW is available for use in Maharashtra and 2609 MW is available for consumption in Mumbai. The power available in Mumbai is generated by private power generators *viz.* Tata Power Company Ltd. and Reliance Infrastructure. Power available for use in Maharashtra is generated by the state power generating company “MahaGenCo/ MSPGCL”, private, interstate, and central power generating plants.

A list of existing power plants in the state is provided in *Annexure I*. The list of proposed power plants by state and central power generating companies is provided in *Annexure III*.

Table 10 – Installed Capacity available in Maharashtra and Mumbai

Power generating station	Installed capacity (MW)
Installed Capacity in Maharashtra (except Mumbai)	
MahaGenCo	9948.83
Interstate hydroelectric projects	444.5
RGPPL	1967
Tarapur (Nuclear – share of state)[26]	552
Share from Centre	3634
Power from Private hydropower projects	120
Wardha Power Company Ltd (Thermal) [27] (Private)	540
JSW energy (Thermal) [28] (Private)	600
Captive Power (Private Power plants)[29]	1051
Renewable (Wind Power – Private)	2309.76
Sub - total	**21167.09**
Installed Capacity available in Mumbai	
Tata & Reliance Thermal Power stations	1900
Tata gas power stations	180
Tata hydroelectric power stations	447
Tata renewable energy	82
Sub - total	**2609**
Total	**23776.09**

Maharashtra state's share in the total installed capacity (in Maharashtra except Mumbai) is 59% (includes share of interstate projects and RGPPL); followed by 21% share of private sector and 20% is contribution of central sector.

[26] Government of Maharashtra, MSETCL, STU Five Year Transmission Plan for the year 2010-11 to 2014-15

[27] Government of Maharashtra, Department of Planning, Directorate of Economics and Statistics: Economic Survey of Maharashtra 2010-11, Ch.9 Infrastructure, December 2010

[28] Government of Maharashtra, Department of Planning, Directorate of Economics and Statistics: Economic Survey of Maharashtra 2010-11, Ch.9 Infrastructure, December 2010

[29] Government of Maharashtra, Department of Planning, Directorate of Economics and Statistics: Economic Survey of Maharashtra 2010-11, Ch.9 Infrastructure, March 2010

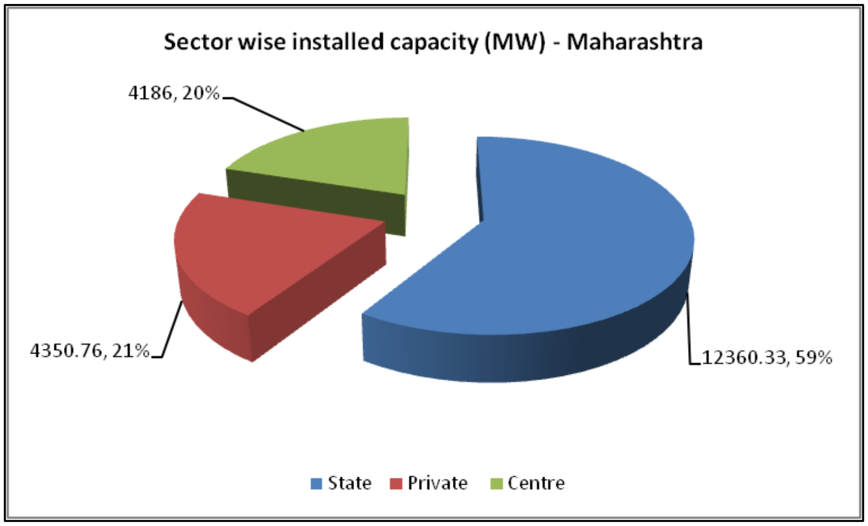


Figure 16 - Sector wise installed capacity (MW) for use in Maharashtra (except Mumbai)

Increase in installed capacity

Table 11 - Installed capacity - Maharashtra

Month	Installed Capacity (MW)	Month	Installed Capacity (MW)	Month	Installed Capacity (MW)
2009-10		**2010-11**		**2011-12**	
April	17429	**April**	18055	**April**	19380
May	17429	**May**	18150	**May**	19680
June	17429	**June**	18280	**June**	19705
July	17478	**July**	18280	**July**	19981
August	17478	**August**	18580	**August**	20481
September	17478	**September**	18580	**September**	20481
October	17523	**October**	18756	**October**	20781
November	17785	**November**	18516	**November**	20781
December	17785	**December**	18925	**December**	20951
January	17795	**January**	19059	**January**	20951
February	18045	**February**	19295	**February**	21546
March	18305	**March**	19295	**March**	23341

State (MahaGenCo) Power Generating Plants

The total installed capacity of MahaGenCo is **11700 MW** from thermal, gas and hydropower plants and renewable energy. It has seven thermal **(coal based)** power generating stations with a total installed capacity of **8400 MW**. The total installed capacity of **hydropower** is **2600 MW**. This includes Koyna power generating as well as small hydropower stations. The state has one gas-based power plant of installed capacity **672 MW** comprising seven units and two units of waste heat recovery of 120 MW each. The renewable energy installed capacity is **25 MW**, which is from solar. A list of power plants is given in *Annexure I*.

Thermal (coal) power plants dominate with 71% of the total installed capacity followed by hydropower (22%) and gas based installed capacity (7%). The contribution of renewable energy is negligible.

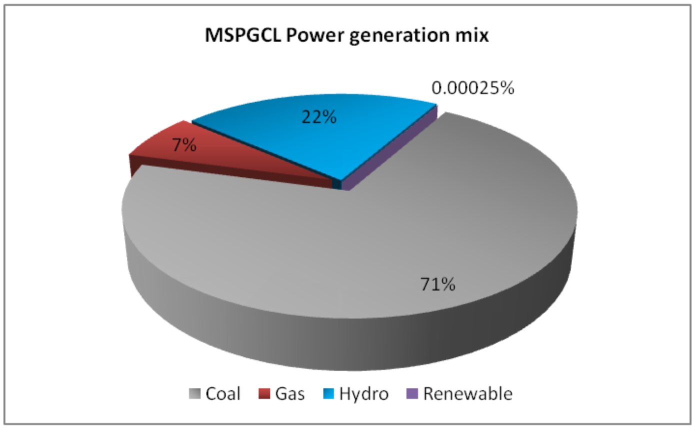


Figure 17 - State (MSPGCL) Power generation sources

Interstate Power Plants

In Maharashtra, there are two interstate hydropower projects *viz.* Pench (160 MW) and Sardar Sarovar (1450 MW). The state receives 33% (53 MW) and 27% (391.50 MW) of electricity from Pench and Sardar Sarovar respectively.

State and Centre Power Plants

The total installed capacity of Ratnagiri Gas and Power Private limited (RGPPL) is 1967 MW. The plant has three blocks *viz.* Block I comprising 640 MW and Block II and III of 663.5 MW each. NTPC and GAIL have a 30.17% stake each in RGPPL, while MSEB Holding Company has 17.90% shares and 21.77% shares are owned by financial institutions[30].

Power Plants operated by Government of India

Nuclear Power Nuclear Power Corporation of India Ltd (NPCIL)

Tarapur Atomic Power Station (TAPS) was the first nuclear power plant in India. The total installed capacity is 1440 MW[31] and the state's share is 552 MW[32].

[30] http://www.rgppl.com/index.php?option=com_content&view=article&id=64&Itemid=75
[31] http://www.npcil.nic.in/main/AllProjectOperationDisplay.aspx

Private Power Plants

Hydropower Plants

The total power available for the state from private hydropower stations is 120 MW.

Thermal Power Plants

Two power plants by private companies have been commissioned *viz*. JSW in Ratnagiri and Wardha Power in Warora from which 600 MW and 270 MW[33] power is available for distribution by MSEDCL through Power Purchase Agreements (PPA). Wardha power plant comprises two units of 135 MW each which were commissioned on June 5, 2010 and October 10, 2010. JSW comprises two units of 300 MW each commissioned on August 24, 2010 and December 9, 2010[34]. A third unit of Wardha Power was also commissioned on January 21, 2011. The number of private power plants (coal and gas based) is increasing. A list of proposed power plants in Maharashtra from private sector is provided in *Annexure I*.

Since power demand has always been more than the power supply, MSEDCL had taken several measures to meet the demand by entering into PPAs with private power generators.

In 1990, MSEB entered into power purchase agreements with three major Independent Power Producers (IPPs) *viz.* Enron (Dabhol -2284 MWLNG); Reliance (447 MW liquid fuel Patalganga Project) and Ispat (Bhadrawati - 1082 MW coal project). Of these three, Enron's Dabhol was the most controversial project. First phase of this project (740 MW) started generation in 1999 but generation stopped since May 2001, after MSEB rescinded the PPA on grounds of false declaration by the company. Timeline of this project is given in the box below. The PPA between Reliance (second IPP) and MSEB was amended after establishment of MERC. However on disclosure of all contracts relating to IPPs, Prayas (an NGO) filed a petition before the MERC, this was because all PPAs need to be approved by MERC as per the Act. In response to this appeal, MERC issued an order that unless MSEB/Reliance approached them for approval of amendments, the same cannot be legally valid. Since then the project has been shelved as Reliance has not approached MERC on this issue. The third IPP (Ispat's Bhadravati coal project) has also been abandoned mainly due to several controversies relating to fuel supply and cost. From 1995 to 2007-08, there was no capacity addition by MSPGCL due to sole reliance on Enron. However, MSGPCL increased the installed capacity thereafter as per the XI FYP.

[32] Government of Maharashtra, MSETCL, STU Five Year Transmission Plan for the year 2010-11 to 2014-15
[33] Government of Maharashtra, Department of Planning, Directorate of Economics and Statistics: Economic Survey of Maharashtra 2010-11, Ch.9 Infrastructure, December 2010
[34] http://www.cea.nic.in/reports/proj_mon/tpp_11plan.pdf

Timeline of the Enron's Dabhol project (now RGPPL):

- **1992-** GoM, GE, Enron, Bechtel signs MoU.
- **1993-** PPA signed.
- **1995-** Construction of phase I began; Change in Government of Maharashtra; Project Scrapped.
- **1996-** Renegotiation; Construction of phase I resumes.
- **1999-** Phase I becomes operational.
- **2000-** MSEB begins to default.
- **2001-** Enron files for bankruptcy; DPC shuts down.
- **July 2005** – The plant is taken over by Ratnagiri Gas and Power Private limited (RGPPL). (RGPPL was incorporated under the Companies Act, 1956 on 8th July, 2005 and is promoted by NTPC Limited & GAIL (India) Limited. The company was set up to take over and revive the assets of Dabhol Power Company Project. RGPPL owns an Integrated Power generation and Re-gasified LNG facility. The power station is India's largest operating gas based combined cycle power station).
- **Oct.2005**-The project was taken over by a conglomerate that included public sector banks, MSEB, GAIL, NTPC and some financial institutions.
- **May 2006** – Ratnagiri Gas and Power Pvt. Ltd. (RGPPL), a special purpose vehicle started operation.
- **4 July 2006** - RGPPL shutting down the plant due to a lack of naphtha supply.
- **April 2009** - The Dabhol Power Plant Project is operational with 900 MW RLNG fired running capacity.
- **31st March 2010**- Ratnagiri Gas and Power Pvt. Ltd. (RGPPL) the company that now owns the project made all six gas turbines operational earlier this year, achieving full capacity of 1,940 MW (de-rated from the original installed capacity of 2,184 MW because of problems with equipment).
- **November 2010**- Half yearly profits at Rs. 220 crore during the current fiscal. [35]

MSEDCL, since its formation entered several PPA/ LoIs with the centre, other states as well as independent power producers. (A list of PPA/ LoIs is attached in *Annexure I*). In 2005-06, the GoM signed MoUs with 8 private companies to generate 12,500 MW power. Electricity would be purchased at competitive prices from these companies. List of these companies is tabulated below. However there is no progress in these projects till date. These projects require vast tracts of land. In an effort to provide land to these companies, the government allotted same piece of land to TPC and Reliance to set up a power plant. No regulatory process has been carried out and there is no further progress besides the signing of MoUs.

[35] http://indianpowersector.com/about/case-study/ & http://www.rgppl.com/

Table 12 - MoUs signed with Private Power Companies in 2005-06

Name of the Company	Power generation (MW)
Central Indian Power Co. ltd.	2000
Ispat Energy	1000
Essar	1500
GMR Energy	1000
Spectrum Technology	500
Tata Power Corp	1500
Jindal Power Corp	1000
Reliance Energy	4000
Total	**12,500**

Captive Power Plants

The installed capacity of captive power plants in the state was 1273.209 in the year 2005-06 which grew to 2926MW[36] up to March 2010. The installed capacity of the captives ranges from 1MW to 350MW. Captive power plants set up use varied fuels such as diesel/ liquid fuels, coal, bagasse, biomass, cogeneration/ waste heat recovery and natural gas. 1051 MW of captive power is available with MSEDCL for distribution.

Renewable Energy

Electricity generation from wind, solar, small hydro projects, bagasse cogeneration, biomass and urban and industrial waste is categorized as renewable energy. The installed capacity of bagasse, biomass and industrial waste power plants are included in the installed capacity of captive power plants. The total installed capacity form wind power was 2733 MW as of March 31, 2012[37].

Power plants for Mumbai

Tata Power has 1400 MW of thermal (coal) power capacity, 447 MW of hydropower capacity, 180 MW of gas based capacity and 82 MW from renewable power. This power is used to meet the requirements of Mumbai, through its own distribution and through BEST (Brihanmumbai Electric Supply & Transport Undertaking)

Reliance has a 500 MW coal based power plant at Dahanu. This power is used for consumption in Mumbai.

[36] Captive Power in India, 2010, pp. 197-203, List of captive power plants
[37] Government of India, Ministry of New and Renewable Energy

Maharashtra - Electricity Demand and Supply position

Demand supply variations

Demand for electricity varies throughout the day, over the course of the week, and seasonally. Demand is also impacted by location, population and climate. To meet the constantly changing demand for electricity, peak and intermediate power plants are a critical component of the electricity supply system.

Base load power plants (Coal, nuclear, combined cycle gas turbine; hydropower depending on regional availability) produce continuous, reliable and efficient power at low costs. These plants run continuously all year except when they require unforeseen repairs or are scheduled for maintenance. Their reliability to meet the base demand - to continuously supply electricity to consumers - helps keep their operation costs low and offers stable, attractive pricing through long term agreements. The rule of thumb is that base load power is usually 35–40% of the maximum load during the year. These plants have high capital costs and low variable costs. Sharp increases in demand are handled by intermediate or peak power plants.

Peak load power plants *i.e.* peaking plants, provide electricity at periods when consumers are using the most power. Peaking stations are designed to be highly responsive to changes in electrical demand and can be started up quickly. However the peak power stations are generally smaller than the base load power plants. These are characterized by low capital costs and higher variable costs.

Intermediate power plants cover electricity demand between base load and peaking plants. They typically operate between 30 and 60% of the time in accordance with daily, weekly and seasonal demands. Given their sporadic nature, wind and solar can only be used as intermediate power sources because they cannot be relied upon to meet constant supply needs, nor can they be immediately called upon to generate electricity during peak demand periods.

Due to large fluctuations in supply and demand, energy providers must be able to respond to changing conditions in order to meet consumer energy needs across time and space demand variations. Demand variations are given below

1. Annual and seasonal demand variations
   Driven by
   a. Economic growth
   b. Weather change
   c. Change in usage such as lighting and air conditioning
2. Weekly demand variations
   Driven by
   a. Working day (industries – mechanical, IT, etc.) Vs. public holidays/ weekends
3. Daily demand variations

Driven by

a. Time of Day
b. Weather

4. Demand would also be affected by population increase and lifestyle changes as urbanization increases.

Peak demand, availability and shortage

Peak demand and availability in Maharashtra is tabulated below. Peak demand refers to the period of highest consumer demand for power. Peak demand has increased significantly in the state from 11895 MW in 2001-02 to 21045 MW in 2011-12. Peak supply increased from 10879 MW in 2001-02 to 16577 MW in 2011-12. The gap between demand and supply increased from 1016 MW to 4468 MW in the same time period. Since Mumbai does not have power cuts, power shortfall is applicable for MSEDCL distribution area.

Table 13 - Peak Demand & Availability status in Maharashtra from 2001-02 to 2011-12[38]

Year	Peak Demand (MW)			Availability (MW)	Peak Shortfall (-) /Surplus (+) (MW)
	State	MSEDCL	Mumbai		
2001-02	11895	10119	1776	10879	-1016
2002-03	13418	11425	1993	10997	-2421
2003-04	13692	11357	2335	11650	-2042
2004-05	14822	12749	2073	11777	-3045
2005-06	16094	14061	2033	11889	-4205
2006-07	17161	14825	2336	12634	-4527
2007-08	18133	15689	2444	12856	-5277
2008-09	18098	15656	2442	13157	-4941
2009-10	19120	16582	2538	14952	-4168
2010-11	19850	17150	2700	15968	-3882
2011-12	21045	18145	2900	16577	-4468

Under normal situations there is a balance between demand and supply. Until 1998-99, there was sufficient generation capacity to meet Maharashtra's peak demand for electricity. Since then, however, demand has exceeded the available system capacity resulting in shortage. Power shortage has increased over the years from 2001-02 till 2011-12.

[38] Government of Maharashtra, MSETCL, STU Five Year Transmission Plan for the year 2010-11 to 2014-15

Table 14- MSEDCL Supply and shortfall of electricity at peak demand (MW)

Year	Peak Demand	Supply	Shortfall
2001-02	10119	9103	1016
2002-03	11425	9004	2421
2003-04	11357	9315	2042
2004-05	12749	9704	3045
2005-06	14061	9856	4205
2006-07	14825	10691	4134
2007-08	15946	10078	5868
2008-09	15630	10747	4883
2009-10	16582	12414	4168
2010-11	17150	13268	3882
2011-12	18145	13677	4468

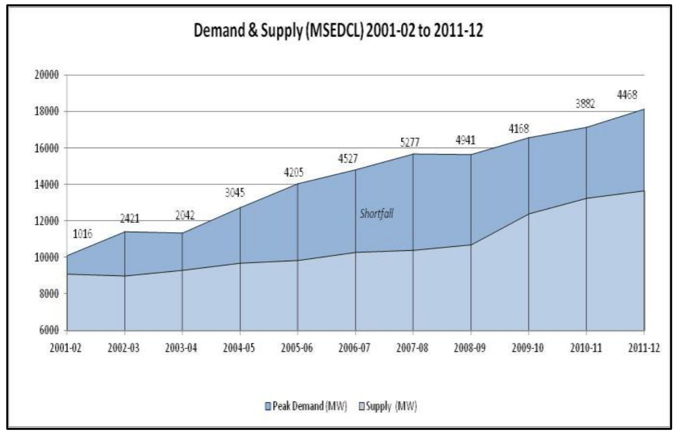


Figure 18 - Demand -Supply (MSEDCL)

Annual / seasonal demand and supply variations in MSEDCL distribution area

Seasonal data analysis is used to identify periods when supply-demand balance comes under strain. Figure 17 shows the seasonal energy demand variation from April 2009 to March 2012 for MSEDCL distribution area. Demand peaks in winter and summer months (December to May) whereas reduces in monsoon (June to September). The highest demand in 2009-10 and 2010-11 was in March while in 2011-12 the demand was at its peak in December. Peak demand-supply gap reduced in 2010-11 (18.2%) but again increased in 2011-12 by 13.1%.

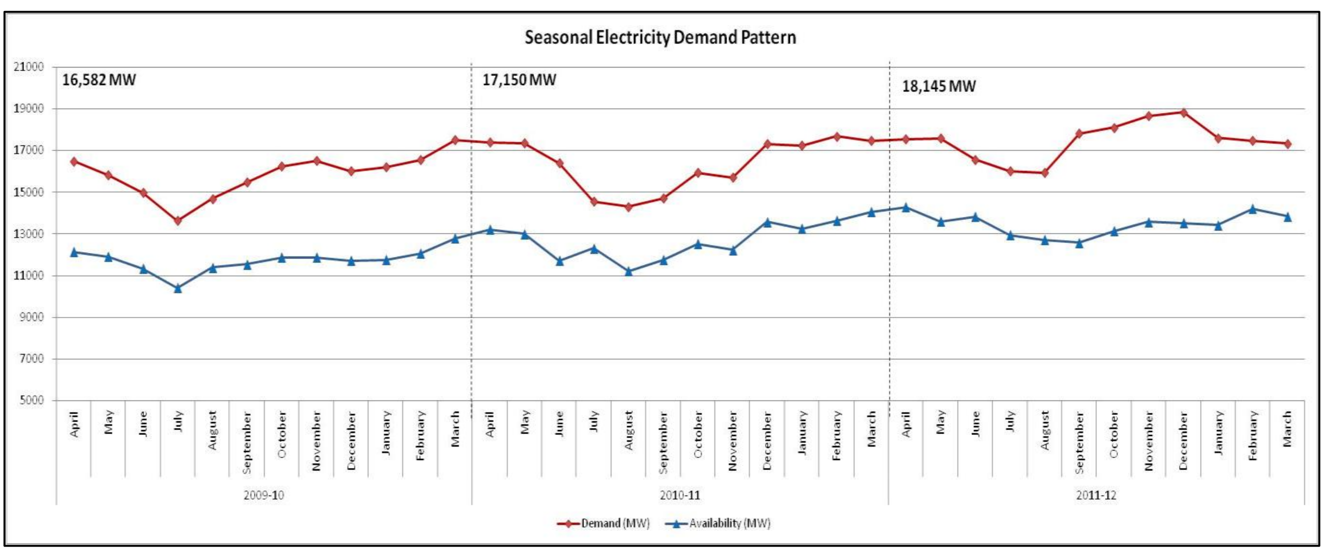


Figure 19- Seasonal Electricity Demand Pattern (2009-10 to 2011-12)

Table 15 – Variation in monthly energy demand

Year	Month	Peak Demand (MW)	Peak Supply (MW)	Peak Demand-Supply Gap (MW)	% of Load shed
2009-10	Apr	16494	12141	4353	26.39
	May	15820	11897	3923	24.80
	Jun	14976	11321	3655	24.41
	Jul	13635	10399	3236	23.73
	Aug	17121	11388	5733	33.49
	Sep	15482	11545	3937	25.43
	Oct	16232	11859	4373	26.94
	Nov	16520	11881	4639	28.08
	De	16000	11713	4287	26.79
	Jan	16210	11746	4464	27.54
	Feb	16548	12069	4479	27.07
	Mar	17512	12788	4724	26.98
		(a)17512	(b)12788	(c)5733	
2010-11	Apr	17378	13206	4172	24.01
	May	17364	13001	4363	25.13
	Jun	16400	11711	4689	28.59
	Jul	14553	12310	2243	15.41
	Aug	14304	11211	3093	21.62
	Sep	14699	11757	2942	20.01
	Oct	15938	12511	3427	21.50
	Nov	15694	12234	3460	22.05
	Dec	17308	13573	3735	21.58
	Jan	17233	13247	3986	23.13
	Feb	17676	13624	4052	22.92
	Mar	17477	14063	3414	19.53
		(a)17676	(b)14063	(c) 4689	
2011-12	Apr	17551	14298	3253	18.53
	May	17596	13582	4014	22.81
	Jun	16564	13838	2726	16.46
	Jul	16023	12930	3093	19.30
	August	15926	12713	3213	20.17
	Sep	17811	12574	5237	29.40
	Oct	18103	13140	4963	27.42
	Nov	18649	13571	5078	27.23
	Dec	18829	13526	5303	28.16
	Jan	17603	13419	4184	23.77
	Feb	17476	14196	3280	18.77
	Mar	17335	13847	3488	20.12
		(a)18829	(b)14298	(c) 5303	

(a)– Installed Capacity at year end; (b) (c) (d) – peak of the year

Daily variation in peak demand and supply

Daily variation in peak demand and supply has been analyzed for monsoon and summer.

In 2009, demand started increasing from the month of August, which usually starts increasing from September. It can be seen that during public holidays and week days the demand is low. The lowest peak demand was 11507 MW on 23rd August 2009 (Sunday) while highest of 15171 MW was on 17th August 2009 (Monday), the first working day of the week.

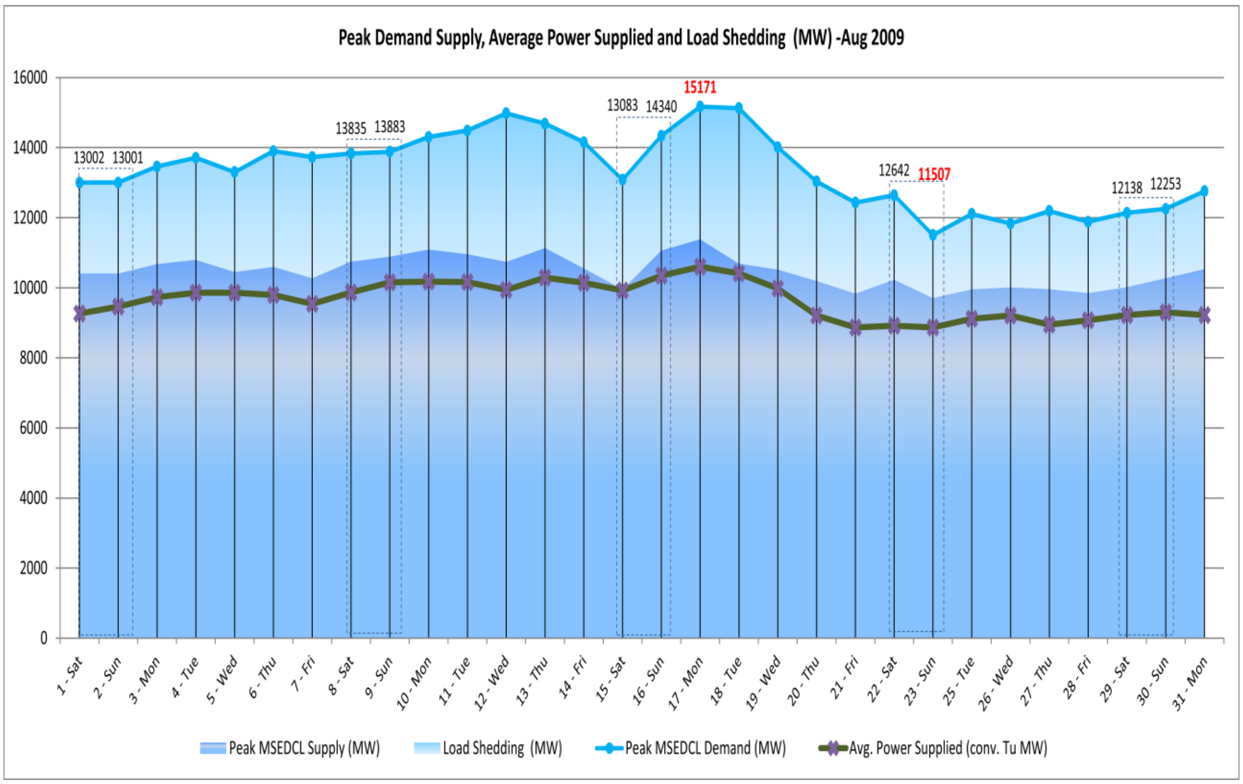


Figure 20 - Daily peaks (demand-supply) and average supply in monsoon (August 2009)

Figures 19 & 22 show morning and evening peak electricity demand for March 2012 (financial year end). Load management provides 14% peak demand relief in the morning (2400 MW) and 25% relief in the evening peak (3500 MW).

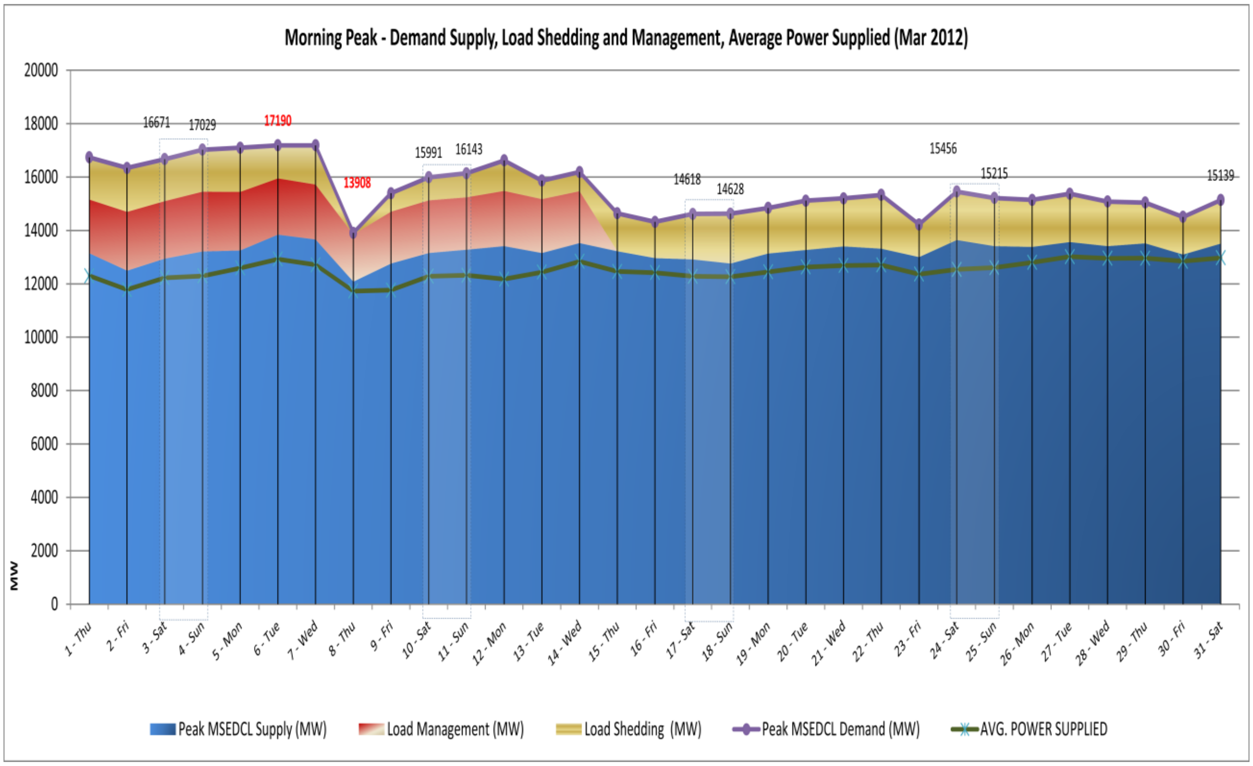


Figure 21 - Daily morning peaks (demand-supply) and average supply in summer month (March 2012)

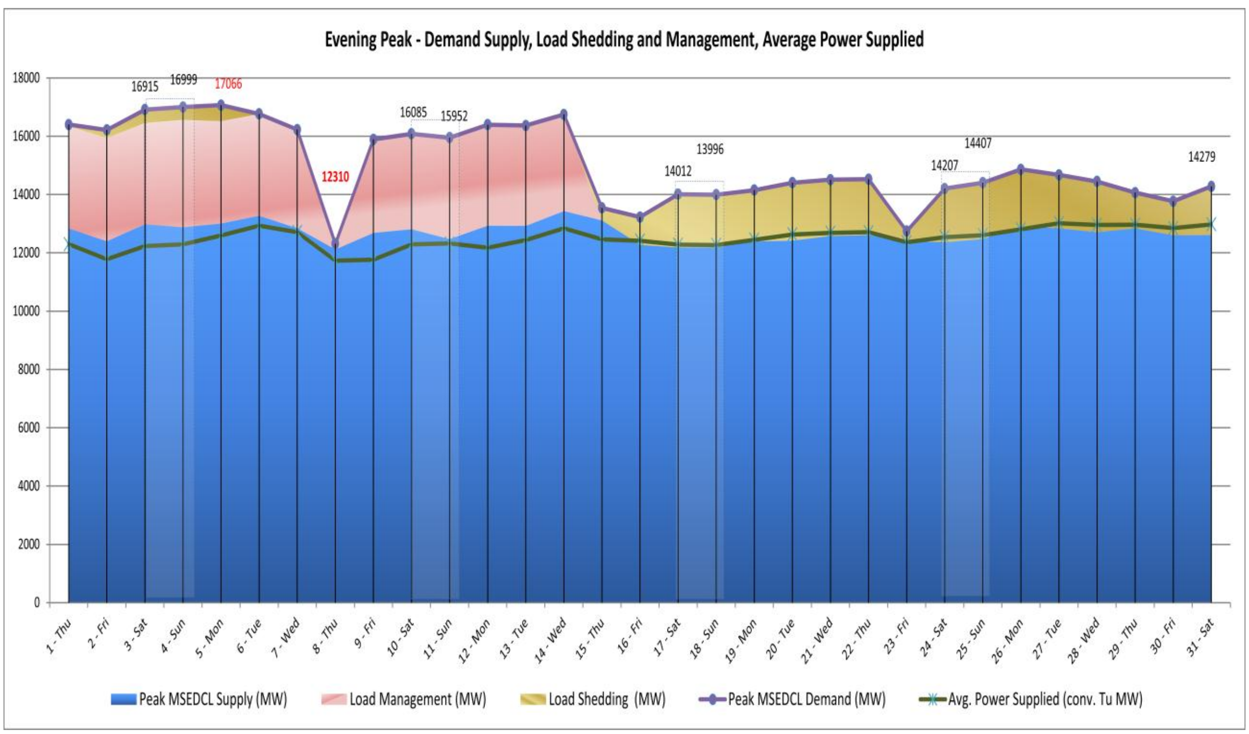


Figure 22- Daily evening peaks (demand-supply) and average supply in summer month (March 2012)

The month of October was chosen for analysis as Diwali happened to be in this month. During this period the peak demand was lowest (26th-28th October), which was lower than the monsoon peak demand, which is the lowest in the year. It can be seen that the demand over the month decreases on weekends and increases on Monday. The demand on Thursday also shows a dip. On an average the demand has increased by 3.7% from Sunday to Monday. The highest peak demand was seen on 10th and 24th of the month. Hourly demand curve for 24th October is also shown (Figure 23).

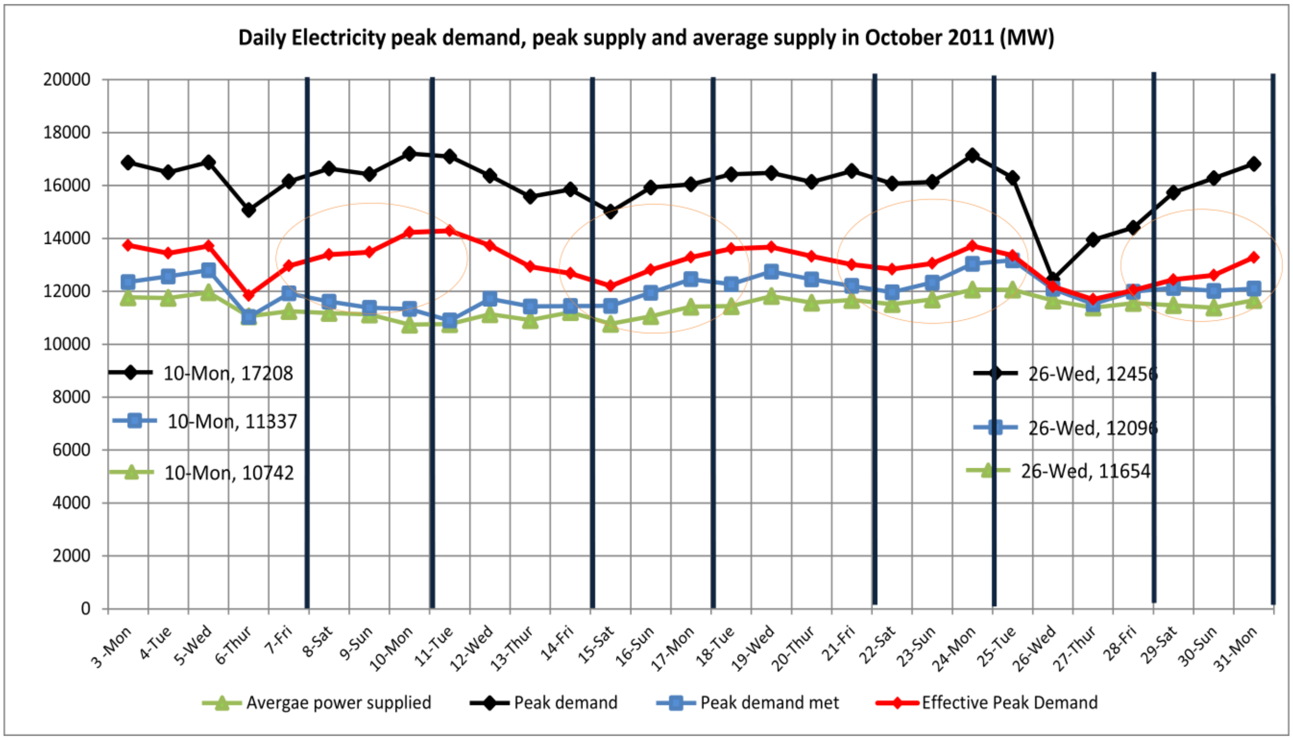


Figure 23 - Daily peaks (demand-supply) and average supply in October 2011

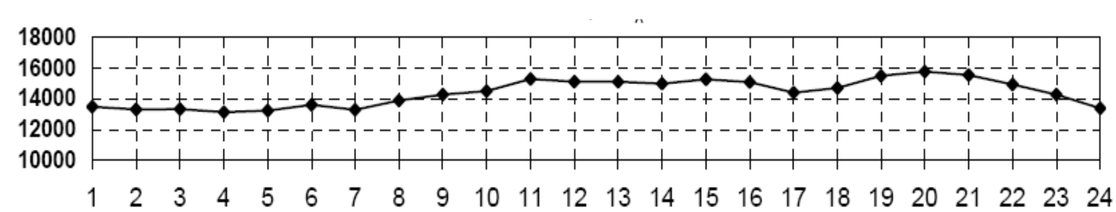


Figure 24 - Hourly demand curve- 24 October 2011

The graph above represents power demand met over 24 hours on October 24, 2011. This was the day of the month with highest peak demand. Power demand is relatively low in the early morning hours and late night hours.

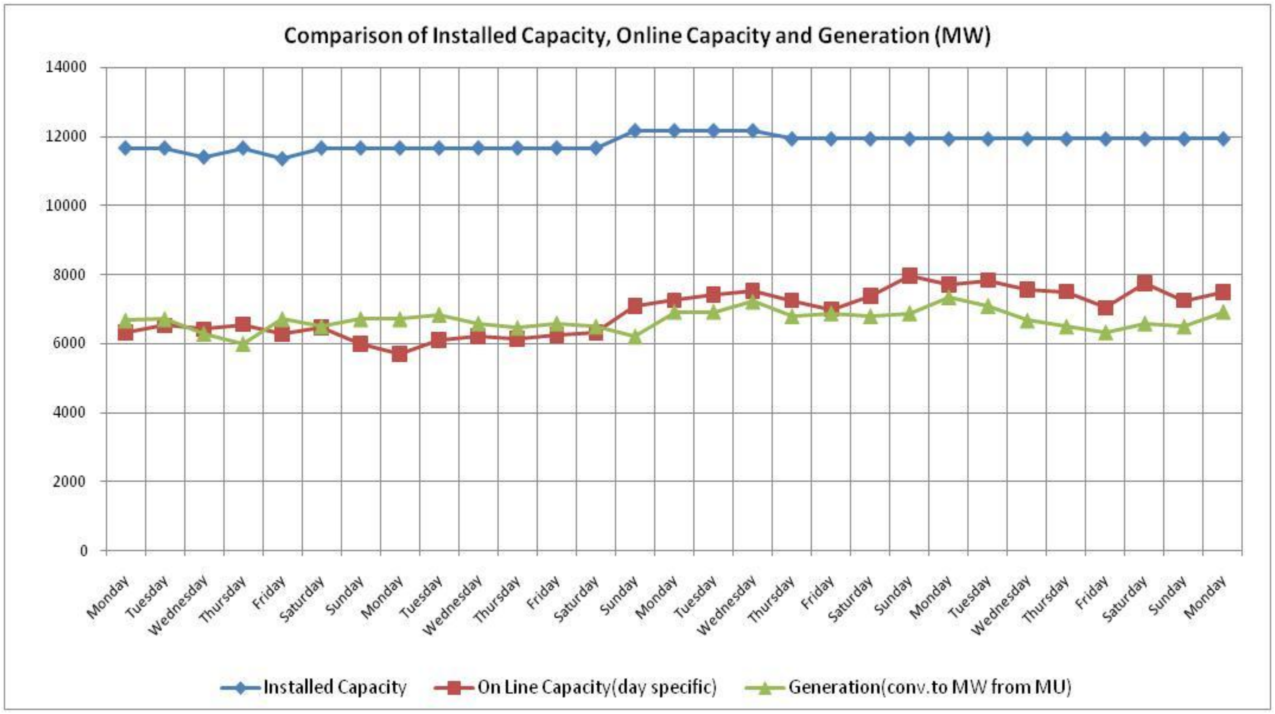


Figure 25 - Comparison of Installed Capacity and Generation

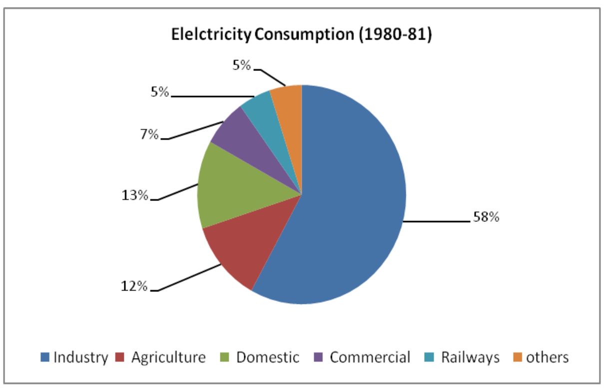
The graph above shows installed capacity, online capacity (OLC) and generation for the day. OLC is the maximum power that can be generated. It is usually less due to real time problems like availability of fuel & other resources, planned & forced outages, etc.

Power generation (converted into MW from 'million units' electricity generated) is close to OLC. If OLC is maintained at par with installed capacity demand could be met easily.

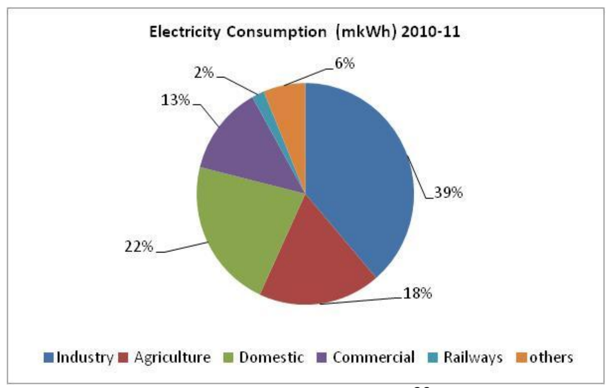
Electricity Consumption across Sectors in Economy

Electricity demand is classified into six different consumer groups: (i) Agriculture, (ii) Industry, (iii) Domestic, (iv) Commercial, (v) Railways and, (vi) Others (*i.e.* municipal, public institutions).

Over the last few decades, economic growth, liberalization, power sector reforms and rapid expansion of urban areas have affected electricity consumption patterns in Maharashtra significantly. Figure below gives the sector-wise break-up of electricity consumption from 1980-81 to 2010-11. Consumption of electricity has increased from 14,034 mkWh to 87,397 mkWh, a change of 522.8% in 20 years. As per the Daily System Report the electricity consumption almost reached 1 lakh MU in 2011-12. The share of industrial consumers has dropped considerably from 58% to 39%, whereas the share of the domestic sector has increased from 13% to 22%, this can be attributed to population growth and changes in lifestyle which increased dependency on electrical appliances. Share in consumption of agriculture and commercial sectors has increased by 6%. Electricity consumption of the domestic has increased the most over the years, largely due. In 1980-81, industries consumed more than half the total demand. In 2010-11, the overall demand of industries decreased as most of the big industries switched to captive power. Industrial sector accounts for 39% of the total electricity consumption, which is followed by the domestic sector with 22%.



14,034 million kWh



87,397 million kWh[39]

Figure 26- Changing share of electricity in Maharashtra across various sectors

Per capita Electricity Consumption

The per capita consumption of electricity of the all states and Union Territories is given below. If we compare Andhra Pradesh, Karnataka, Gujarat and Tamil Nadu which are more or less of the same geographical area and economic status as that of Maharashtra, it can be seen that per capita consumption of electricity in Maharashtra is lower than Gujarat and Tamil Nadu. Per capita power consumption in different states in India is as follows:

[39] Government of Maharashtra, Department of Planning, Directorate of Economics and Statistics: Economic Survey of Maharashtra 2010-11, Ch.9 Infrastructure

Table 16- Per Capita electricity consumption in India

States / UTs	Per Capita Consumption (kWh)	States / UTs	Per Capita Consumption (kWh)
Haryana	1222.21	**Rajasthan**	736.20
Himachal Pradesh	1379.99	**Uttar Pradesh**	348.37
Jammu & Kashmir	952.02	**Uttarakhand**	1112.29
Punjab	1526.86	**Chandigarh**	1340.00
Tamil Nadu	1131.58	**Delhi**	1651.26
Puducherry	1743.37	**Tripura**	335.47
Lakshadweep	418.14	**Gujarat**	1615.24
Mizoram	376.99	**Madhya Pradesh**	602.07
Bihar	122.11	**Chhattisgarh**	1546.94
Jharkhand	880.43	**Maharashtra**	**1028.22**
Orissa	874.26	**Goa**	2263.63
West Bengal	550.16	**Daman & Diu**	7118.23
A & N Islands	493.98	**D & N Haveli**	11863.64
Sikkim	850.00	**Nagaland**	218.03
Arunachal Pradesh	470.00	**Andhra Pradesh**	966.99
Assam	204.80	**Karnataka**	903.24
Manipur	240.22	**Kerala**	525.25
Meghalaya	675.19	**India**	779

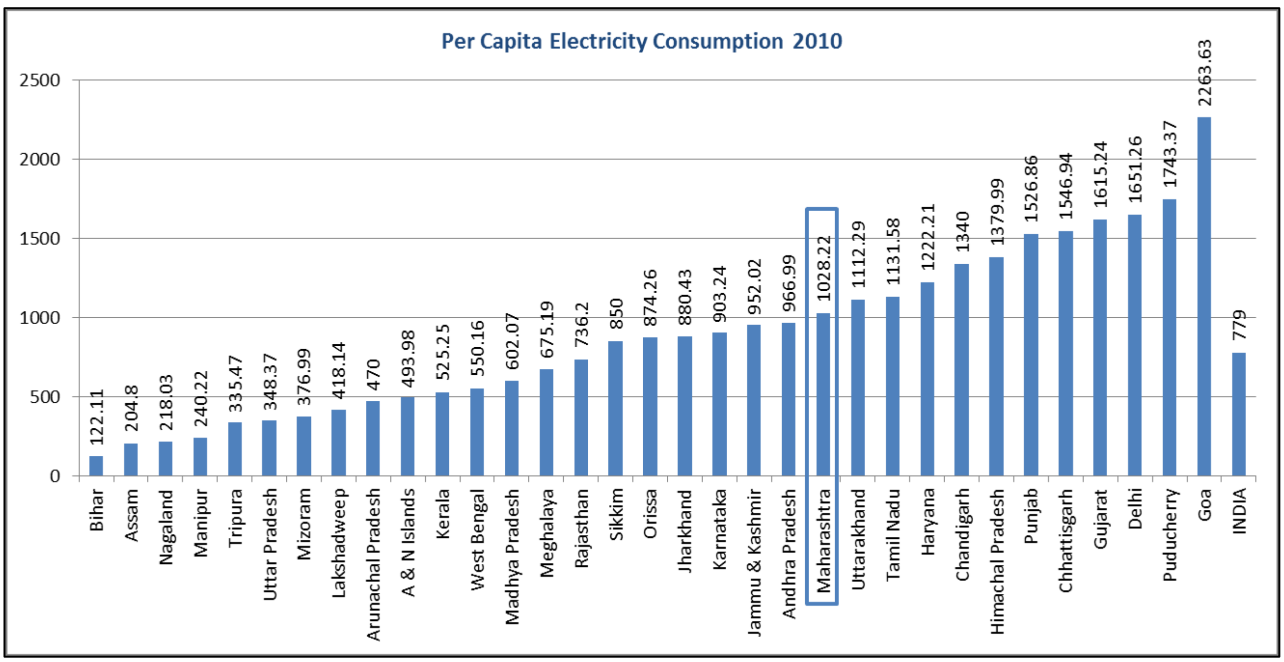


Figure 27- Generation and Consumption of Electricity in selected states

Sector-wise Electricity Consumption

The aggregate energy consumption during 2010-11 was 87,937 mkWh higher by 10.4% compared to the previous year (79,139 mkWh) and higher by 56.9% as compared to 2004-05. Energy consumption for each of the sectors is tabulated below[40].

Table 17-Energy consumption in Maharashtra (million kWh)

Category	04-05	05-06	06-07	07-08	08-09	09-10	10-11	%change	11-12*
Industry	22515	25692	26535	30323	28850	30866	34416	11.5	26687
Domestic	12916	13572	14284	15553	16878	18171	19547	7.6	16484
Agriculture	10733	11094	9749	12676	12733	13925	16257	16.7	15515
Commercial	5420	4841	6940	6661	9102	10546	11571	9.7	9047
Administrative Purposes									
Public Works	2174	2148	2272	2520	2560	2658	2310	-13.1	2260
Railways	1850	1861	1987	2024	2110	2119	2707	27.7	1657
Miscellaneous	76	79	318	82	761	854	589	-31.0	217
Total	**55684**	**59287**	**62085**	**69838**	**72994**	**79139**	**87397**		**71867**
% Total change		**6.5**	**4.7**	**12.5**	**4.5**	**8.4**	**10.4**		

*Upto December 2011

The industrial sector (39%) is the largest consumer of electricity followed by domestic (22%), agriculture (18%) and commercial sector (13%). There was a high increase in the consumption of electricity in the commercial sector (43.4%) whereas the use by the agriculture sector decreased by 12% in the year 2006-07.

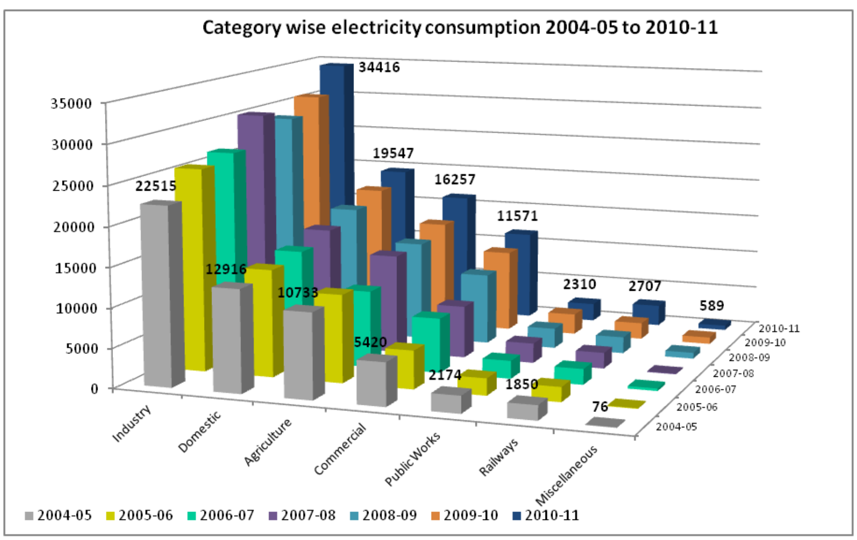


Figure 28- Category wise electricity consumption from 2004-05 to 2010-11

[40] Government of Maharashtra, Department of Planning, Directorate of Economics and Statistics: Economic Survey of Maharashtra

Industrial consumers

The industrial sector is the largest power consumer. A few energy intensive industries are fertilizers, aluminium, textiles, cement, iron and steel pulp and paper with iron and steel being the largest consumer of energy. A few energy intensive industries under the Energy Conservation Act 2001 are listed below.

Thermal Power Station – 30000 metric tonnes of oil equivalent (MTOE) per year & above.

Fertilizer – 30000 MTOE per year and above.

Cement - 30000 MTOE per year and above

Iron & steel - 30000 MTOE per year and above

Chlor-Alkali-12000 MTOE per year and above.

Aluminum - 7500 MTOE per year and above

Railways workshop - 30000 MTOE per year and above

Textile - 3000 MTOE per year and above

Pulp & paper - 30000 MTOE per year and above

Transport

Chemicals and

Sugar Industry

Other than these many other small and medium industries as well as the IT industries require energy. The IT industries in particular require energy for space cooling as well. In the current year industrial load shedding was for 24 hours in the beginning and was later increased to 40 hours every week. The MCCIA stated that due to heavy power cut offs the industrial production decreased by around 16% during this time period. The industrial power consumption however had increased from 25,692 in 2005-06 to 26,535 million kWh in the year 2006-07.

Commercial consumers

The commercial users could be divided into small shops, malls, plazas, multiplexes, hotels (small restaurants, 3 and 5 star hotels) and hospitals. The MSEDCL distributed electricity to 13.79 lakhs commercial consumers as on 31.3.2012. The electricity consumed by the commercial sector in the year 2010-11 was 11571 million kWh. The malls and multiplexes consume a large amount of power. Apart from the daily lighting needs, they require power for advertisements of products that are constantly run on screens, advertisements banners, space cooling as well escalators that operate continuously.

Domestic consumers

The domestic electricity consumption increased with changing lifestyles with most of the households using electronic appliances like washing machine, air conditioner, geyser, boiler, heater, microwave, refrigerator, *etc*. The demand by the domestic sector is high in the morning and evening hours. The electricity consumption for this sector increased from 18,171 kWh for 2009-10 to 19,547 kWh for 2010-11 and which will continue to increase with the rise in population and standards of living. There were 143 lakh domestic consumers as on 31.03.2012 as stated by the MSEDCL and electricity consumed was 20000 million kWh for 2011-12[41].

Maharashtra - Rural energy scenario

The rural consumers need energy as electricity for agriculture, cottage based industries and lighting; and for cooking by using traditional sources. Thus the rural energy scenario is dividing into the electricity users (mostly agriculture consumers as power requirement is more) and the fuel wood consumers for cooking which comprises women.

Electricity Requirement

70% of the population still lives in rural areas and meeting their energy requirements in a sustainable manner is a challenge. Electricity is predominantly required for agriculture (lift irrigation) and other important activities like small and medium industries, khadi and cottage industries, schools health centers, and Gram Panchayat.

Today after 60 years of independence, Maharashtra state boasts of 100% rural electrification with financial support from Rural Electrification Corporation (REC) and GoM. In spite of this there is a long list of paid pending agricultural consumers and long duration of power cut offs. In the current year rural areas faced a power cut off for 12-16 hrs. This has not only affected the agricultural industry but also made life difficult for the rural population. Some of the issues faced by the rural sector are listed below:

- High cost of supply due to low density and low load factors
- High T & D losses
- Low paying capacity of consumers
- Need of subsidy for some category of consumers

[41] Government of Maharashtra, Department of Planning, Directorate of Economics and Statistics: Economic Survey of Maharashtra 2011-12, Ch.9 Infrastructure

- Lack of commercial funding for expansion of network

Definition of village electrification [42]

> The basic infrastructure such as distribution transformer and or distribution lines is made available in the inhabited locality within the revenue boundary of the village including at least one hamlet/Dalit Basti as applicable and
>
> Any of the public places like Schools, Panchayat Office, Health Centres, Dispensaries, Community centers etc. avail power supply on demand and
>
> The ratings of distribution transformer and LT lines to be provided in the village would be finalized as per the anticipated number of connections decided in consultation with the Panchayat / Zilla Parishad/District Administration who will also issue the necessary certificate of village electrification on completion of the works.
>
> The number of household electrified should be minimum 10% for villages which are unelectrified, before the village is declared electrified. The revision of definition would be prospective.

Currently, rural households get limited period electricity for both household electrification and electrification of irrigation pump sets. The scenario of pump set electrification in Maharashtra is accelerating; rather, more pump sets than the capacity of groundwater reserves are energized as on July 31st 2012. This puts a great pressure on the groundwater table and it can have profound long term ill-effects. Around 38 lakh irrigation pump sets (IPS) have been energized till date, while the handling capacity is just over 24 lakh. Household electrification is a different concept which is often neglected in trying to prioritize IPS electrification.

Here comes the importance of need of electricity. Both the urban dweller and the rural dweller need tube lights, fans, television, computer, refrigerator and lamps (compact fluorescent lamps instead of incandescent bulbs). City dwellers undoubtedly '*consume*' more electricity, but that does not mean that they '*need*' more electricity than their rural brothers and sisters. In urban areas, more consumption is commonly 'affordable'. Converse is not always true. We must not assume the converse that rural consumers cannot afford electricity consumption. Rather, the inclusive growth of the state demands the capability of every individual to bear the cost of basic necessities – like water and power.

[42] Government of India, Ministry of Power, Rural Electrification powermin.nic.in/rural_electrification/main.htm

Priority was given to pump set electrification, and not to household electrification. Occupation was given the priority over household. That is the reason we see a huge percentage of villages electrified, but a meager percentage of households electrified. Even the status of village electrification shows zero un-electrified villages but a lot of partially electrified villages[43]. RGGVY registers a village electrified even if electricity is provided to only some part of it for some time. The definition of village electrification as per the Ministry of Power, Government of India states that a village can be declared electrified only when at least 10% of its households are electrified. This 10% cap just to declare it electrified is inappropriate. 10 families receiving electricity from a population of 100 families is not village electrification.

This may increase the number of electrified villages, but the goal and need of total electrification remains distant.

Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY) was started in 2005 under Bharat Nirman, the ambitious national level infrastructure project by the Government of India. Village electrification increased from 74% to 91%, and rural household electrification increased from 43% to 56%.

RGGVY seems to have been established for the (comparatively underdeveloped) eastern states – Uttar Pradesh, Bihar, Jharkhand and Orissa. Out of the 105314 electrified villages (till 30.06.2012), 82324 - 78% - are from these four states. More surprisingly, out of the planned village electrification of 110887 villages (till 30.06.2012), 84492 - 76% - villages are from these four. Even if Maharashtra is a well performing state in terms of economy and urbanization because of well-developed urban centres in the western part (Mumbai, Thane, Pune, Navi Mumbai), the eastern and south-central parts (Marathwada and Vidarbha) of Maharashtra are still underdeveloped. The Yojana must reach the yet unreached parts of the whole country.

Agriculture consumers

Rain fed agriculture poses many difficulties to the farmer, as the untimely rain can undo all efforts and investment of the farmer, forcing him into debt and migration. Moreover the crops fetch low prices and therefore yield lower income. With assured irrigation, the farmer can grow high risk and value added crops like cotton or medium risk crops like paddy or low risk crops like sugarcane and earn a decent income. As health and education services are getting privatized and becoming more expensive by the day and social functions like marriages becoming expensive, the farmer is in need of guaranteed income. Assured irrigation and assured price for his produce is the farmer's necessity.

Electricity consumed by agriculture consumers rose to 30% from about 8% in 1975. The promise of "free power" to agriculture wins elections was demonstrated in the 2004 elections to Parliament and assemblies (Maharashtra & Andhra Pradesh). It is estimated that there are

[43] http://www.powermin.nic.in/bharatnirman/pdf/Electrification_Achieved.pdf

around 22,000 irrigation pump sets in Maharashtra. Around 26% of the total electricity used is for running of these pump sets. Government of Maharashtra has withdrawn free power to agriculture consumers in the state with effect from 1st June, 2005.

There exists a complex relationship between water supply and electricity supply on the side of the government, and one between rainfall and electricity consumption especially in the case of agricultural consumers. Efficient agriculture needs sufficient water and electricity is thus required mainly for pumping water. Only 17.9% of the state's cropped land is under irrigation as per the Economic Survey 2011-12. This makes almost 82% of cropped land depend extensively on groundwater. Just as dam storage or even the amount of precipitation is limited (although it varies slightly every year), groundwater is also limited. Inadequate water supply for farming through irrigation or by using check dams/bunds increases the pumping out of groundwater.

The number of energized pump sets in Maharashtra as on **August 31st 2012** is **38,09,586** where the 'Estimated ultimate groundwater potential in terms of electrical pump sets' as specified by the CEA is **24,49,800**.

Electrical Pump Set Potential – **24,49,800**

Actual Pump Set Electrification – **38,09,586**

55.5% more than advised groundwater exploited

Around 1977-78, MSEB started charging its agricultural consumers (for consumption of electricity by their electrical pumps) on the 'flat-rate basis,' instead of charging them for their actual metered consumption. This flat rate was fixed on the basis of the capacity (horsepower) of the pump. At the time, the number of agricultural consumers and the volume of the electricity used by them were quite small. As a result, the decision to stop metering their electricity consumption did not prove disastrous. The subsequent years saw a rapid increase in the number of agricultural pumps and also in their electricity consumption, which still was not metered. In the flat rate system the farmers were also given consumption subsidy which was availed by a limited number of farmers who were using excessive electricity to grow crops like sugarcane and which were fed with excessive amount of water. About 2 to 3% of total farmers in the state were members of large lift irrigation schemes and received substantial portion of the subsidy given to agriculture consumers (*As per survey conducted by Prayas in 1995-96*). Around 80% farmers did not have electric pumps and did not receive subsidy. Instead of decreasing the subsidy the politicians kept on increasing it. The needful farmers either got less or no subsidy at all and only a few rich farmers reaped the benefit. For the years 1995-96 to 1998-99 the MSEB (govt.) gave a subsidy of around Rs. 1500 crores, whereas in 1999 – 2000 a subsidy of Rs. 1600 crores was given. In 2012-13, subsidies worth Rs.2500 crore would be given to farmers by way of concession in electricity bill[44]. The present trend of power consumption in agriculture is ecologically unsustainable and ruinous to farmers, power utilities and the economy as a whole.

Energy for Cooking

It is important to pay attention to the energy needs of villages not only in terms of electricity but also for cooking. Villagers usually use traditional fuels mainly fuel wood, dung and agro residues as sources of cooking energy. They also have no / improper ventilation which creates indoor pollution causing health hazards by leading to a high incidence of respiratory infections and diseases among women and children mostly. Many alternative means have been designed and developed but these are not commercially viable. More research needs to be carried out to make lives better for the rural women.

[44] Government of Maharashtra, Department of Finance, Maharashtra State Budget, 2012-13

Problems

Load shedding

Power shortage kept on increasing from 10% during 2001-02 to 44.4% during 2007-08. In 2003-04, peak demand amounted to 13,279 MW, which required the shedding of 2,367 MW of load. During 2006-07, the peak demand of 16,388 MW was registered on 30th December 06, with load shedding of 3912 MW. During 2007-08, upto December, the peak demand (17,489 MW) was registered on 18th December 07 with load shedding of 4618 MW.

The minimum peak demand supply gap was 2726 MW in June 2011. In April 2011 and February 2012 – the summer months – when the demand is the highest, the load shed was observed to be the lowest (3250 MW).

To bridge the gap between demand and supply, the state utility has resorted to load shedding in recent years, resulting in disruption of lifestyle, loss of production and causing inconvenience to consumers.

In the year 2007 -08, since there were no rains, so the agriculture demand increased as water had to be pumped. The entire state except Mumbai faced load shedding. The industrial belt of Pune faced load shedding of 40hrs; rural areas for 12-14hrs; semi- urban areas for 8-9 hrs. This resulted in an increased demand for diesel in Pune, which resulted in its shortage. Industrial production also decreased by 16% (MCCIA).

Power shortage results in loss of production or requires use of expensive backup power for industrial consumers, while in case of residential consumers a shortage causes inconvenience with no direct economic loss. (A brief outline of the findings of the Godbole Committee report is given in *Annexure II*).

MSEDCL abides itself by a Load Shedding Protocol. It has classified regions in its jurisdiction according to Distribution and commercial losses and load is shed in direct proportion to the losses.

MSEDCL Circular 43: April 21, 2012

- Presently, load shedding is based on DCL – Distribution and Collection Loss (70% to Distribution loss and 30% to collection loss)
- Newly added parameters to decide on load shedding matters
    - LT distribution loss
    - LT collection efficiency
    - Revenue collection in ‘Ag’ category

Electricity Tariff and Subsidies

Electricity Tariff

Tariff rates on electricity differ among states and between consumer categories in each state. Moreover, state governments not only provide subsidies on tariff rates (by providing electricity to consumers at discounted rates), but also grant capital subsidies to the state utilities.

Consumers are divided into broad economic sectors, but for the tariff studies the following economic sectors are considered *viz.* domestic, commercial, industrial and agricultural. Each of these categories is further divided into sub categories based on their consumption levels. State electricity utilities calculate electricity tariffs on the basis of revenue required and sale forecast. These tariffs are regulated by regulatory commissions. So utilities approach State Electricity Regulatory Commissions (SERC) for approval of tariff rates. The approved tariffs mostly are lower than those requested by utilities. Peoples' participation through public hearing is conducted by SERC officials at district headquarters before final approval of tariffs.

The average tariffs in Maharashtra and other select SEBs is tabulated below. Between the consumer categories, the industrial sector pays higher tariff in comparison to other sectors. Amongst the domestic sector, consumers below poverty line pay lower tariff.

Table 18- Average tariffs in select SEBs (paise/kWh)

Year	07-08	08-09	07-08	08-09	07-08	08-09	07-08	08-09	07-08	08-09
State SEBs	**Domestic**		**Commercial**		**Agricultural**		**Industrial**		**Average**	
Maharashtra	**308.00**	**345.23**	**620.95**	**692.10**	**173.00**	**194.08**	**443.44**	**445.99**	**361.81**	**403.69**
Gujarat	305.31	379.45	487.82	563.91	119.52	197.49	458.00	537.72	337.31	417.84
Karnataka	319.19	320.73	276.39	268.93	72.87	82.32	467.23	469.27	305.62	303.42
Kerala	172.10	191.71	668.20	743.65	105.44	135.33	404.46	474.71	350.61	379.96
Tamil Nadu	153.07	165.17	606.30	616.23	0.04	0.04	455.01	457.90	296.66	290.69
Andhra Pradesh	242.90	240.23	586.59	575.88	8.17	861.00	365.45	373.98	254.15	251.60
Uttar Pradesh	187.08	157.18	374.47	358.49	162.95	153.06	432.63	431.81	268.40	266.36
All India	242.23	252.96	494.34	509.88	77.57	94.73	416.41	432.74	306.46	325.76

As can be seen from table 16, average tariff in Maharashtra is 15% higher, while Uttar Pradesh has tariff 14% lower than all India tariff. Average tariff in Karnataka was at par with the all India average tariff in the year 2007-08. In 2008-09 the average tariff in Maharashtra was higher by 19% than the average all India tariff.

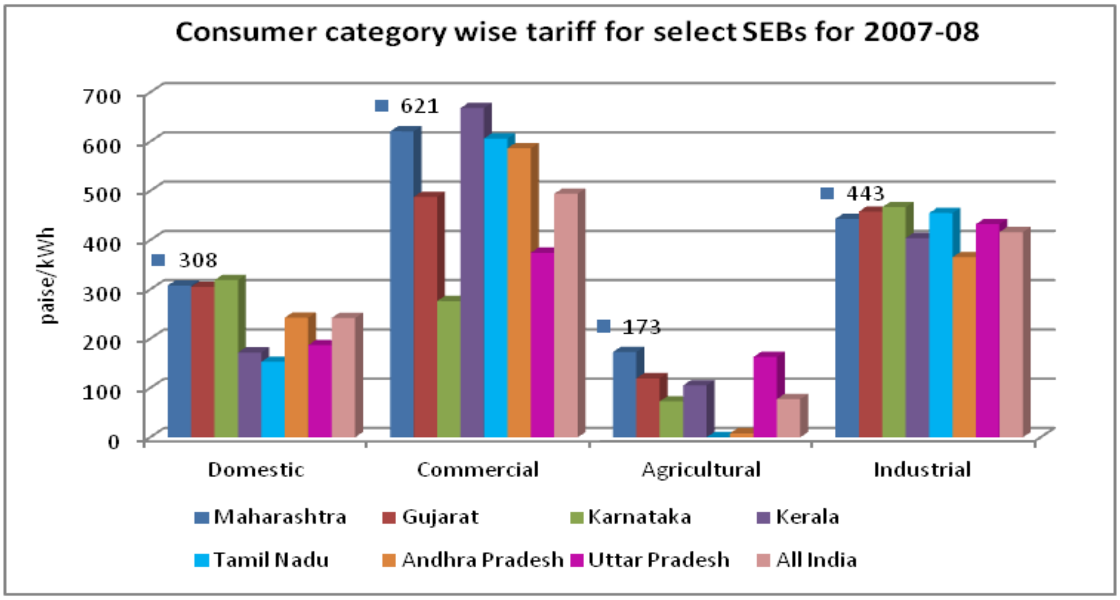


Figure 29 - Tariff across various economic sectors for select SEB (2007-08)

In the year 2007-08, in the domestic sector Jharkhand followed by Jammu and Kashmir and Tamil Nadu had the lowest tariffs. Rajasthan, Haryana and Karnataka have high domestic tariffs. Kerala has the highest tariff for commercial sector followed by Maharashtra and Tamil Nadu. For the agricultural sector, Tamil Nadu has lowest tariff followed by Punjab and Andhra Pradesh, while Assam has the highest industrial tariffs followed by Rajasthan and Karnataka. The lowest industrial tariffs are for the state of Jammu & Kashmir followed by Meghalaya and Uttarakhand.

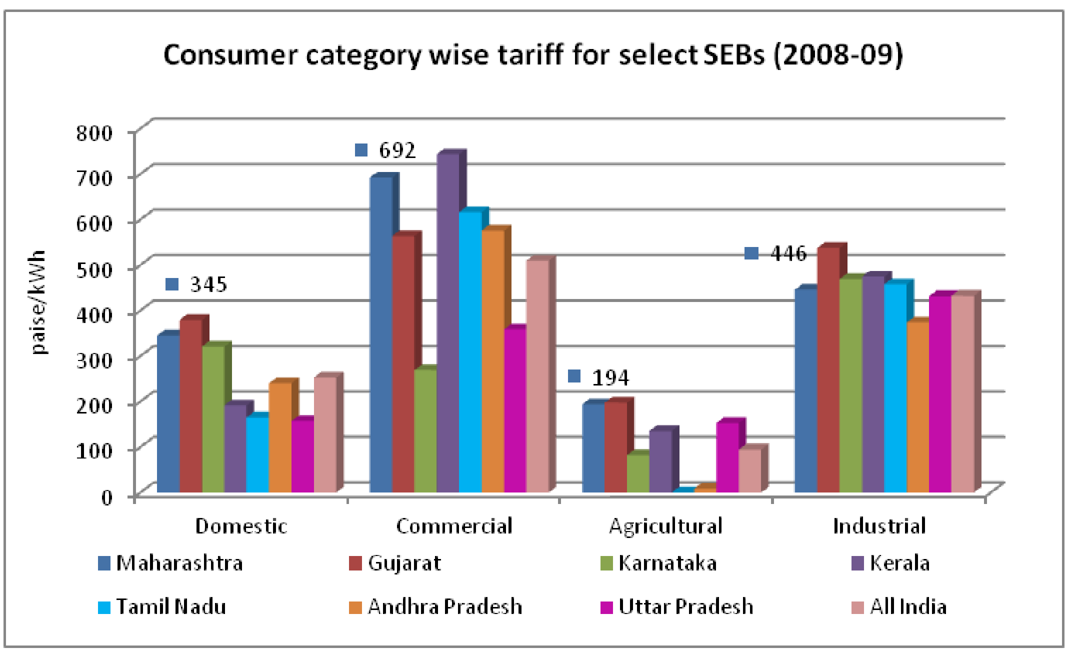


Figure 30 - Tariff across economic sectors for select SEBs (2008-09)

It can be seen from figure 29 below that the average tariff in Maharashtra for 2009-10 was higher by 29% than all India tariff.

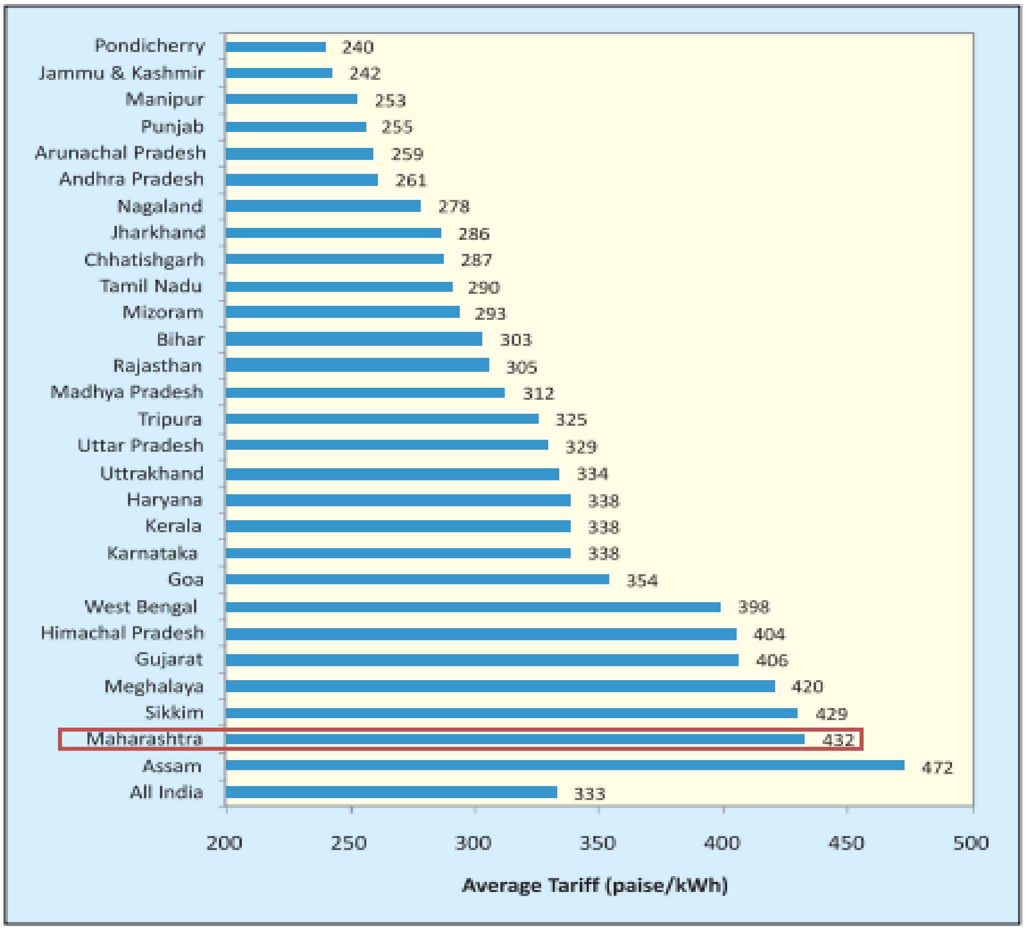


Figure 31- State wise variation in average tariff (paise/kWh sold) for 2009-10

Electricity subsidies

Subsidy is assistance provided to a business, economic sector or producers. A subsidy is viewed opposite of tax. Like indirect taxes, subsidies can alter relative prices and thereby affect decisions concerning production, consumption and allocation of resources in the industry.

Subsidy can be categorized into two types *viz.* full subsidy (paid out of the public exchequer) and cross subsidy (one group of customers pay for other groups). Cross-subsidies arise in the context of regulated price structures which distinguish between prices according to use/products for the same group of goods/services.

Agricultural sector in India consumed 29% of the power generated in 1999, but contributed to only 3.36% of the total electricity sales revenue. This pattern has been stable over the last two decades and, as such, industrial and commercial consumers of electricity have cross-subsidized power consumption of the agricultural sector (Gulati and Narayanan 2003). This is true for almost all states in India[45].

Subsidies for energy can be broadly divided under two heads *viz.* producer or consumer subsidies. Producer subsidies are provided to companies to encourage investment and increase output. Consumer subsidies support energy consumption by lowering prices at which energy products are sold.

Subsidies have multiple effects on government budget. The subsidy becomes a part and parcel of the government system, once started never to be removed.

Types of subsidies

- Grant and other direct payments
- Market price support
- Tax concessions
- In-kind subsidies
- Cross subsidies
- Credit subsidies and government guarantees
- Hybrid subsidies
- Derivative subsidies
- Subsidies through government procurement

Functioning of subsidies – regulated prices

Subsidy is – price support – price control. There are two primary forms of price control, a price ceiling (Price -cap), the maximum price that can be charged, and a price floor, the minimum price that can be charged. Commonly they are known as 'subsidies' and 'price supports'. The government controls price either by declaring "maximum price" or by "minimum price". Both the estimations are non-desirable as compared with free market equilibrium.

- Maximum price –price ceiling create shortages.
- Minimum price – price floor – create surplus.

Price controls are Governmental restrictions on the prices that can be charged for goods and services in a market. The intention behind implementing such controls stems from the desire to maintain affordability of staple foods and goods, to prevent price going up during shortages or, or price going down during surpluses.

[45] International Food Policy Research Institute: Discussion Paper 00716: Investment, Subsidies, and Pro-Poor Growth in Rural India; September 2007

In India and Maharashtra, we see price ceilings especially in markets of energy, petroleum products, staple food (Ration shops), and public transportation. In Maharashtra, Government Regulatory Authority (MERC) sets a maximum price that can be charged by the companies selling electricity in Maharashtra.

A price ceiling is a government-imposed limit on the price charged for a product. India/ Maharashtra Government put price ceilings in intention to protect consumers from conditions that could make necessary commodities such as electricity in this example unattainable.

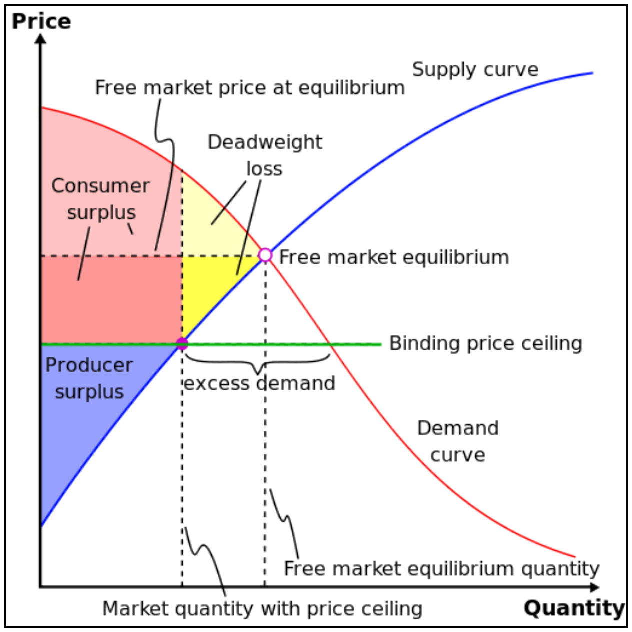


Figure 32 – Regulated price structure- Subsidy

When, Government of India / Maharashtra announces a subsidy on electricity /water pumps/ petroleum products (petrol/ kerosene /LPG, etc.), construction of greenhouses etc. it assures the consumer (the relatively poor sections of the society) a price 'below' the market price of the product. The sellers of this product have less incentive to sell because of low price. The consumers have the incentive to demand the relatively cheap products in more quantities, resulting in shortage of the product.

A price ceiling is often set below the free-market price (Figure 31[46]). This has several effects. Suppliers find they can't charge what they could charge in open markets. As a result, some suppliers drop out, thereby reducing supply. Meanwhile, consumers find they can now buy the product for less, so quantity demanded increases. Thus quantity demanded exceeds quantity supplied, creating shortage.

[46] Price ceiling, http://en.wikipedia.org/wiki/File:Binding-price-ceiling.svg

Beneficiaries (Supposedly) of Electricity Subsidy

The supposed target of subsidy – are poor sections of the society, who arguably cannot afford electricity at the given point of time. The residential consumers, or BPL consumer pay less, and industrial consumers pay more for the same unit of electricity. However, though it appears that the poor consume cheaper electricity, they have to bear the impact of increased prices of other energy related industry made products. The higher electricity bills of industries are passed on to the final consumer by raising the prices of their products. Thus the end consumer pays twice – once for the costly products – inflation, second the huge administrative cost – that goes into collecting taxes and redistributing them in various welfare schemes such as free or subsidized electricity.

Subsidies in the electricity sector in India

India originally introduced subsidies in the 1960s to support the green revolution, with major spending to (artificially) keep down the costs of fertilizer, irrigation water from public systems, and rural electricity - that drove many of the private irrigation pumps attached to wells. In addition India nationalized the main banks and directed them to provide credit to farmers at concessional interest rates. During the early phases of the green revolution payment of subsidies on inputs contributed to rapid expansion of production of cereals and thereby to poverty reduction, subsequently it is less clear that the subsidies have continued to do so[47].

Electricity pricing or lack thereof, emerged as a powerful political tool in the late 1970s during the post green revolution period. The trend between elections and electricity pricing began in Andhra Pradesh in 1977, when Congress party was the first in India to campaign on the basis of free power. By 1989, the government was spending 25% of total expenditure on agricultural electricity subsidies, and politicians were required to maintain these subsidies to either gain election or remain in power. In 2004, the Congress Party on Andhra Pradesh campaigned on free power.

During the early days of the electric power industry, both government and business favored utility regulation for manifold reasons. Regulation offered a risk free way to finance the creation of electric industry. Establishment of electric industry required large capital for infrastructure building. At the dawn of the electrical era, government guaranteed – businessmen who took risk – a fair return on their investment through 'regulated rates'.

Subsidies are introduced in the power sector both through cross subsidization among the different categories of consumers and budgetary support. Budgetary support becomes necessary because the SEBs have to show a three percent return on net fixed assets as stipulated in the Electricity (Supply) Act, 1948. But if they do not have the flexibility in

[47] Organization for Economic Cooperation and Development, Global Forum on Agriculture, Steve Wiggins, ODI; Jonathan Brooks: The Use of Input Subsidies in Developing Countries - Policies for Agricultural Development, Poverty Reduction and Food Security - OECD Headquarters, Paris, 29-30 November 2010

increasing the tariff rates to ensure this statutory rate of return, the concerned state governments have to provide necessary budgetary support[48].

Expenditure on electricity subsidies for agriculture, an input subsidy aimed at improving agricultural productivity and the incomes of the agricultural work force, exceeds that spent on health or education[49].

According to a report by Power Finance Corporation Ltd "Performance of State Power Utilities for the years 2007-08 to 2009-10", 89 utilities in the country earned Rs. 1,90,948 crore in the year 2009-10. However, their total expenditure was higher by 75.74% - to the tune of Rs.2,52,125 crore.

Table 19 - Income, expenditure and cost recovery of 89 utilities

	2007-08	2008-09	2009-10
Total income excluding subsidy (Rs. Crore)	1,49,622	1,71,639	1,90,948
Total expenditure (Rs. Crore)	1,83,595	2,23,403	2,52,125
Recovery of cot (%)	81.50	76.83	75.74

It can be seen from the graph below that the subsidy released by the government is lesser than the subsidy booked by the utilities.

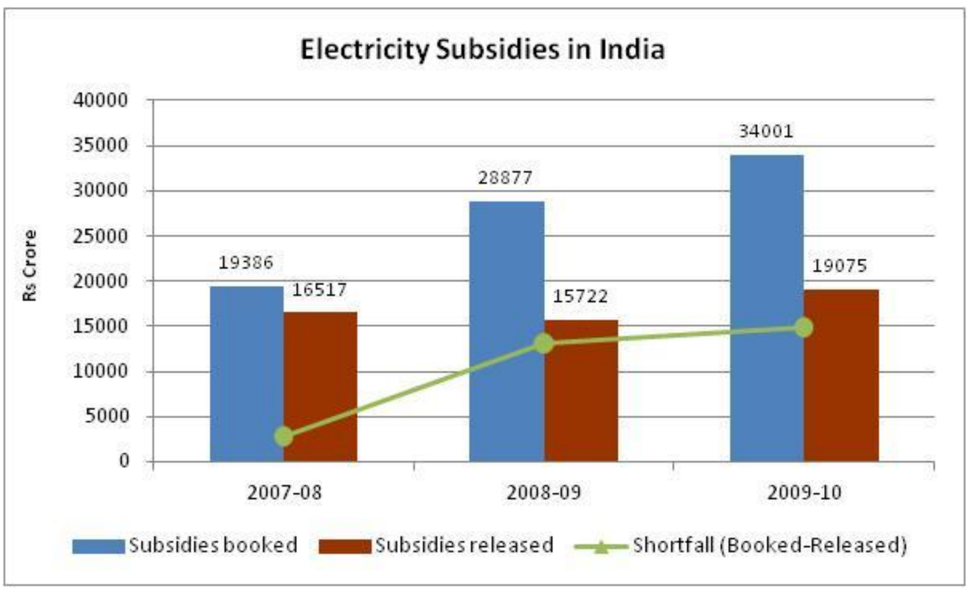


Figure 33-Electricity Subsidies in India

[48] National Institute of Public Finance and Policy - Budgetary Subsidies in India Subsidizing Social and Economic Services
[49] http://www.ncsu.edu/cenrep/workshops/TREE/documents/Jessoe_electric.pdf

With rising fuel costs - a pattern that may be aggravated by deficient rainfalls and the resulting increase in dependence on thermal power- this trend of increase in the subsidy support is likely to persist for the distribution utilities.

Impact of electricity subsidies[50]

Impact to the State

- Providing subsidies in the electricity sector decreases government revenue.

Impact to the utility

- SEBs attributed losses to agriculture as it could not be measured. It is estimated that about 30 to 40% of the consumption shown against the agricultural sector is an overestimate. This means that losses even in industry, which was happening on account of a nexus between the ground staff of the SEBs and the errant consumers, were being put on the account of agriculture since the agriculture sector had no meters or had defective meters.
- Lower revenue generation from agricultural sector (9.4% of the total revenue for the year 2010-11), so limited interest in serving this sector.
- Due to cross subsidy most of the industrial and commercial consumers have started showing their dissatisfaction and are moving towards captive generation technologies and direct purchase from generators, leaving the utilities in further financial distress.
- Subsidies often promote inefficiencies. The utilities become financially weak with declining service quality, as subsidies are not often funded adequately.
    - SEBs push most of the losses on agriculture sector, as most of the billing is on a flat rate based on pump set capacity, thereby hiding their inefficiencies.
    - Subsidies may promote inefficient use of resources and indirectly raise the cost of service provision.
    - Poorest sections of the society are worst affected as they lack access to service and have to generally depend on other high cost alternatives.

Impact on farmers/ agricultural consumers

Subsidy not only damage utilities' efficiency and state government finances, but also has a negative impact on the farmers. Overuse of water, induced by subsidized electricity has led to soil degradation, soil nutrient imbalance and ground water depletion, which may result in a decrease in

[50] http://planningcommission.nic.in/reports/genrep/arep_seb11_12.pdf

- Electricity subsidies enable agricultural users to access electricity at prices below the marginal cost of supply, thereby lowering the cost of irrigation and groundwater extraction. This induces farmers to grow more water intensive cash crops resulting in extensive extraction of groundwater. Overuse of groundwater led to the depletion of this limited resource.
- Subsidies provided are mostly cornered by well-off farmers who have resources to invest in irrigation infrastructure.
- Due to lower revenue from agricultural consumers, the quality of power gets hampered. The irony, however, is that the farming community in general is willing to pay the required tariff for receiving good quality power. Poor quality has indirect cost for farmers. Frequent breakdowns result in water being unavailable during peak irrigation times when it is most needed. This poor service creates the need for investment in backup facilities like diesel pumps. It also impairs pump operating efficiency resulting in financial costs for the farmers. Low voltage also results in motor burn out for which the farmer has to spend money and time.

Though there has been a consensus among Indian policy makers to phase out electricity subsidies in the agricultural sector, there is stiff resistance to attempts made in this regard. As has been discussed earlier, subsidies are captured by a small group and do not benefit the intended beneficiaries. Electricity consumption by the agricultural sector needs to be rationalized.

Lacunae in the System

The energy sector, particularly the power sector has several; influences from the political sector, be it setting up of power plants or distribution of electricity. Other than this there are several drawbacks in the system cited below.

- Politically influenced sector
- Most of the politicians and industrialists don't pay electricity bills. No strict measures are taken against these defaulters.
- Poor revenue generation/ bill collection
- Theft of power - This is a major drawback and details of theft record are also not maintained. No strict measures are taken as well which increases the menace. Theft includes stealing of power as well as tampering with the electricity meters.
- Un-metered power supply to farmers - Improvements in the tariff structure by metering the agriculture power supply instead of a flat rate. Prevent politicians from declaring free power and high subsidies to the agriculture sector to win elections. This results in lack of accounting for electricity generated, distributed and consumed.
- Free power to the agricultural consumers – As the power sector is politically influenced, free power and subsidies to farmers becomes a large vote bank for the politicians. Free power does not improve the efficiency and additional problems arise. Farmers tend to pump a large amount of groundwater or practice flood irrigation. This results in problems such as salinity and water logging and a large wastage of a precious resource like water.
- Scrap plants installed by foreign energy investors - When companies like Enron invest in the power sector in India the material they use to set up the plants should be verified before installation and the set up should be of good quality and not scrap. As in the case of Dabhol, wherein discussions with MSEB officials it was noted that the scrapped plant was installed as a result not all the gas is used for power generation due to leakages
- Operation and maintenance of plants. The age of plants and leakages or any other problems thereof
- Five year plan targets not met
    - 9th Plan (1997-'02) target of 40,245 MW while capacity addition was about 21,000 MW; private sector target: 17,589 MW vs. a realized addition of 6,735 MW
    - 10th Plan (2002-'07) target 41,010 MW, revised down to 36,956 MW, Commissioned: 13,416 MW
    - 11th Plan (2007 -12) target of 78,700 MW was planned while the actual achievement has been 54,963 MW[51].

[51] Government of India, Planning Commission, Power and Energy Division, Annual Report on the working of State Power Utilities and Electricity Departments, 2011-12; Government of India, Ministry of Power, Central Electricity Authority, Operational Performance of Generating Stations, 2011-12

Projections

Future Electricity Demand in Maharashtra

Economic growth is a key driver for energy demand. Future energy demand is determined by these factors:

- Increased population growth that will compete for all kinds of depleting resources
- Accelerated Urbanization
- Increasing energy use
- Climate change
- Sustainability

The fast rate of economic growth of the state has proved wrong the projections made on energy demand by experts. Several industries/ SEZs are coming up in Maharashtra and meeting their power needs poses a major challenge. Current power generation relies mainly on burning fossil fuels. As coal supplies are available at present in the country, coal fired power plants dominate the energy sector. However, there is an urgent need to tap alternate source of power generation to meet the growing needs of the increasing population. In the current scenario of growing population, rapidly changing life styles and phenomenal growth in energy demands, finding renewable and environment-friendly sources of energy is being increasingly felt critical to sustainable development. In addition to this, it is necessary to use energy efficient equipment that uses less energy. It has been seen that the demand is always more while the availability is less.

Peak demand projections

The peak demand increase on an average by 6% every year, based on which future peak demand projections are calculated till 2035.

Table 20 - Peak demand projections

Year	Peak Demand (MW)
2009 (up to Dec 2009)	15,988
2010	16,947
2015	22,679
2020	30,350
2025	40,615
2030	54,352
2035	72,736

The peak demand in 2009 up to December 2009 was 15988 MW and the peak demand in 2035 is projected to be 72,736 MW.

Electricity Consumption projections

Total electricity consumption in Maharashtra shows a CAGR of a 7.8% growth in electricity consumption is seen every year, for the past 6 years. Considering the same annual growth rate for the next 13 years, the total consumption in the year 2025 would be around 2,32,000 MU. And the per capita consumption would be around 1850 units per year.

Table 21 - Growth rate of electricity consumption

Year/ Consumption (MU)	04-05	05-06	06-07	07-08	08-09	09-10	10-11	CAGR
	55684	59287	62085	69838	72994	79139	87397	7.8%

Table 22- Population growth (1961-2011)

Year	Population	Growth/year
1961	39554000	
1971	50412000	1085000
1981	62784000	1237000
1991	78937000	1615000
2001	96879000	1794000
2011	112373000	1549400

Population growth year on year increased till 2001. But late in the first decade of this century, the population growth receded from the previous year on year (y-o-y) growth.

According to the United Nations Population Fund (UNFPA) report, population of Maharashtra will grow to around 120 million in 2016, a rise of 8 million from 112 million in the five-year period 2011-2016. Considering a stable rise in population in the consequent two five-year periods 2016-2026, the population can be projected to be 136 million in 2026. The same has been considered as the population in 2025 for the projection of electricity consumption.

Table 23 - Projection of Electricity Consumption (2025)

Year	2011	2025
Population	112372972	136000000
Total Consumption (MU)	87397	232000
Per Capita consumption (kWh)	778	1700

Electricity Sources for the Future

Alternate Sources of Energy

The use of coal in power generation has negative impacts. In addition to the environmental and social consequences of coal mining, coal-based power generation contributes significantly to local (and regional) air pollution through the emission of particulates, sulfur and nitrogen oxides in stack flue gases, and water pollution through release of waste heat and effluents. In the recent years the efficiency of coal based power plants has improved but it still remains low in absolute terms. Moreover, there are no fixed patterns in heat rates in terms of seasonal variations, and, in many cases, there is little or no correlation of heat rates with plant load factor (PLF). Large hydropower projects also cause social and environmental problems such as displacement of people, submergence of fertile lands and forests as well disturbance to the fauna and their habitat.

The solution to future energy needs lies in greater use of renewable energy such as wind, biomass, solar, tidal, small hydropower as they rely on inexhaustible natural sources for their fuel and do not create pollution.

Hydropower is widely used for decades; however other renewable technologies have yet to make a mark in the market. These sources produce little or no greenhouse gases. Most of these technologies are at an early stage of market development, so their costs are generally higher than the already existing conventional system. A step has already been taken in the direction as solar and wind power generation is already in use but is costly. The economics will improve as they develop technically in the years to come.

The Government of Maharashtra established MEDA (Maharashtra Energy Development Agency) in 1985 to undertake development of renewable energy and facilitate energy conservation in the State of Maharashtra. There is a vast potential for renewable energy, especially in areas such as solar power, biomass and wind power. These renewable sources will reduce our dependence on fossil fuels and large hydropower projects and also gain carbon credits by reducing carbon emissions.

Wind power

Wind has been the fastest growing energy technology in the world for the past decade. In 1999, the world wind industry installed a record amount of new utility-scale wind generation equipment, more than 3,900 megawatts (MW). Total wind installations have increased with an average of 40 percent annually from 1995-1999 to nearly 14,000 MW worldwide. Wind energy has only recently gained a foothold in India, and is now well-recognized as a viable alternative source of energy in many states.

Large-scale wind farms provide power for national electrical grids, whereas small individual turbines are used to provide electricity to rural areas and locations outside the electrical grid.

Wind power potential in Maharashtra is 4584 MW with 31 potential sites. The state has taken up a leading position in wind energy projects in India with around 800 windmills installed in Satara, Sangli Ahmednagar, Dhule, Nasik and Nandurbar having an installed capacity of 1373.93 MW. (Refer *Annexure I* for list). During 2006-07, 1663 million kWh of energy was generated by these projects. Asia's single largest wind farm is developed in Dhule district with an installed capacity of 545 MW.

Studies conducted by Down to Earth, have revealed that Maharashtra is not wind energy capacity to its full potential. Though incentives are reaped power generation has not increased which needs to be changed. Currently wind energy policies are more incentive based than performance based. A huge incentive is offered on the installed capacity; however, the need is to provide such incentives and rebates on the power generation capacity.

Small Hydropower

Hydropower is a renewable, non-polluting and environmentally benign source of energy. It is perhaps the oldest renewable energy technique known to the mankind for mechanical energy conversion as well as electricity generation. Of the total installed capacity in India, 33,194 MW belongs to hydropower. Hydropower power projects are categorized as large and small hydro, with projects upto 25 MW station capacity being Small Hydro Projects (SHP).

India has a century old history of hydropower and the beginning was from small hydro. The first hydro power plant was of 130 KW set up in Darjeeling during 1897, marked the development of hydropower in the country. With the advancement of technology, and increasing requirement of electricity, the thrust of electricity generation was shifted to large size hydro and thermal power stations. Small hydro projects are economically viable and have relatively short gestation period. As on 31.3.08, Maharashtra had 27 projects with 207.08 MW capacity. The advantages of hydro power include minimal pollution levels, good reliability compared with other renewables, low operating costs, and cost competitiveness with fossil-fuel power generation.

Biomass

Biomass energy accounts for nearly a quarter of total primary energy consumption in India and further it accounts for over 70% of rural energy consumption pattern. Biomass resources for energy consist of fuel wood, crop residue (agricultural by product), vegetable oil and cattle dung. Biomass can be used to generate power by way of combustion and gasification. Industrial as well as agricultural biomass could be used. Energy from biomass can be used in the villages as agriculture residue is available in plenty. Biomass gasifier can be used to produce clean power.

The potential of grid quality power from surplus biomass material in the State is 781 MW. The MSEDCL has signed energy purchase agreement with 24 biomass developers having total capacity of 268 MW. These projects are likely to commission in the year 2008-09.

Solar energy

Solar power harnesses the natural source of sunlight to generate electricity. The solar industry can be divided into two general types: a) solar photovoltaics (PV) are used to generate electricity. b) Solar thermal uses heat from the Sun to generate hot water. These systems could be grid connected or standalone local grid solutions. In certain rural places particularly for communities with widely separated houses, solar power systems prove to be an attractive option for rural electrification schemes. Some tribal villages have been made self-sufficient by use of solar technologies and energy efficient lighting.

Technology in the solar industry is growing and improving at one of the fastest paces of any renewable energy sector.

Bagasse based energy

Bagasse based cogeneration is extensively used by the sugar industry, where the fuel sugarcane residue is available virtually free for the captive unit. In this process the sugar mills generate sufficient power to sell the surplus to the grid after meeting their own requirement.

Challenges Ahead

Humankind has faced a daunting set of challenges at every age, but today's generation has to deal with unique challenges. Even as large numbers of people enjoy unprecedented levels of material prosperity, a greater number remains mired in chronic poverty, lacking access to the most basic amenities and with minimal opportunities for social and economic progress. Energy is critical to human development and connects in fundamental ways to these challenges.

In many developing nations energy is a growing concern among businesses, governments and consumers. The main concern is that the energy-supply infrastructure will not keep up with the increasing demand, thereby becoming a constraint to growth. The conditions in global energy markets are also aggravating the situation, with high and volatile prices and supply risks from weather-related shocks, political uncertainty, or evolving greenhouse gas (GHG) regulation. Governments and businesses are exploring ways to resolve the challenges they face and ensure that insufficient energy supplies will not halt sustained growth. By 2030 India is expected to overtake Japan and Russia to become the third largest global consumer of energy. However, if consumption follows the current pattern and trajectory, the country is projected to run out of coal, its primary source of energy, in forty years. Furthermore, its domestic reserves of oil and gas are limited. Imported coal is more expensive than domestic coal as it requires additional investments in roads and railways, which would thereby raise the cost of power generation[52].

After independence, the Indian Government created the National Planning Commission (NPC) and began its full-scale experiment of national-level economic planning with objectives of domestic self-sufficiency, rapid increase in the standard of living of Indian people, decreasing economic inequality and poverty and instituting a socialistic pattern of society. Electricity was viewed as a crucial instrument for social development in India and a rigid control by the government was considered essential for meeting the objectives. Private companies providing electricity were considered unacceptable, as they would focus on areas with greatest demand – cities and urban areas – thereby neglecting rural areas due to meagre return on their investments. This was considered inequitable so the government aimed its policies to provide cheap electricity to villages and rural areas, which would help increase electricity access and demand for irrigation and village-based small scale industries. In order to promote agriculture, agricultural tariffs were lowered and then in 1980s, agricultural pumps were de-metered.

It was seen that the direct benefit of subsidising fertiliser and under-pricing power and water mainly went largely to fertilizer producers and high income farmers. Under-pricing water and power has a negative effect on the environment, production and on the small income farmers. De-metering agricultural pumps motivates to farmers especially the larger ones to cultivate water intensive cash crops for which they pump water from deep wells at a relatively low cost. This has led to miscalculation of distribution losses by the distribution companies (state

[52] Energy Security Series: The Brookings Foreign Policy Studies, India, pp. 14

electricity boards) as the distribution company passes off the distribution losses on irrigation pump sets in order reduce the distribution losses[53].

The 1990-1991 economic crisis faced by India provided an opportunity for unshackling the economy by de-licensing a number of sectors and subsequently the power sector was opened for private investment including foreign investment. Private investors were expected to produce electricity for sale to State Electricity Boards, which would control transmission and distribution. However due to very low tariffs to certain categories of consumers as well as heavy T & D losses and thefts, the SEBs were financially weak and the private investors' feared non-payment. So they insisted on arrangements that guaranteed purchase of electricity by the State governments backed by additional guarantees by central government. In 1991, the government amended the Electricity (Supply) Act 1948 to allow private companies own power plants and generate electricity as Independent Power Producers (IPPs). In Maharashtra, Dabhol power plant is the output of the 1991 IPP liberalisation. The state generation utilities did not take efforts to increase power generation or upgrade old worn out units or make considerable efforts in increasing green energy sources or reduce distribution losses or conserve energy. The multiple effect of the lack of efforts from the state utilities resulted in demand outpacing supply, thereby leading to power shortage which was curbed by load shedding.

The growing economy and changing lifestyle have increased the demand for electricity. In the past decades power generation was not increased and the MSEDCL lost a huge client base, as most of the industries opted for captive power generation. Maharashtra state has a power shortage of 3000-5000MW. To meet the ever increasing demand the immediate stand taken by the government is "build new power plants in large numbers". So Maharashtra State government has proposed an allowed an ambitious target of around 68,980MW of power generation from 57 power plants across Maharashtra. These power generation plants are state, central or privately owned. The share of private power has increased due to de-licensing of thermal generation and removal of restrains from captive power generation as per the Electricity Act 2003. Most of the projects are facing problems in acquiring land. Considering the delays in land acquisition for power projects, the state Ministry of Power has invoked an emergency clause for faster land acquisition for the proposed nuclear power project (Jaitapur) in the state.

Constructing new power plants requires vast tracts of land and water. In quest for making the State power self-sufficient and / or surplus; agricultural land is being diverted for setting up power plants. If all these projects were to take off, Maharashtra's generation from the new plants would be roughly around 47,000MW by year 2014. The new power generation also includes up-gradation of 3090MW of MahaGenCo Chandrapur, Parli and Koradi thermal power plants. These power plants are taken up for upgradation under the National Renovation and

[53] Economic and Political Weekly: Anjana Das and Jyoti Parikh: The Political Economy of Power; Vol. - XXXV No. 14, April 01, 2000

Modernisation program launched by Government of India, Ministry of Power with assistance from the World Bank.

The energy (electricity) sector has wide scope for improvement in areas ranging from scientific demand forecasting, improving efficiency of existing power plants, demand side management measures, using energy options (green energy) that limit environmental degradation and preserve the integrity of natural systems, etc. Accurate forecasting of demand is very crucial for planning investments in the energy sector. To forecast demand there are several aspects that need to be studied scientifically and accurately. It is necessary to know the precise T&D losses, for which it is of importance to know the power consumed by all categories of consumers especially the agricultural consumers. This would necessitate metering of agricultural pumps. It is also necessary to precisely calculate the revenue losses due to non-payment of bills and theft of electricity.

There is a disparity in access to electricity between urban and rural areas. The development is urban centric and the attention of power utilities is more focused on the urban centres. More and more power is pulled by the urban centres whereas most of the rural areas lurk in darkness. In spite of most of the power generation plants being located in backward or underdeveloped regions of the state; these regions face more power cuts. There are many places in rural Maharashtra that are not even connected to the power grid, whereas in some places the transmission and distribution network exists, yet there is no power supplied. In some tribal areas large amount of finances have been wasted to construct the necessary distribution network infrastructure; yet these regions continue to lurk in darkness.

At present several energy prospects - state owned and private - have been undertaken across the state. It is necessary to evaluate the cumulative impact that these power projects (thermal and nuclear) will have in the long run and take up only as many projects as are essential and realistically feasible. Along with this, it is necessary to explore and develop alternate sources or renewable sources of energy, and also crucial to conserve and use energy efficiently by bringing down T&D losses up to the international standards (6% and 8% respectively). This can be achieved by eliminating thefts as well as improving revenue collection. If the State has to be free from load shedding and provide power to all it would be imperative to bring a paradigm shift in the power sector rather than continuing with the business-as-usual (BAU) scenario.

The BAU scenario in the State based on the polluting and depleting fossil fuels and nuclear fuels is ecologically and socially unsustainable. Witness to the unsustainable energy growth in the State is the large number of projects (coal based and a major nuclear powered) undertaken in the State. Large tracts of fertile land or forest and water will be diverted for these projects. Before planning new generation units, it is essential to take into account both the short term and long term consequences of energy use.

The BAU approach taken by the state will result in loss of livelihood, pollute the ambient air and degrade the land quality. The path for our future energy use has to be paved on energy sources that will be cleaner and will have a minimal impact on the environment and climate.

There are several challenges that need to be tackled in future. Few of the critical future challenges are listed below.

- Increased population growth that will compete for all kinds of depleting resources
- Accelerated Urbanization
- Rise in standard of living
- Increasing energy use
- Climate change
- Sustainability

All these challenges will impact the energy sector (generation, demand and supply). Proactive measures need to be taken in order to deal with these challenges. There is a need for rapid growth to meet developmental needs in order to ensure energy security. The emphasis must be on cleaner power generation including limiting carbon emissions.

There is no single solution to meet these challenges. Finding new methods for producing energy, particularly blend of conventional and renewable sources of energy, is of utmost importance in tackling problems related with population growth. Considering the urban rural divide in terms of electricity supply and infrastructure development, the solutions that would work in an urban centre may not work for its rural counterpart. The same applies for electricity demand in terms of variability according to time of day and year.

The Way Forward

There is an urgent need for a paradigm shift in our energy policy. Rather than generating millions of MW of additional capacity based on thermal and centralized power supply system, we need to adopt an *'Integrated Energy Resource Management (IERM)'* approach which will have renewable energy sources, energy efficient technologies, demand side management measure and decentralized supply systems at its core.

The state of Maharashtra has to progress towards a sustainable energy future. The state should not only become energy self-reliant but also power surplus and be able to sell the surplus power outside the state and earn profits out of it.

Current energy habits must change in order to reduce significant public health risks, avoid placing intolerable stress on critical natural systems, and to manage the substantial risks posed by global climate change. Four thrust areas have been identified as follows.

Upgrade and optimise efficiency of existing State owned power plants;

Strengthen transmission & distribution (T&D) network (Smart Grid);

Increase green energy sources and promote decentralised off grid power generation; and

Energy conservation across economic sectors

These priority areas are dealt with in detail in the subsequent chapters that follow. The first chapter "Upgrade and optimise efficiency of existing State owned power plants" covers various aspects related to existing state run thermal (coal fired) power plants in the state. The thermal power plants in the state are aging and it is necessary to upgrade them so that their efficiency can be improved, energy output increased and emissions reduced. Improved efficiency will also help in conservation of fuel. A list of the state run (thermal) power plants and their efficiency is also provided and the factors that have contributed to the reduced efficiency have also been included. It was understood that coal quality and supply play a major role in the efficiency of power plants. More so ever coal will continue to dominate the power sector in the years to come. Taking into consideration these factors a report on coal supply, quality and the market scenario is also included, in this chapter with special distinction.

The second chapter "Strengthen transmission & distribution (T&D) network (smart grids)" deals with losses in energy when it is moved from the source of generation to large distances and the final delivery to the source. Technical and commercial aspects are responsible for losses have also been covered. Various solutions that would bring down T&D losses have been explored. The chapter also explains the concept and current status of smart grids.

The third chapter "Increase green energy sources and promote decentralised off grid power generation" explores the green and clean sources of energy and the potential for each of the sources. It takes into consideration various initiatives to promote clean energy such as cogeneration from sugar factories, promoting solar power, wind power, etc. and incentives offered for investments in renewable sector. It also explains the benefits of decentralised generation especially in rural areas to ensure assured power supply.

The fourth chapter "Implement measures for energy conservation" identifies various initiatives taken at the national and state level such as institutions set up, schemes, incentives, subsidies, etc. to promote energy conservation measures. It also provides potential energy savings across various economic sectors in the state. It introduces the latest trends in energy savings in the construction industry such as green buildings.

Solution 1

Upgrade and Optimize Efficiency of Thermal Power Plants

Goal - Identify techniques for up-gradation and efficiency optimization to achieve maximum potential of state owned power plants

Introduction

In the early 1950s and 1960s the government plans centered on co-developing irrigation and power sectors, and there was greater emphasis on hydroelectricity. But these hydropower plants were suffering from low generation as water resources depended heavily on the erratic monsoon. So the focus was shifted to generation of electricity from coal. Other than this there were several other reasons for shifting focus to coal based plants such as construction time, delays in civil works, and resistance from local groups against the construction of large hydroelectric dams as they led to large scale displacement, etc.[54] By the early 1970s the government had to rely much more on indigenous coal, especially since the global oil crisis made the use of indigenous coal relatively cheaper. This forced the government to emphasize coal usage in many energy intensive sectors, including electricity generation[55]. This resulted in a rapid increase in coal based capacity.

Coal based power plants are and will remain in the forefront as they provide cheap power. These plants have high capital costs and low variable costs and produce continuous, reliable, efficient power at low cost. They often take a long time to start up and are relatively inefficient at less than full output. These plants run throughout the year except in case of repairs or scheduled maintenance. Their reliability to provide base demand (*i.e.* to continuously supply electricity to consumers) helps keep their operation costs low and offers stable, attractive pricing through long term agreements. The rule of thumb is that base load power is usually 35–40% of the maximum load during the year.

Coal based plants would continue to dominate the energy market for the foreseeable future considering the increasing demand for electricity, current standing of renewable energy and construction time taken for setting up new power plants. Bridging the demand supply gap is a serious problem as supply is not increasing in proportion to the demand. The burgeoning demand for power has long outstripped supply. In this context it is of utmost importance to improve the efficiency of the existing coal fired power generating units. It is also necessary that new power plants should function efficiently and be well maintained.

Maharashtra state had a remarkable growth of 14.23%[56] in the financial year 2010-11. To support this growth, uninterrupted and quality power would be crucial. Considering the growth graph of the state, large scale capacity additions are in the pipeline (*Annexure III*). Though these capacity additions may seem impressive, there would be shortfalls due to a variety of factors such as obtaining environmental & governmental clearances, land acquisition, water allocation,

[54] Energy Technology Innovation Policy, A joint project of the Science, Technology and Public Policy Program and the Environment and Natural Resources Program, Belfer Center for Science and International Affairs – AP.Chikkatur & AD.Sagar: "Cleaner Power in India: Towards a Clean-Coal-Technology Roadmap" pp. 31

[55] Harvard University, Kennedy School of Government, The Pew Centre on Global Climate Change Coal Initiative, AP.Chikatur: A Resource and Technology Assessment of Coal Utilization in India, Cambridge, October 2008, pp. 20

[56] http://planningcommission.nic.in/data/datatable/0904/tab_104.pdf

fuel constraints; as witnessed earlier, shortages of construction equipment, which would leading to delays in the commissioning the projects.

Coal supply and quality pose major issues. Indigenous Indian coals exhibit high ash content (35-40%), high levels of silica and alumina, and are highly abrasive. Average coal consumption is estimated at 5,000 tons/MW, which is higher than most imported coals because of a low heating value (3,500 kcal/kg) and high ash content. The total coal demand for power generating plants in India was 625 million tons (MT) in the year 2010-11 of which 90 MT coal was imported. The 12th Five Year Plan, projected annual coal requirement increases to 842 MT and the estimated domestic coal availability is 700 MT by 2016-2017 thus India's dependence on imported coals is expected to increase to 142 MT annually.

Escalating coal prices have disrupted a number of new coal plants. Tata Power Company's 4000 MW ultra-mega thermal power plant in Mundra on imported coal would supply at Rs. 2.26 per unit for the next 25 years. This arrangement worked till coal prices were in the range of US $30-40 per ton. Coal costs surged to US $110-120 per ton, distorting the supply side costs. Reliance Power's 4000 MW Krishnapattanam project and JSW Energy's 2000 MW project at Ratnagiri are delayed due to the same reasons. However, the dominance of coal in the country's energy mix is not likely to change till 2031-32[57], and the same scenario will prevail in Maharashtra, though rising coal prices coupled with inefficiencies in coal supply and coal quality continue to paralyze the electricity sector.

Since the state's power generating company (MSGPCL) contributes a large share in power generation, the focus is primarily on suggesting processes necessary to optimize the efficiency of MSGPCL power plants. Higher efficiency in power generation is an important aspect of energy security. It reduces environmental costs and lowers the cost of electricity.

[57] Government of India, Planning Commission, Integrated Energy Policy, August 2006

Efficiency of Coal-Fired Thermal Power Plants

A coal fired thermal power plant consists of the following mechanical equipment. These are the actual machines installed in a coal power station. To increase the efficiency of coal power plants, it is essential to maintain and monitor the performance of all the machinery involved in a synergistic manner.

Table 24: Mechanical equipment of a power plant

Coal conveyor	Electro Static Precipitator	Cooling tower
Coal hopper	Cooling water pump	Low pressure steam turbine
Coal pulverizer	Cooling tower	Steam Control valve
Boiler steam drum	High pressure steam turbine	Surface condenser
Bottom ash hopper	Intermediate pressure steam turbine	Condensate pump
Boiler	Cooling water pump	Electrical generator

There are some common problems associated with power generating units which collectively affect plant output. Most of the problems arise due to the use of fuel which is not as per the design standards but is of lower grade.

- Boiler leakage is the most common problem affecting the performance of thermal power generation units in Maharashtra. Analysis of Daily System Reports released by Maharashtra State Load Dispatch Centre (MSLDC) provides details about ongoing planned outages and sudden forced outages each day. It is seen that forced outages occur maximum times due to boiler tube leakage as compared to other reasons. MSPGCL monitors boiler tube leakages daily and has a separate portal for the same[58]. MSGPCL officials revealed that the boiler tubes get damaged more or less due to poor coal quality. Ash and other impurities intrinsic to Indian coal cause cracks to the boiler tubes and eventually damage them.
- Coal pulverizer is susceptible to inefficiency as its blades and churners face impurities like stones in the coal frequently. In addition to stone content, the inefficient pulverization increases the Specific Coal Consumption (SPCC). One of the reasons for private power plants' efficiency is good quality coal which is always unadulterated.
- Clinker gets formed in the boiler tubes primarily due to poor quality coal *viz.* low gross calorific value, higher ash content, presence of stone, shale and sand, etc. the impurities in coal get deposited on the inner sides of boiler tubes that carry water and steam (or any high pressure fluid). It happens more in case of pipes catering steam to low pressure turbines. Clinkering reduces efficiency of boilers and may also cause leakage to boiler tubes.

[58] http://www.mahagenco.in/BTLManager/login.php

Primary Performance Parameters of a Power Station

Operating Availability (Av)

Operating availability of a power generating station in a year is defined as

$$Av = T - PO - FO$$

T-Total time in a year; PO - total duration of planned outages; FO- total duration of forced outages

Plant Load Factor (PLF)

It is the most important performance parameter of a power station. It is the efficiency with which electricity is generated as against the installed capacity of the generating station. (Availability (Av) is a subset parameter of the PLF)

Forced Outage

Forced outage is unplanned stoppage or sudden breakdown that occurs in a power station due to these problems. Advanced technology and equipment, skilled workforce, working discipline can greatly reduce the number of forced outages.

Planned Outage

Regular maintenance works are necessary for any power generating station – rather they are necessary for any constituent of the manufacturing and infrastructure sector. Annual and Capital overhaul are planned well in advance, and they require around 30 and 50 days respectively.

Secondary *Performance Parameters*

Secondary parameters affect the primary performance parameters.

Realization of coal

It is the percentage of coal that actually gets effectively utilized in generating power.

Specific Coal Consumption (SPCC)

It is the amount of coal (in Kg) required to produce one unit (kWh) of electricity at the generating station. SPCC of a power plant reduces with the coal quality and should be as low as possible.

Auxiliary Consumption

It is the power consumed by the power plant itself as a percentage of power generated.

Gross Calorific value

Amount of heat (in Kcal) produced per Kg of fuel.

Performance evaluation of Thermal power stations

CEA carries out performance analysis of thermal power plants in India. Key performance parameters for the year 2009-10 are as follows[59]

- Total electricity generation increased by 6.6% and thermal generation increased by 8.6%.
- This growth was achieved at PLF of 77.68% at the national level.
- PLF of state utilities was worst among all power producers
- None of the best performing power stations in India were from Maharashtra
- Planned outage is about 6% for majority of the power stations
- Main cause of Forced Outage is Boiler Tube Leakage

Private sector IPPs topped the PLF chart with 85.68%.

Table 25 - Sector wise PLF

Sector	PLF (%)
State Utilities	71.13
Private Utilities in State	82.41
Central Utilities	85.64
Private IPPs	85.68

The best performing thermal power stations in India were 5 private companies, 11 NTPC stations and 5 state power stations *viz.* 2 of PSEB (Punjab) and 2 of APGENCO (Andhra Pradesh). These stations have pegged their PLF at above 90%. This shows that power generating stations in Maharashtra have performed worse. PLF of thermal stations in Maharashtra is 69.71% which is lesser than 71% national average (2009-10)[60].

Average national Operating Availability (OA) of thermal power plants was 85.1%. If we consider the same average OA for Maharashtra, it means that MSPGCL thermal power stations were unavailable for 55 days in a year. Even if we deduct annual overhaul of 30 days for every power station, 25 days of unavailability, mostly due to forced outages is a matter of great concern for power stations in Maharashtra. This is a major factor reducing the PLF.

Capital overhaul of a power station requires about 35 days, but it is not carried out annually. It is seen that one out of six-eight units of power generation undergo capital overhaul in a year.

[59] Government of India, Ministry of Power, Central Electricity Authority, Thermal Performance Review 2009-10
[60] Government of Maharashtra, MSPGCL, Annual Report 2009-10

Efficiency of MSPGCL's Coal-based Thermal Power Plants

MSGPCL operates seven coal power plants comprising 40 units of which 33 units generate power. Seven of the 39 units have been scrapped due to ageing and inefficient performance. The table below provides unit wise capacity of MSGPCL coal fired power stations, the date of commissioning and the plant efficiencies.

Most of the units are commissioned in the 70s and the 80s. The installed capacity is 20 to 30 years old, while the economic life of a thermal power plant is only about 25-30 years old. But it is important to check the remaining life of various components after 20 years (or 160,000 hours of operation). The efficiency of most units has declined which has resulted in producing less electricity than that for which they were originally set up. Some units have been scrapped, while some need to be shut down, but, some can be rehabilitated using modern techniques. High efficiency of power plants reduces emissions thereby protecting the environment and conserves fuel.

Fresh investments in renovation and modernisation (R&M) and life extension (LE) can help improve the performance of older plants and their generation at a much lower gestation period than a new plant. However, there is considerable lack of enthusiasm with regards to R&M, and the government plans have consistently missed their targets. Since the above mentioned plants are under the public sector domain, procedural and other bottlenecks need to be addressed urgently by the government to facilitate maximum utilisation of existing assets[61].

[61] India Infrastructure Research - Thermal Power Generation in India (Volume I), pp. 31

Table 26 - Installed Capacity, Year of Commissioning & Efficiency of MSPGCL power stations

Thermal Power Station	Date of commissioning	Total No. of Units	No. of working units	Unit Capacity (MW)	Total power station capacity	Working capacity (MW)	Average efficiency (%)
Koradi	1974,1975,1976,1977	7	7	4 x 105	1040	1040	**57**
	1978			1 x 200			
	1982,1983			2 x 210			
Nasik	1970,1971	5	3	2 x 125[62]	880	630	**60**
	1979,1980,1981			3 x 210			
Bhusawal	1968	5	4	1 x 55[63]	1475	1420	**61**
	1971,1982			2 x 210			
	2012			2 x 500			**-**
Paras	1961	4	2	30[64]	585	500	**-**
	1967			1 x 55[65]			**60**
	2008[66], 2010			2 x 250			**-**
Parli	1971	7	5	2 x 20[67]	1180	1130	**64**
	1980,1985, 1989			3 x 210			
	2007,			2 x 250			**-**
Khaperkheda	1989,1991,2000,2001	5	5	4 x 210	1340	1340	**70**
	2011			1 x 500			
Chandrapur	1983,1984,1985,1986	7	7	4 x 210	2340	2340	**59**
	1991,1992,1997			3 x 500			
Total		**40**	**33**		**8840**	**8400**	

[62] NOTE - The installed capacity of these units was initially 140MW, but has de-rated to 125MW w.e.f 20-04-2007 vide CEA letter no. CEA/PLG/DMLF/513/ (CDHUVARAN)/2007 dated 20/04/2007. The efficiency has been calculated taking into consideration the original installed capacity of 140MW

[63] NOTE - The installed capacity of this unit was 62.5MW initially, which was derated to 58 MW and later to 55 MW. So the efficiency has been calculated taking into consideration the old installed capacity. The total installed capacity is therefore 478MW

[64] http://www.parastps.co.in/index.php?option=com_content&view=article&id=53&Itemid=58

[65] NOTE - The capacity of this unit was 58MW, based on which the efficiency has been calculated. The power generation figures for the new unit of 250MW commissioned in the year 2008 are not available and hence efficiency has not been calculated.

[66] http://www.mahagenco.in/investor/pprojects_completion.shtm#parastps

[67] NOTE: These two units had an installed capacity of 30MW when installed. The capacity of both the units derated to 20MW from 20/4/2007. The efficiency was calculated prior to the de-rating considering 30MW each- http://www.parlitps.com/about-us.asp

Analysis of performance parameters of MSPGCL coal based power plants

Primary performance parameters of MSGPCL coal based power stations are given below (please refer table 10)

- ***Operational Availability (Av)*** increased to about 87% for the years 2007-08, 08-09, 09-10, but reduced drastically in 2010-11 to 81.64%. Unavailability of coal was the major factor responsible for reduction in Av in 2010-11. Availability of coal coupled with timely operation and maintenance can increase Av to 90%.
- ***Average Plant Load Factor (PLF)*** for 2010-11 is 61%. As per the analysis of various units of power stations as indicated in the previous tables (table 1, 3-8), the average efficiency was 61%. PLF has steadily reduced from 2007-08 till 2009-10. Indian coal has high ash content which reduces GCV of coal resulting in an increase in the amount of coal required to generate per unit of electricity, thereby reducing the PLF. Though imported coal is of better quality, it is not suited for most of the power generation units in the state as they have conventional designs. Generation units in India are designed for Indian coal, which make them dependent only on local coal. Coal related factors that affect PLF
    - Wet coal in monsoon
    - Improperly washed coal
    - Lower quality of coal –Coal has high ash content and contains shale, sand and stones
    - Irregular coal supply

Other factors that affect PLF

- Lack of proper operation and maintenance
- Forced outages
- Unavailability and / or poor quality of water

- ***Planned Outage*** percentage has steadied on a fair level. Annual and capital overhaul is a fairly constant type of outage, and no significant diversions from normal should be seen in this. There is a direct relation between the number of units overhauled and the percentage of planned outage.
- ***Forced Outage*** is far better than that in 2006-07 when it was 10% of the total time. Boiler tube leakage still remains the main contributing cause of forced outage. Ideally it should reduce to 2-3% at maximum. Coal unavailability is the recent factor contributing largely towards forced outage. The primary performance parameters are indicated in the table below.

Table 27-Primary performance parameters

	2006-07	2007-08	2008-09	2009-10	2010-11
Operating Availability %	82.11	87.58	86.69	88.4	81.64
Plant Load Factor %	73.64	76.99	70.61	69.71	61.23
Planned Outage %	7.9	7.95	8.41	5.82	5.41
Forced Outage %	10	4.47	4.9	5.78	5.07
Annual Overhaul (Generation units per year)	23	26	24	18	17

Secondary performance parameters of MSGPCL power plants are indicated in table 5. These parameters are most affected over the years.

- ***Realization of coal-*** In the last 6 years, the percentage of coal that is effectively used in power generation has reduced from 91% to 86%, almost 1% reduction per year.
- ***Specific coal consumption (SPCC)*** has increased steadily in the past 6 years. It may have been due top very poor coal quality or the improper and undisciplined O&M works at the generating station.
- ***Auxiliary consumption*** -In 2010-11, MSPGCL consumed 10.63% of its produced power on itself. Whether it spent it on itself or it was diverted somewhere else is a different topic, but auxiliary consumption has seldom touched such an alarming level.
- ***Gross calorific value (GCV)*** decreased from 3455 to 3245 kcal/kg indicating the deterioration in coal quality. The units are designed with a GCV in the range of 3500 to 5000 kCal/kg.

Table 28 -Secondary performance parameters

	2006-07	2007-08	2008-09	2009-10	2010-11
Realization of coal (%)	91.31	91.29	88.11	89.49	86
Specific Coal Consumption (Kg/KWh)	0.765	0.796	0.828	0.826	0.852
Boiler Tube Leakage (%)	2.86	2.94	2.38	3.02	2.55
BTL as % of FO (%)		65.77			
Sp. Oil Consumption (ml/KWh)	1.91	1.78	4.12	3.56	5.75
Auxiliary Consumption (% of Generation)	8.99	8.78	9.49	9.93	10.63
Average Gross Calorific Value Kcal/Kg	-		3455	3537	3245
Heat rate (Kcal/KWh)	-		2898	2989	2817
Transit Loss (%)	-	0.43	0.96	1.99	0.5

The efficiency in power generation depends on the type of generation, condition of power plant (operation and maintenance), ambient conditions and design of the power plant[68]. Efficiency improvement has a positive effect on energy security, local and regional air pollution abatement, and employment[69]. The efficiency of the old units of each of the MSGPCL coal based power plants is discussed in the paragraphs below. The details of installed capacity, generation and efficiency of each of the MSGPCL coal power plants are provided in *Annexure V*.

[68] Frans van Aart Energy Efficiency in IPPC installations - Energy Efficiency In Power Plants - October 21, Vienna
[69] http://www02.abb.com/db/db0003/db002698.nsf/0/a3881ed5c3dbc647c12575080036dafd/$file/Energy_efficiency__makes_difference_191108.pdf

Koradi Thermal Power Plant

Koradi thermal power station is located at Koradi in Nagpur. Total installed capacity of Koradi thermal power station is 1040 MW.

Table 29- Unit wise installed capacity of Koradi thermal power station (2012)

वीज निर्मिती क्षमता	१०४० MW (१ x २०० MW; २ x २१० MW)
केंद्र कार्यरत करण्याची तारीख	संच १ (१०५ MW) - ३ जून, १९७४
	संच २ (१०५ MW) - २४ मार्च, १९७५
	संच ३ (१०५ MW) - ३ मार्च, १९७६
	संच ४ (१०५ MW) - २२ जुलै, १९७६
	संच ५ (२०० MW) - १५ जुलै, १९७८
	संच ६ (२१० MW) - ३० मार्च, १९८२
	संच ७ (२१० MW) - १३ जानेवारी, १९८३
सरासरी कार्यक्षमता (संच १- ७)	५७%

Of the seven total units, four with a 105 MW capacity each are closed since January 2011, but not yet scrapped. These four units were commissioned between the years 1974 to 1976 and had an installed capacity 120 MW, which was derated to 115MW from 1990 and later to 105 MW from the year 2007[70]. These units are old and have outlived their normal life span. The generation from these units have reduced over the years since their commissioning.

Installed capacity in 1974-75 was 120 MW with the first unit commissioned. In 1975-76 the second unit (120 MW) was commissioned, increasing the installed capacity to 240 MW, followed by commissioning of the third and fourth units (120 MW each) in 1976-77 and 1979-80, increasing the total installed capacity to 680 MW in the year 1979-80.

The installation of all seven units increased the total installed capacity to 1100 MW in 1983-84. In 1990, with the first four units derated, installed capacity reduced to 1080 MW.

On April 19, 2007 the four old units which were derated to 115 MW each were further derated to 105MW, thereby reducing the total installed capacity of Koradi thermal power station to 1040 MW.

The installed capacity and generation has been graphically represented below. The efficiency of Koradi thermal power station is 57%, which is calculated up to the year 2007 since the commissioning of its first unit.

[70] Government of India, MECON Ltd., Report on achievable heat rate and auxiliary power consumption of thermal power stations, 2007

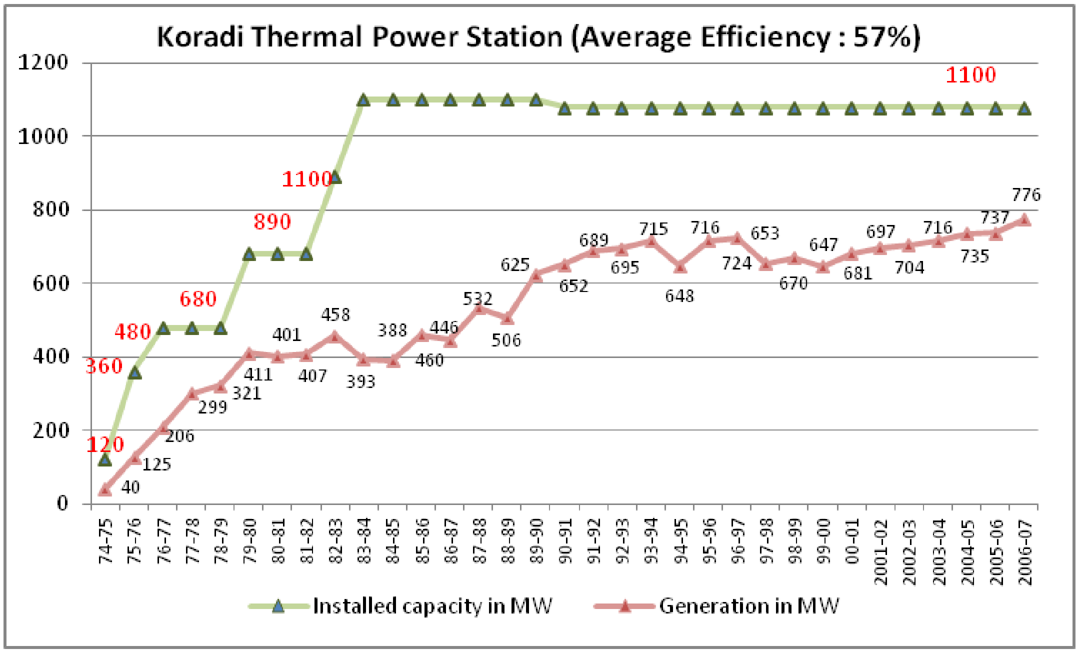


Figure 34- कोराडी औष्णिक विद्युत केंद्राची वीज निर्मिती क्षमता व प्रत्यक्ष वीज निर्मिती (1974-75 to 2006-07)

The first four units of the plant were designed in the seventies based on prevailing pollution norms and technology of those days. A few reasons which pose problems in meeting the desired performance levels are cited below[71].

- Old design of boiler, turbine & auxiliaries
- Poor quality of coal
- Increase in cooling water (CW) inlet temperature as compared to design value
- Vibration in turbine generator (TG) bearings in case of Units 1 to 4
- Ageing of the units and
- Poor state of the instrumentation & control.

Renovation and Modernization for Unit 6 has been undertaken from March 2012.

To improve generation capacity, 4 old units of 120MW commissioned in the 70s are being replaced with 1 unit of 660 MW equipped with supercritical technology. In addition to this replacement, two new units of 660 MW supercritical technology are under execution.

[71] Government of India, MECON Ltd., Report on achievable heat rate and auxiliary power consumption of thermal power stations, 2007

Nasik Thermal Power Station

Nasik thermal power station is located at Eklahare in Nasik, Maharashtra. The current total installed capacity of this power station is 630 MW, comprising total three units of 210 MW installed capacities.

The first two units of the power plant have aged and have been closed in 2012 due to environmental concerns. Their capacity when commissioned in the seventies was 140 MW which was derated by 15MW from 2007 to 125 MW each.

Table 30 - Unit wise installed capacity Nasik thermal power station (2012)

वीज निर्मिती क्षमता	६३० MW (३ x २१० MW)
केंद्र कार्यरत करण्याची तारीख	संच १ (१४० MW): १६ ऑगस्ट, १९७० (बंद केले) संच २ (१४० MW): २१ मार्च, १९७२ (बंद केले) संच ३ (२१० MW) - २६ एप्रिल, १९७९ संच ४ (२१० MW) - ७ ऑक्टोबर, १९८० संच ५ (२१० MW) - ३० जानेवारी, १९८१
सरासरी कार्यक्षमता (संच १ - ५)	६०%

Total installed capacity of Nasik thermal power station has decreased to 630 MW from its previous installed capacity of 910 MW. Installed capacity and generation is given in the graph below.

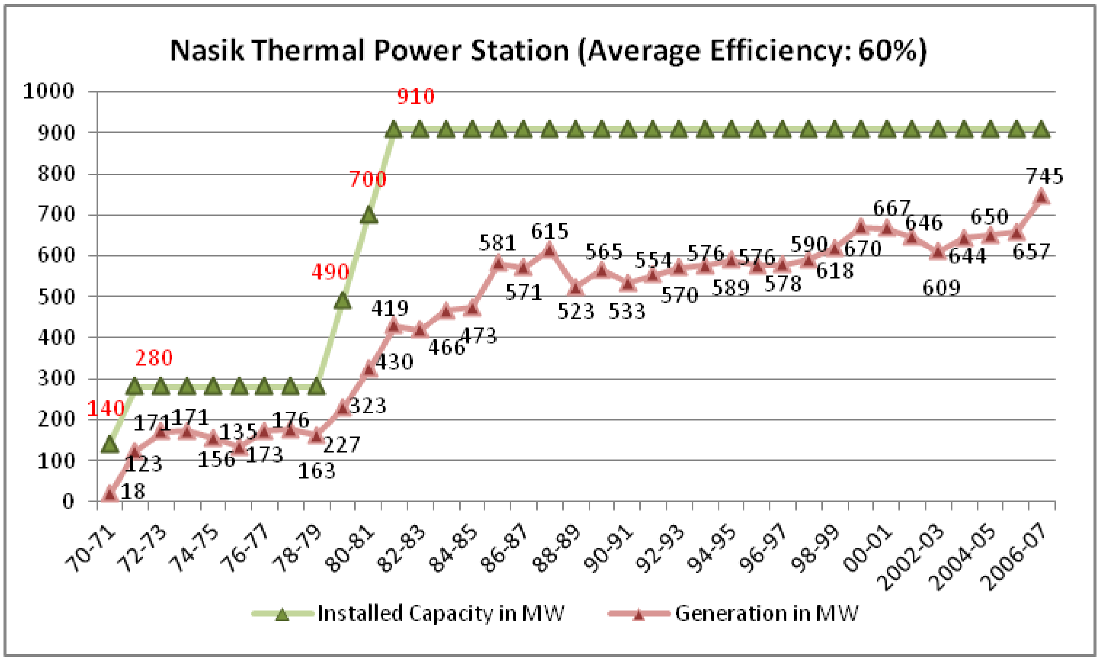


Figure 35 - नाशिक औष्णिक विद्युत केंद्राची वीज निर्मिती क्षमता व प्रत्यक्ष वीज निर्मिती (1970-71 to 2006-07)

As compared to the designed quality of coal, the quality of coal supplied to the power plant is inferior in terms of ash content, GCV, volatile matter and moisture. This is the case with almost all the MSGPCL run power stations. There are times when coal quality is at par with design specifications which positively affects the efficiency of the power stations. It is observed that if imported coal or coal having the desired GCV is used, plant performance improves.

The first two units were designed to operate with coal of GCV 5900 kcal/kg whereas the other three units are designed to operate with coal of GCV 5000 kcal/kg. The available coal has an average GCV of about 3850 kcal/kg. Also, constituents of coal like moisture, Hydrogen and ash show a wide variation as compared to the designed coal quality. This results into poor performance of the units in terms of improper heat transfer and reduced boiler efficiency. Since the quality of coal is poor, higher of quantity coal needs to be fired in the boilers. Units 3, 4 and 5 have been designed for coal with GCV of 5000 kcal/kg, but the coal being supplied varies from 3700 kcal/kg to 3900 kcal/kg. This results in extra loading of mills and fans. Poor quality of coal results in increased heat rate and increased auxiliary power consumption of the units[72].

Renovation and Modernization of Unit 3 has been undertaken from June 2011.

A 660 MW unit is in planning stage (2017-18).

[72] Government of India, MECON Ltd., Report on achievable heat rate and auxiliary power consumption of thermal power stations, 2007, pp. 187

Bhusawal Thermal Power Station

Bhusawal thermal power station is located at Deepnagar in Jalgaon district of Maharashtra. The total installed capacity of this power plant is 1420 MW and comprises total five units. The first three units were installed during years 1968 to 1982. These units are old and have outlived their normal life span.

Table 31 - Unit wise installed capacity of Bhusawal thermal power station (2012)

वीज निर्मिती क्षमता	१४२० MW (२ x २१० MW; २ x ५०० MW)
केंद्र कार्यरत करण्याची तारीख	संच १ (५८ MW) – १७ जुलै, १९६८ (बंद केले) संच २ (२१० MW) - ३० ऑगस्ट, १९७९ संच ३ (२१० MW) - ४ मे, १९८२ संच ४ (५०० MW) - मार्च, २०१२ संच ५ (५०० MW) - जून २०१२
सरासरी कार्यक्षमता (संच १ - ३)	६१%

The first unit was commissioned in July 17, 1968. Its installed capacity was 62.5 MW which was derated to 55 MW from April 20, 2007. Unit 1 was utilised to generate power for a span of around 42 years and was scrapped *w.e.f.* November 16, 2010. The average age of the plants is 25-28 years and unit 1 had clearly outlived its normal lifespan. Installed capacity and generation of the older units 1, 2 and 3 installed from the sixties, seventies and eighties is presented graphically below. The average efficiency of these 3 units since their date of commissioning till 2006- 07 is 61%.

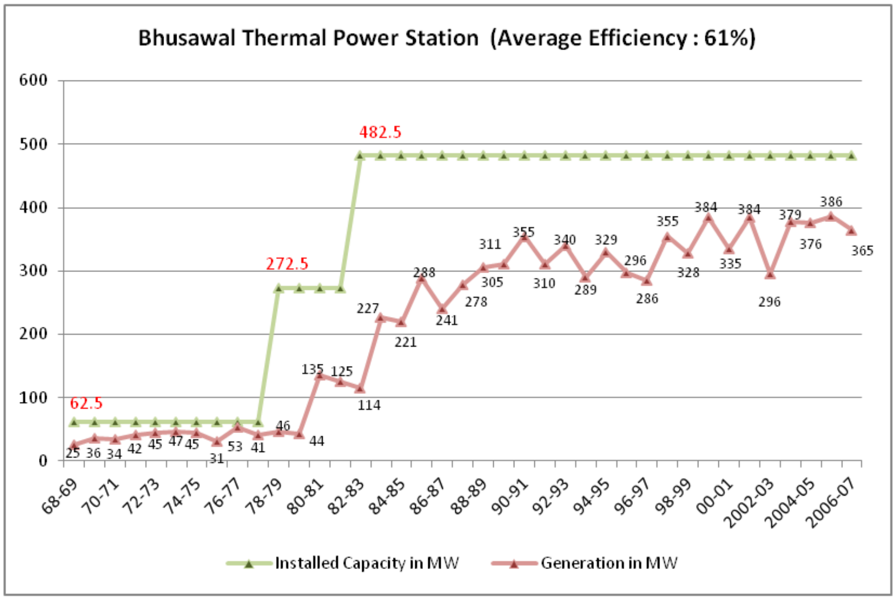


Figure 36- भुसावळ औष्णिक विद्युत केंद्राची वीज निर्मिती क्षमता व प्रत्यक्ष वीज निर्मिती (1968-69 to 2006-07)

Units 4 and 5 have been recently commissioned in March and June 2012 with an installed capacity of 500 MW each. Thus, total installed capacity of Bhusawal thermal power station is 1420 MW.

Units 1, 2 and 3 were designed in the seventies based on prevailing pollution norms and technology of those days. Few broad reasons which pose problems in meeting the desired performance level of the units are[73]

- Poor quality of coal
- Less availability of boiler feeder pump (BFP) in summer
- Problem of temperature rise in Unit Auxiliary Transformer (UAT) and
- Ageing of the units

The design GCV of coal in units 2 and 3 has been considered as 5000 kcal/kg whereas the actual GCV of coal being supplied varies from 3000 kcal/kg to 4000 kcal/kg. This results in the deterioration of the equipment in the long run.

Renovation and Modernization of Unit 2 has been undertaken from June 2011.

One 660 MW unit is under planning stage. (2016-17)

[73] Government of India, MECON Ltd., Report on achievable heat rate and auxiliary power consumption of thermal power stations, 2007, pp. 200

Paras Thermal Power Station

Paras thermal power station is located at Paras in Akola. There was no capacity addition till as late as 2008 and total installed capacity of the power plant was 62.5 MW. The plant comprised two units *viz.* unit 1 of 30 MW and unit 2 of 62.5 MW.

Unit 1 was scrapped in 1991 due to ageing and inefficient performance.

Unit 2 was commissioned on October 25, 1967. In its operating life span, it was derated twice, once to 58 MW from 1980-81 and a second time to 55 MW from April 20, 2007[74]. This unit was thus derated by 12% from its designed capacity since commissioning. The average efficiency of unit 2 of Paras thermal power station was 60%, since its commissioning till 2006-07.

It was the first power station in MSEB (now MSGPCL) to use pulverized coal for its boilers and hydrogen gas for cooling of generator. Generation details of unit 1 were not available, so its efficiency could not be calculated. Unit wise installed capacity is indicated below.

Table 32 - Unit wise installed capacity of Paras thermal power station (2012)

वीज निर्मिती क्षमता	५०० MW
केंद्र कार्यरत करण्याची तारीख	संच १ (३० MW) - ३१ मार्च १९६१ (बंद केले) संच २ (६२.५ MW) – २५ ऑक्टोबर १९६७ (बंद केले) संच ३ (२५० MW) - ३१ मार्च, २००८ संच ४ (२५० MW) - ३१ ऑगस्ट, २०१०
सरासरी कार्यक्षमता (संच २)	६०%

The installed capacity *vis a vis* generation of unit 2 is graphically presented in figure 4 below. This unit has achieved efficiency as high as 95% in the year 2005-06 while average efficiency from its date of commissioning till 2006-07 was 60%.

[74] http://www.parastps.co.in/index.php?option=com_content&view=article&id=53&Itemid=58

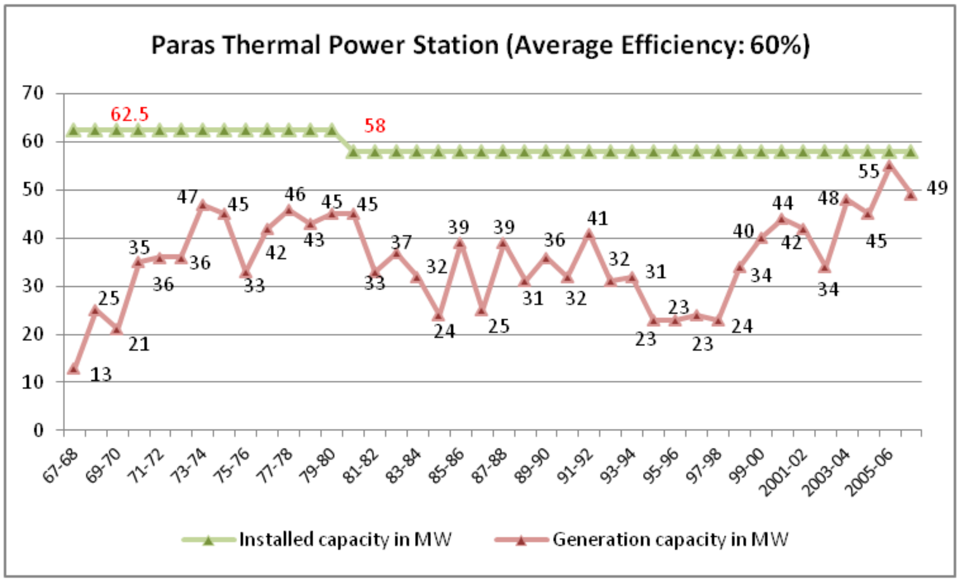


Figure 37 - पारस औष्णिक विद्युत केंद्राची वीज निर्मिती क्षमता व प्रत्यक्ष वीज निर्मिती

Unit 2 had aged and outlived its normal lifespan, deteriorating its performance and was decommissioned in November 16, 2010, a span of 43 years.

A 250 MW unit is in the planning stage (2017-18).

Parli Thermal Power Station

Parli thermal power station is located at Parli Vaijnath in Beed district of Maharashtra. In the seventies and eighties, five power generating units were installed in two stages. The first stage comprised units 1 & 2 of 30 MW each commissioned in 1971, and second stage comprised units 3, 4 & 5 of 210 MW capacity each installed from 1980 to 1987. Total units installed are tabulated below.

Table 33- Unit wise installed capacity of Parli thermal power station (2012)

वीज निर्मिती क्षमता	११३० MW (३ x २१० MW; २ x २५० MW)
केंद्र कार्यरत करण्याची तारीख	संच १ (३० MW) - १७ मे १९७१ (बंद केले) संच १ (३० MW) - १५ नोव्हेंबर १९७१ (बंद केले) संच ३ (२१० MW) - १० ऑक्टोबर १९८० संच ४ (२१० MW) - २६ मार्च १९८५ संच ५ (२१० MW) - ३१ डिसेंबर १९८७ संच ६ (२५० MW) - १ नोव्हेंबर २००७ संच ७ (२५० MW) - ३१ जुलै २०१०
सरासरी कार्यक्षमता (संच १-५)	६४%

Stage 1 units were derated to 20 MW from April 20, 2007 and were retired and closed in December 15, 2012. The average efficiency (from 1971-72 to 2006-07) of stage 1 and 2 of Parli thermal power station is 64%.

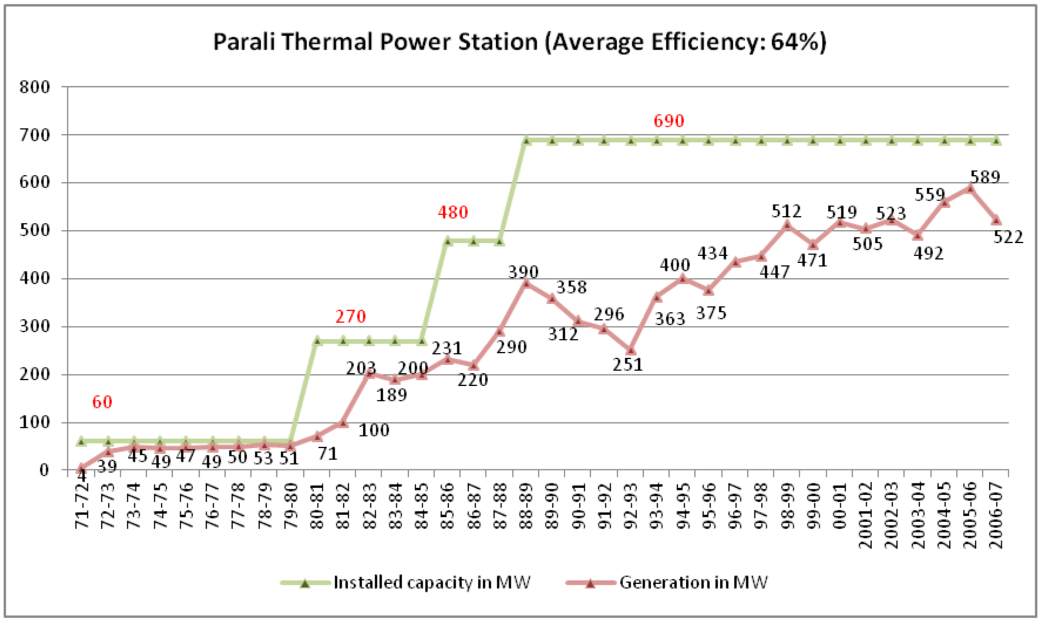


Figure 38 - परळी औष्णिक विद्युत केंद्राची वीज निर्मिती क्षमता व प्रत्यक्ष वीज निर्मिती

Installed capacity of Parli thermal power station was increased in 2007 and in 2010 with the commissioning of units 6 & 7 under stage 3. Installed capacity of units 6 and 7 is 250 MW each. The current installed capacity of the power plant is 1130 MW.

The coal received at the power station is of low grade (3500-3600 kcal/kg) as compared to design quality (4445 to 5000 kcal/kg) of coal. This increases the heat rate and auxiliary consumption of the units[75].

Since the units are around 25 to 36 years old, they have deteriorated over the time due to wear and tear, different temperature regime, etc. This results in increase in heat rate of the units, thereby reducing the efficiency. Performance of cooling tower also decreases due to ageing civil structure.

Stage 1 units would be replaced by unit 8 with a capacity of 250 MW, which will be operational in July 2013.

Renovation and Modernization of Unit 3 has been undertaken from September 2011.

One 250 MW unit is under completion.

[75] Government of India, MECON Ltd., Report on achievable heat rate and auxiliary power consumption of thermal power stations, 2007, pp.234, 247

Khaparkheda Thermal Power Station

Khaparkheda thermal power station is located in Nagpur. It is the oldest power station in MSPGCL and had an installed capacity of 30 MW (3 x 10). During the subsequent years 3 units of 30 MW each were added, increasing the capacity to 120 MW. The old power stations of 3 x 10 MW were shut down in 1976 and the 3 x 30 MW units were closed on June 22, 1991.

Table 34 - Unit wise installed capacity of Khaparkheda thermal power station (2012)

वीज निर्मिती क्षमता	१३४० MW (४ x २१० MW)
केंद्र कार्यरत करण्याची तारीख	संच १ (२१० MW(: २६ मार्च, १९८९ संच २ (२१० MW): ८ जानेवारी, १९९० संच ३ (२१० MW): ३१ मे, २००० संच ४ (२१० MW): ७ जानेवारी, २००१ संच ५ (५००) जुलै २०११
सरासरी कार्यक्षमता (संच १-४)	७०%

Four power generating units were installed during years 1989 to 2001 in two stages. Units 1 and 2 were installed in 1989-90, while units 3 & 4 were installed in 2000-01. The average efficiency of these units is 70%. Figure 6 indicates the installed capacity *vis a vis* generation of the power plant.

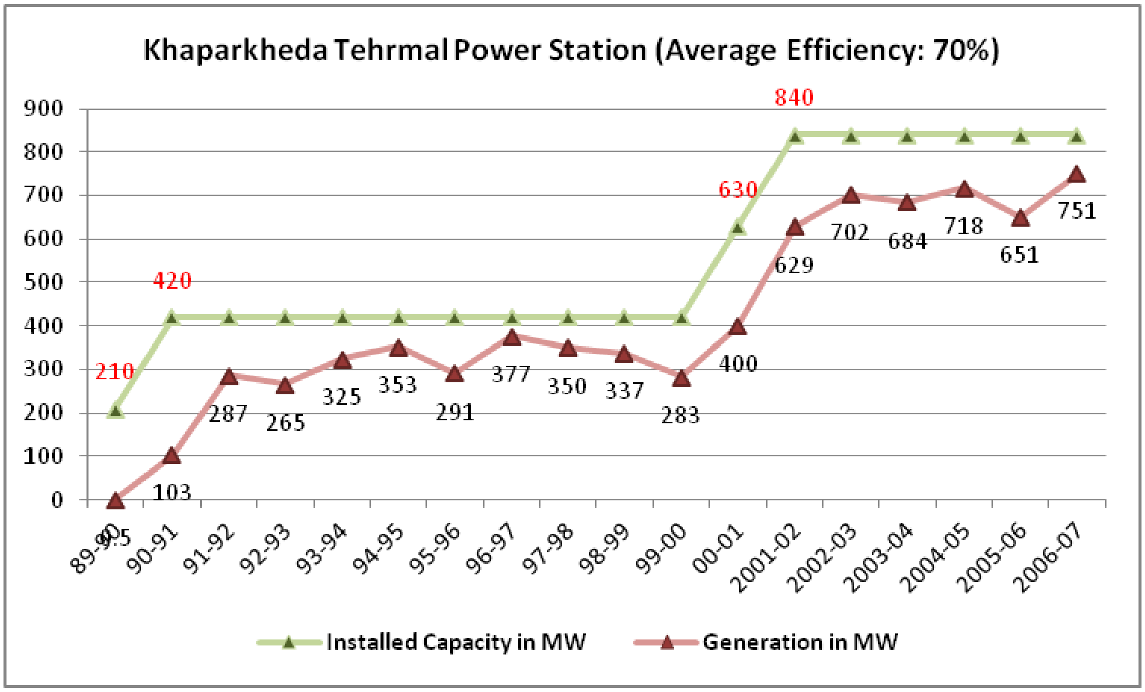


Figure 39-खापरखेडा औष्णिक विद्युत केंद्राची वीज निर्मिती क्षमता व प्रत्यक्ष वीज निर्मिती

The average age of stage 1 and 2 units range from 11-23 years. Natural deterioration due to several factors such as wear & tear, different temperature regimes etc. results in the increase in heat rate of units.

Sometimes the coal received is of low grade and muddy with high moisture content which results in less generation and increase in auxiliary power consumption. Due to deterioration in the quality of coal the percentage of coal mill rejects has also increase from the designed value of 0.5% it has increased to 1.5% for stage 1 units and 1% for the stage 2 units.

Though this power plant has the highest average efficiency as compared to other MSPGCL power stations, its performance still has a scope for improvement if excellent quality coal is used.

Chandrapur Thermal Power Station

There are 7 power generating units in Chandrapur thermal power station installed during years 1983 to 1997 in two stages. Units 1 to 4 were installed in the years 1983 to 86 and units 5 & 6 were installed in 1991 – 92, while unit 7 in 1997. The table above

Table 35 - - Unit wise installed capacity of Chandrapur thermal power station (2012)

वीज निर्मिती क्षमता	२३४० MW (४ x २१० MW; ३ x ५०० MW)
केंद्र कार्यरत करण्याची तारीख	संच १ (२१० MW): १५ ऑगस्ट, १९८३ संच २ (२१० MW): २४ जुलै, १९८४ संच ३ (२१० MW): ३ मार्च, १९८५ संच ४ (२१० MW): ८ मार्च, १९८६ संच ५ (५०० MW): २२ मार्च, १९९१ संच ६ (५०० MW): ११ मार्च, १९९२ संच ७ (५०० MW): १ ऑक्टोबर, १९९७
सरासरी कार्यक्षमता (संच १-४)	५९%

Performance of the units is not up to the desired levels. Few broad reasons which pose problems in meeting the desired performance level of the units are[76]

- Poor quality of coal
- Increase in CW inlet temp.
- Obsolete design of first two boilers and
- Ageing of the units.

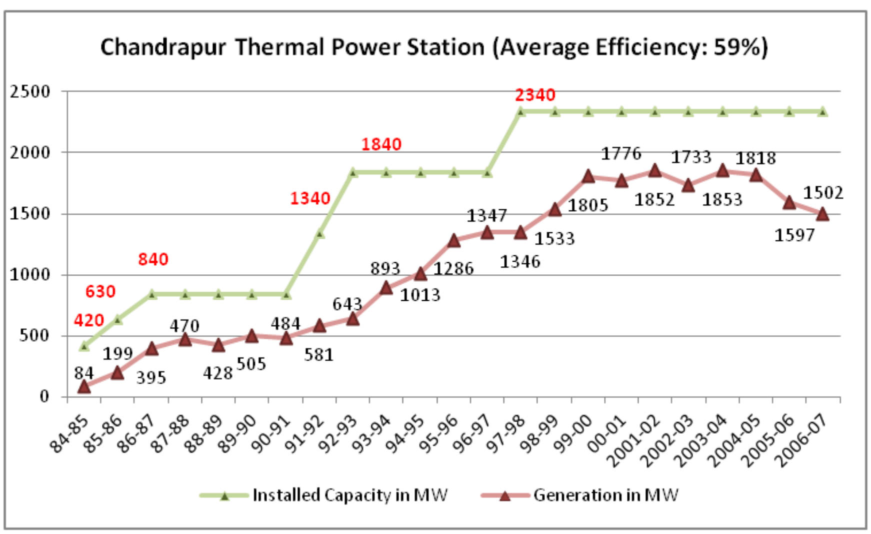


Figure 40 -चंद्रपूर महाऔष्णिक विद्युत केंद्राची वीज निर्मिती क्षमता व प्रत्यक्ष वीज निर्मिती

[76] Government of India, MECON Ltd., Report on achievable heat rate and auxiliary power consumption of thermal power stations, 2007, pp. 131

Units 1 and 2 are of conventional type and there are several design constraints, due to which the desired load cannot be achieved. Age of these units ranges from 28-29 years, due to which natural wear and tear of the equipment is expected.

It is observed that since commissioning, the units on a monthly basis have operated at an average load of 160-180MW. When tried to load above 190 MW there are chances of boiler tube failure. Efficiency of units 4 and 5 is affected due to poor quality of coal[77].

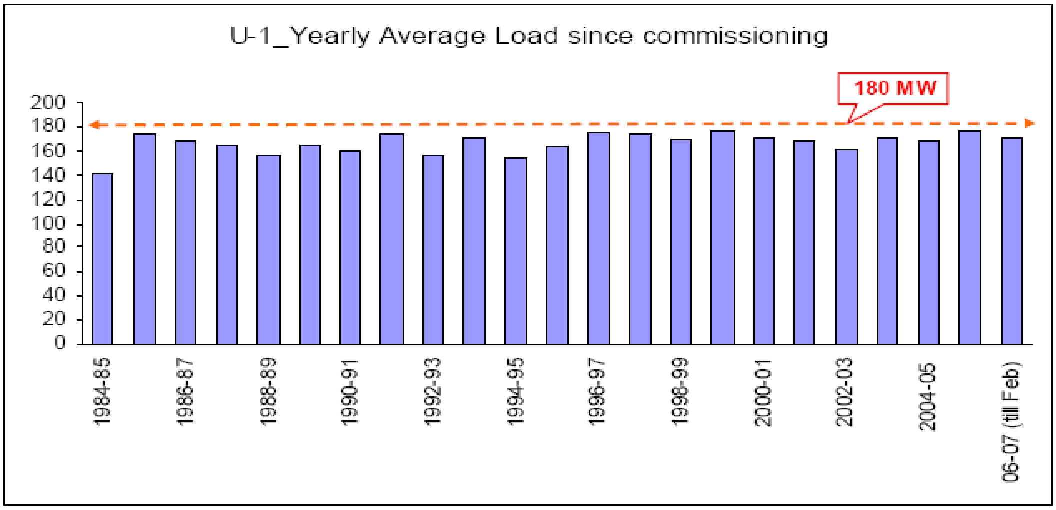


Figure 41- Average Load of Unit 1

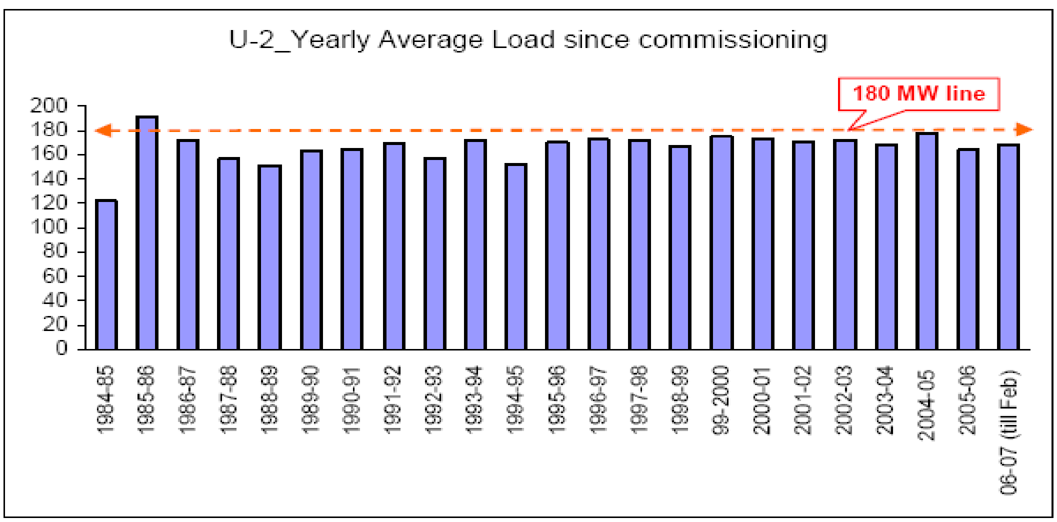


Figure 42- Average load of Unit 2

[77] Government of India, MECON Ltd., Report on achievable heat rate and auxiliary power consumption of thermal power stations, 2007, pp. 136, 137

The boilers of units 6, 7 and 8 are adversely affected due to clinker problem. Clinkers cause tipping/ outages of power plants. Clinkers have been a recurring problem in all coal-fired boilers for as long as humans have operated coal boilers. Clinkers occur in small stoves used for heating a home and in giant commercial/industrial boilers. Clinkers, also known as slag, consist of the noncombustible elements and minerals found in coal that melt and fuse together as lumpy ashes from coal combustion[78].

The sand content in coal is primarily the problem for clinkering and slagging. The sand also contains iron and calcium impurities due to which ash fusion temperature decrease. The clinkering problem gives rise to frequent soot bowing as well as frequent bottom ash evacuation.

The average age of stage 2 units is 15-20 years. The units are designed to operate with coal of GCV 3750 kcal/kg for units 5 & 6 and 3500 kcal/kg for unit 7. However the available coal has GCV of about 3000 - 3300 kcal/kg. The constituents of coal such as moisture, Hydrogen and ash show wide variation as compared to the designed coal quality. Poor quality of coal and clinkering problems also affect the heat rate.

Renovation and Modernization for Units 1 & 2 has been undertaken in October 2010.

Two 250 MW units are under execution.

[78] What Causes Clinkers in Coal Fired Boilers? http://www.ehow.com/info_12152358_causes-clinkers-coal-fired-boilers.html#ixzz27Mp1IySR

Renovation and Modernization

Renovation and Modernization is distinctively different from the regular Operation and Maintenance (O&M). R&M makes way for a disciplined and efficient O&M. O&M is a procedure to be undertaken quite frequently while R&M is scheduled once in about ten years.

Central Electricity Authority started the Phase-I Renovation and Modernization (R&M) Program in 1984 for power generating units in 34 power stations in India[79].

After Phase-I R&M in the 7th plan, subsequent five-year plans paved way for further R&M works covering much of the generating units in the country. 163 units were covered in 7th plan period and 198 in the 8th plan period. Life Extension (LE)[80] was started to supplement R&M in the 9th plan period. 127, 57 and 76 thermal generating units went through R&M and 25, 106 and 53 units went through LE during 9th, 10th and 11th plan periods respectively.

Average R&M expenditure has increased from Rs.4-6 crore/unit to Rs.60 crore/unit, while LE expenditure has increased from Rs.60-65 crore/unit to around Rs.250 crore/unit[81].

Table 36 -R&M and LE – Units covered and cost incurred

Five Year Plan	Thermal power stations		Units covered		R&M Total Expenditure (Rs. Crore)	LE Total Expenditure (Rs. Crore)	Expenditure on R&M/unit (Rs. Crore)	Expenditure on LE/unit (Rs. Crore)	Additional generation achieved (MU)	Installed Capacity covered (MW)
	R&M	LE	R&M	LE						
7	34	--	163	--	1066 cr.	--	6.5 cr.	--	10000	13570
8	44	--	198	--	862 cr.	--	4.35 cr.	--	5000	20869
9	29	7	127	25	850 cr.	1560 cr.	6.7 cr.	62.4 cr.	14500	18991
10	13	32	57	106	977 cr.	9200 cr.	17 cr.	87 cr.	23700 (anticipated)	10747
11	21	23	76	53	4487 cr.	12433 cr.	59 cr.	235 cr.	14000 (anticipated)	26283
Planned for 2012-17										
12	8	32	23	72	4971 cr.	28868 cr.	216 cr.	400 cr.	6900 (anticipated)	16532

[79] http://www.cea.nic.in/reports/renov_modern/national_plan.pdf
[80] http://www.cea.nic.in/reports/renov_modern/th_randm_annex-a.pdf
[81] http://www.cea.nic.in/thermal_rnm.html

Table 37 -R&M works in MSPGCL power plants in the 10th and 11th five-year plans[82]

Plan and Year	Year of commis-sioning	Plant	Units	Proposed cost (Rs. Crore)	Incurred cost (Rs. Crore)	Actual Energy Efficiency and R&M undertaken[83]
10 (2002-07)	1979 1980 1981	Nashik	3 4 5	484.7	469	Unit 3 (June 2011)
	1989 1990	Khaparkheda	1 2	54.2	53.2	
	1979 1982	Bhusawal	2 3	246.8	210.1	Unit 2 (June 2011)
11 (2007-12)	1978 1982 1983	Koradi	5 6 7	573	309.4	Unit 6 (March 2012)
	1983 1984 1985 1986 1991 1992	Chandrapur	1 2 3 4 5 6	335.13	335.16	Unit 1 & 2 (October 2010)
	1980 1985 1987	Parli	3 4 5	312.9	108.4	Unit 3 (September 2011)

O&M works are carried out frequently. Planned outage is essential and inevitable, but forced outage is a result of indiscipline and error, human and mechanical, which reduce PLF. Evaluation of power plant performance presented earlier in this chapter illustrates factors affecting PLF and the extent to which they affect. In spite of O&M and R&M, the PLF of 61% in 2011. We shall have a look at the solutions other than institutional reforms to improve power plant performance.

The table below provides a comparison between central, state and private power generators in India. It can be seen that central and private generators are more efficient than MSPGCL. Moreover, NTPC boasts best PLF (85%) in the country, while state utilities' average PLF is about 71%[84]. PLF of MSPGCL power stations reduced to 61.23% in 2010-11[85]. Around 80% of coal in India is produced by Coal India Limited (CIL), a state owned "Maharatna" Company[86]. Even

[82] India Infrastructure Research, Thermal Power Generation in India
[83] http://www.mahagenco.in/PIP/home.php
[84] Government of India, Ministry of Power, Central Electricity Authority, Thermal Performance Review 2009-10
[85] Government of Maharashtra, MSPGCL, Annual Report 2010-11 http://www.mahagenco.in/soa/AnnualReportENGLISH-FY_2010-2011.pdf
[86] http://www.coalindia.in/Company.aspx?tab=0

though NTPC and MSPGCL buy coal from subsidiaries of the same coal producer, yet there is huge difference in their respective efficiencies.

Table 38-Plant Load Factor Comparison – MSPGCL, NTPC and Private Power Producers

Company/Year	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11
MSPGCL[87]	73.05	73.64	76.99	70.61	69.71	61
Tata Power[88]	78	77.8	85.78	87.63	71.37	64.92
Reliance Infra[89]	--	101.53	100.99	102.33	101	--
NTPC[90]	87.5	89.4	92.2	91.14	90.81	85

Around 62,000MW of coal power plants are in the pipeline (*Annexure III*). Of these, MSPGCL has planned capacity addition of 13,350 MW, which replacement of older less efficient units with newer more efficient ones. Most of the upcoming plants are based on the new super critical technology. Current sub critical technologies used to build 250 MW and 500 MW power generating units have conversion efficiency of 30%, while super critical technology ensures 41-42% fuel conversion efficiency[91]. In super critical technology, the boiler is better able to convert the fuel into heat; in other words the heat loss is reduced and equivalently boiler efficiency increases. With a large number of power plants expected to come online coal consumption in the power sector is also expected to rise.

Improving efficiency of coal fired plants is utmost importance, but at the same time it should be ensured that these plants do not adversely impact environment. So pollution control technologies need to be installed in power plants.

Efficiency improvement by one percentage point would reduce CO_2 emissions by about 2.5%

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[87] Government of Maharashtra, MSPGCL, Annual Report
[88] http://planningcommission.nic.in/data/datatable/0904/tab_98.pdf
[89] Government of India, Ministry of Power, Central Electricity Authority, Thermal Performance Review
[90] http://www.ntpc.co.in/index.php?option=com_content&view=article&id=40&Itemid=86&lang=en
[91] http://www.sourcewatch.org/index.php/Supercritical

Solutions to coal crisis

Institutional

1. Resolve regulation issues between Ministry of Coal and Ministry of Environment and Forests – stakeholders and law makers should work together to reduce differences between environment, rights of local populace and coal sector.

Dump all the waste in an eco-friendly manner
Utilize the fly-ash constructively for e.g. to manufacture bricks
Do not over exploit water resources
Make proper compensations to the displaced people

2. Make sensible FSAs – Fuel Supply Agreements – so that both the sides of the deal benefit fairly in the business dependent on 'natural resources'.

Agreements should be agreeable to both sides

3. Allocate coal on a competitive basis

Guarantee for the contracted coal quantity as a condition for allocation contract

4. Coal is a limited resource – Bring policy changes in coal power generation

Start the substitution of coal with a proper feasible and sustainable alternative like gas. Explore renewable energy options; promote extensive research in making renewable energy as viable as coal energy. This will reduce the pressure on coal and coal power.

5. Coal imports are making the power costly and the dimensions of the issue are increasing.

Technological

1. There is no single solution to monitor the fuel quality. By incorporating a number of strategies, care that the fuel quality is excellent must be taken.

Check fuel entering the power station
Insist for good Gross Calorific Value coal
Make provisions so that coal does not get wet or even moist

2. Instead of spending hundreds of crore on Life Extension (LE) works, replace the units that have passed their lifetime.
3. Make way for Super Critical Technology – 660 MW and above power generation units
4. Introduce computerized control in the management system of power plants

Conclusion

The power plants are suffering from underutilization of capacity due to (low PLFs) and being out of operation for longer periods of time (due to non-availability of water). In many cases the poor quality of coal and irregular supply limited the generation.

There is a plenty of room for improving the efficiency of coal power plants. A modest improvement in PLF upto 75% can avoid installation of 9000 MW coal capacity till 2025. 34,000 MW of coal based capacity would have to be added by 2025 if performance in the power sector is not improved. However improving power plant efficiency to 75% will reduce the addition of coal power to 24,700 MW.

Capital expenditure of Rs. 45000 crore[92] will be saved till 2025

India is a developing economy and to satisfy the base load power requirement in the immediate future the dependence will be on power plants based on coal. Reliable electricity is the key to economic development. Coal power stations provide the base load of electricity to the state as well as to the country.

The standard life of a power generation unit is 25-30 years[93]. But it is important to check the remaining life of these components after 20 years (or 1,60,000 hours of operation) in addition to yearly operation and maintenance. Almost all of the units have are old and have outlived their normal life span.

Replace old units

One of the solutions would be to replace the older power generating units with units equipped with latest technology and designed optimally for available coal. MSPGCL has initiated closure and retirement of its oldest units that were installed in the sixties and seventies. Power generation companies will have to bear huge costs for this renewal which will ultimately be recovered from consumers.

Life Extension, Renovation and Modernization

As discussed earlier, Life Extension (LE) of units supplements R&M. LE works increase the lifetime of a power generating unit by 15 years[94]. However after undertaking LE and R&M works unless designed fuel quality is ensured, the upgradation would be rendered useless.

[92] 5 crore per MW of coal based power
[93] http://www.cea.nic.in/reports/renov_modern/national_plan.pdf
[94] http://www.nlcindia.com/index.php?file_name=about_01e

Coal quality and Supply

Provide coal with the designed or close to the designed values. Assured, regular and good quality coal should be supplied to power plants.

With the phasing in of supercritical technology coupled with all the measure mentioned above, an ambitious PLF of 85% can also be achieved. Thus, more and more fossil fuel energy can be saved if improvement is consistent.

> In spite of tremendous scope for improvement through O&M of power plants, the crux of the problem lies in supply and quality of coal. Most outages are caused because of coal shortage, poor quality of coal, or due to reasons like boiler tube leakage which are direct results of inferior quality coal. Continuous supply of excellent quality coal can potentially increase PLF of MSPGCL coal fired plants to 75%.

Case studies on performance enhancement initiatives by power producers in India and abroad

Case Study 1- Dahanu Thermal Power Station, Reliance Energy

Dahanu Thermal Power Station owned and run by Reliance Energy achieved the highest ever Plant Load Factor (PLF) of 102.33% in India (2009-10)[95]. PLF greater than or equal to 100% means that the power station generated electricity at full rated output without any disruption. Ideally, PLF exceeding 100% seems impossible, but a power generating unit is designed with an added *tolerance* capacity; thus a 250 MW unit can sometimes deliver output power of 251 MW (100.4% PLF).

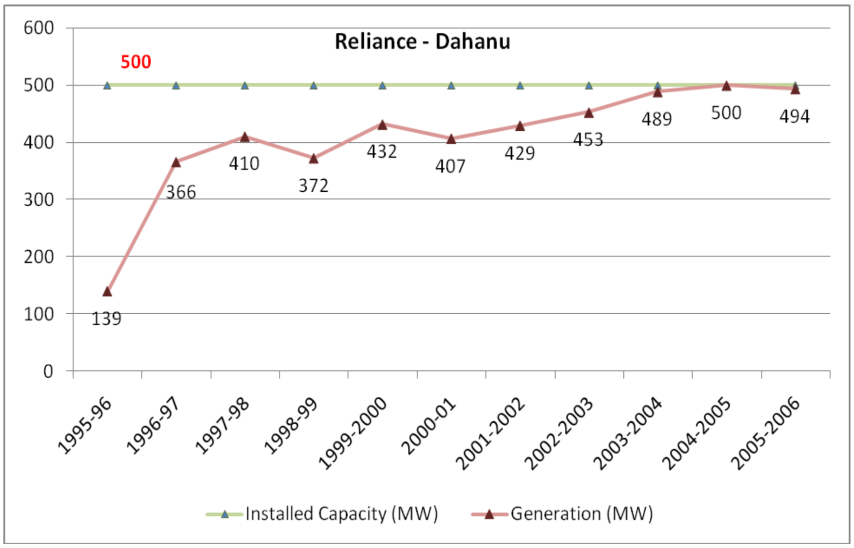

Figure 43-रिलायन्सची वीज निर्मिती क्षमता व प्रत्यक्ष वीज निर्मिती

Performance improvement strategies undertaken by Dahanu TPS are worth to be studied and implemented[96].

MSPGCL officials recounted the close relationship between the government and private power producers. State owned coal producers (CIL and its subsidiaries) preferably sell the top quality coal to private enterprises through unofficial agreements. Coal found in India is of low quality as compared to coal found in other parts of the world. The finest quality coal that comes out of this is generally sold to private power producers. State owned power producers are left with poor coal[97].

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[95] Government of India, Ministry of Power, Central Electricity Authority, Thermal Performance Review 2009-10

[96] http://www.energymanagertraining.com/announcements/issue28/Winners/1_Santosh%20Mahadeo%20Mestry.pdf

[97] LiveMint, "WCL supplying inferior quality coal: MahaGenCo", Makarand Gadgil, October 14, 2011 http://www.livemint.com/2011/10/14220042/WCL-supplying-inferior-quality.html

Non availability of coal, poor quality of coal, more ash content in coal, lower GCV of coal, wet coal are some of the practical difficulties that arise; and significantly lower the PLF. State owned power producers are worst affected by this which results in poorer and poorer performance.

The excellent Plant Load Factor of Dahanu TPS might have resulted from this fact. And this also might be the reason for lower PLFs of MSPGCL power plants.

Case Study 2 –National Thermal Power Corporation (NTPC)

NTPC is India's largest power producer and fifth largest enterprise in India. Total installed capacity of the company is 39,174 MW (including Joint Ventures) with 16 coal-based and 7 gas-based stations. NTPC has been operating its plants at high efficiency levels. Although the company has 17.75% of the total national capacity, it contributes 27.40% of total power generation due to its focus on high efficiency.

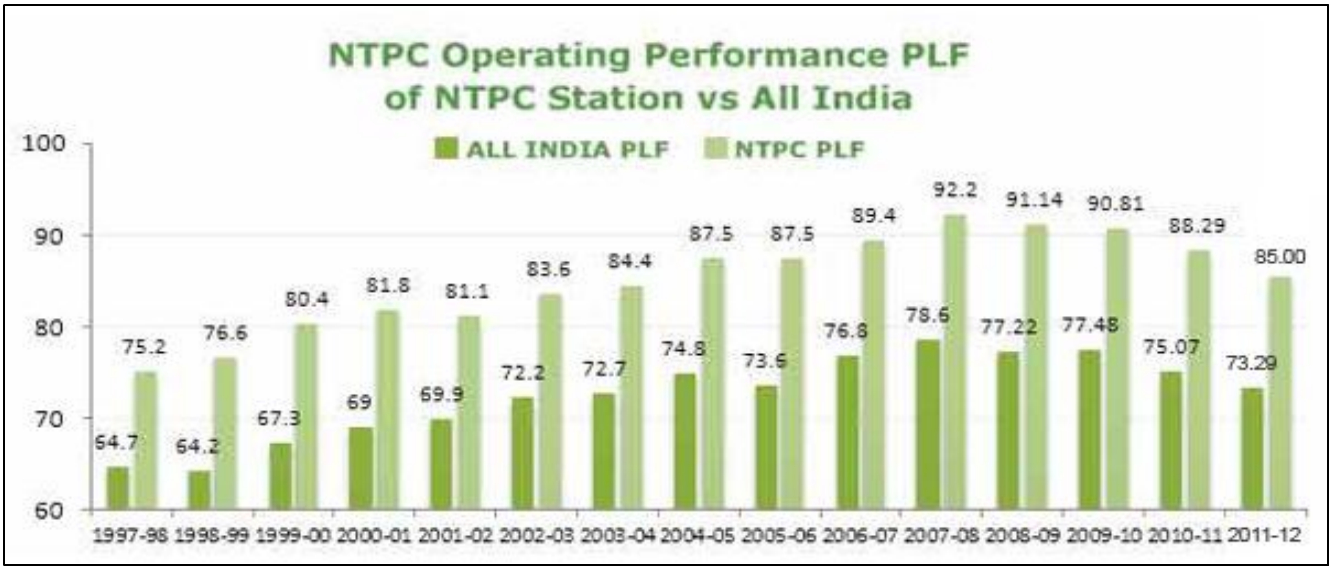

Figure 44-Performance of NTPC – Evaluation by NTPC

The Times of India, "Maharashtra Electricity Regulatory Commission overlooks MahaGenCo's failure to lift WCL coal", Ashish Roy, June 22, 2012
http://articles.timesofindia.indiatimes.com/2012-06-22/nagpur/32368265_1_wcl-western-coalfields-limited-mahagenco

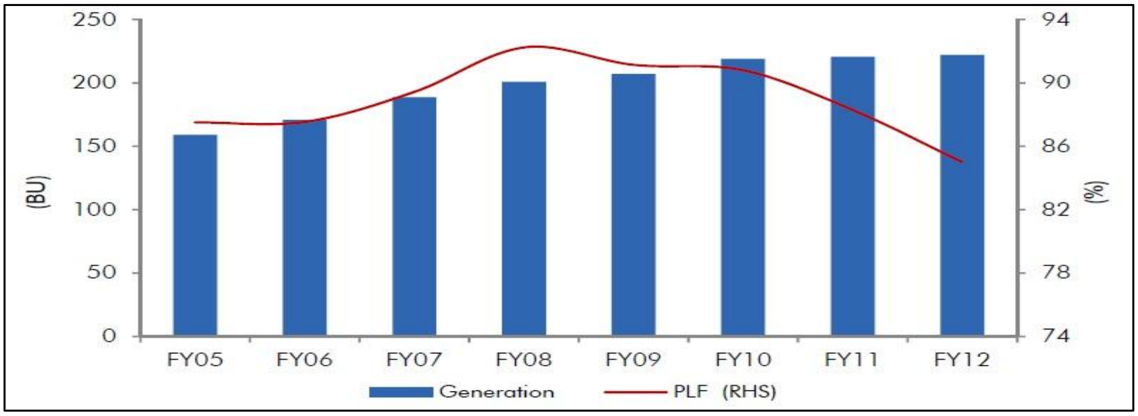

Figure 45-Performance of NTPC – evaluation by third party[98]

NTPC has taken the following steps to enhance their performance[99]

1. Adoption of newest technology
    a. Pneumatic conveyors for fly ash
    b. Ash water recirculation system
    c. Pipe conveyors for coal
2. Online systems
    a. Online life assessment
    b. Online coal flow measurement
    c. Acoustic pyrometers
    d. 3-D model of complete plant layout
3. High efficiency Electrostatic precipitators (efficiency of the order of 99.97%)
4. Soft logic in control systems like Electrical breakers (forced outage minimization)
5. Collaboration with academic and research institutions

[98] http://www.business-standard.com/content/research_pdf/ntpc_160512.pdf
[99] http://www.asiapacificpartnership.org/pdf/PGTTF/events-april-08/Asia_Pacific_Partnership_India_Peer_Review_NTPC_ppt.pdf

History of Coal – the primary fuel for power generation

Coal is a vitally important resource in India as more than 50% power produced is attributed to coal. Coal has a clear cut majority in power generation both in the country and in the state. That is the reason why coal is critically important as a primary energy resource. Given the interdependence between coal and coal power sector it is important to have a better understanding of issues associated with the coal sector. Coal quality is an important factor in the efficiency of power plants. But constraints like uncertainties, poor coal quality need to be taken into consideration. It has been observed that in many cases, lack of regular coal supply and poor quality of coal has limited generation. Poor quality coal increases wear and tear of power plant equipment. Use of low-quality coal increases auxiliary consumption, operation and maintenance costs and time, and reduces overall efficiency. The subsequent paragraphs deal with these issues.

Coal India Limited (CIL)[100] is a central government owned coal manufacturer of India, and is the single largest coal manufacturer in the world. It has been granted 'Maharatna' status by the Government of India (Ministry of Heavy Industries and Public Enterprises) for its stature and achievements[101].

CIL was formed on November 1, 1975 after the nationalization of coking coal mines in May 1972 and that of non-coking coal mines in May 1973. It has seven wholly owned coal producing subsidiaries.

1. Eastern Coalfields Limited (ECL), Sanctoria, West Bengal
2. Bharat Coking Coal Limited (BCCL), Dhanbad, Jharkhand
3. Central Coalfields Limited (CCL), Ranchi, Jharkhand
4. South Eastern Coalfields Limited (SECL), Bilaspur, Chhattisgarh
5. Western Coalfields Limited (WCL), Nagpur, Maharashtra
6. Northern Coalfields Limited (NCL), Singrauli, Madhya Pradesh
7. Mahanadi Coalfields Limited (MCL), Sambalpur, Orissa

[100] http://www.coalindia.in/Company.aspx?tab=0

[101] The criteria for Maharatna status is as follows:

- Having Navratna status.
- Listed on Indian stock exchange with minimum prescribed public shareholding under SEBI regulations.
- An average annual turnover of more than Rs. 20,000 crore during the last 3 years. Earlier it was Rs 25,000 Crore.
- An average annual net worth of more than Rs. 10,000 crore during the last 3 years. Earlier it was Rs. 15,000 crore.
- An average annual net profit after tax of more than Rs. 2500 crore during the last 3 years. Earlier it was Rs. 5000 crore.
- Should have significant global presence/international operations.

The Maharatna status gives the PSEs financial and managerial autonomy to invest up to Rs. 5000 crore in a new venture without seeking government approval.

Coal production for the last five years is tabulated below. We can see that the production increased for the first three years, but after that it has stabilized in spite of the ever increasing demand. Non coking coal is used in power generating plants. Coal production for India and CIL (monopoly in coal production in India) is tabulated below.

Table 39- Production (Million tons) by Coal type - CIL (2008-2012)

	2008	2009	2010	2011	2012
	Raw prod.	Raw prod.	Raw prod.	Raw prod.	Raw prod.
Non Coking Coal	353.30	377.19	395.13	389.97	392.48
Coking Coal	26.16	26.54	36.13	41.35	43.36
Total	379.46	403.73	431.26	431.32	435.84

Table 40- Production (Million tons) by coal type – All India (2007-2011)

	2008	2009	2010	2011	2012
	Raw prod.	Raw prod.	Raw prod.	Raw prod.	Raw prod.
Non Coking Coal	398.73	422.63	457.95	487.63	483.54
Coking Coal	32.10	34.45	33.81	44.41	49.53
Total	430.83	457.08	491.76	532.04	533.07

Coal is found primarily in the states of Jharkhand, West Bengal, Chhattisgarh, Madhya Pradesh, Maharashtra, Orissa and Andhra Pradesh. Lignite reserves are situated in Rajasthan and Gujarat, but most prominently in Tamil Nadu. India owns fifth largest estimated coal reserves (Geological Resources of Coal) in the world - 285.86 billion tons[102]; of which, 113.4 billion tons are proven resources.

[102] http://coal.gov.in/welcome.html

Figure 46- Coal and lignite reserves map of India[103]

Institutional barriers

Annual requirement of coal in India was pegged at 604.33 MT by Planning Commission in 2009-10[104]. Actual supply of raw coal was 580 MT, 513 MT from indigenous sources and 67 MT from imports.

In spite of having excellent coal resources, we have to accede to coal import. The main obstruction as cited by the Coal Ministry is delay caused by forest and environment clearances. Ministry of Environment and Forests (MoEF) has barred coal producers from mining coal in some places, and has also halted mining operations in some[105]. The Coal Ministry and coal manufacturers always grapple with MoEF for clearances due to which production is hampered. There is a serious debate running constantly between giving service to the accelerating growth and preserving the environment.

[103] Maps of India http://www.mapsofindia.com/maps/india/coalreserves.htm

[104] Provisional Coal Statistics, 2009-10

[105] The Economic Times, “Government panel says 'Go, No-Go' concept of forest area classification legally not tenable and should be abandoned”, Sarita Singh, June 29, 2011 http://articles.economictimes.indiatimes.com/2011-07-29/news/29829405_1_environment-ministry-coal-blocks-forest-clearance

80% of coal produced per year goes for power generation.[106] Other prominent buyers of coal are Cement, Sponge Iron and Steel manufacturers. Others include heavy energy consuming industries that have captive power plants with coal linkage agreements with the coal producers.

Fuel Supply Agreement

The agreement between fuel producer and power generator (MSPGCL) that decides the contracted fuel quantity, the period of supply, the minimum compulsory amount to be supplied as a percentage of the contracted quantity, the penalty for supply default is the Fuel Supply Agreement (FSA).

CIL released changes in FSAs in April 2012 wherein CIL was liable to supply at least 80% of the contracted coal quantity and not 100%. The penalty, if less than 80% is supplied was pegged at just 0.01% of the shortfall[107]. Also, 80% quantity was to be supplied in a period of three years and no penalty was to be issued against the coal supplier (CIL) in this period. FSA also gave supplier the power to terminate the agreement unilaterally, which was unacceptable. This FSA was overtly one-sided and it exploited the interests of CIL and the helplessness of power producers.

Very few power producers agreed to this FSA. NTPC opposed it strongly, and after the intervention of PMO the clause of 0.01% penalty was changed to a penalty of 10% of the shortfall[108]. As CIL governs more than two third of coal production in India, it included one sided clauses in the agreement. This has resulted in delay in confirmation of clauses in FSA and agreement on both sides.

In addition to the tussle between coal and environment ministries, this in itself is a barrier in growth of energy sector. This weakens the public sector enterprises and deteriorates the standard of provision of basic services to the consumer.

This lop-sided nature of the agreement shows that CIL, in spite of being the single largest coal manufacturer in the world, still has to struggle for profits. The growth in coal production by CIL has not been commendable.

In this fight between the coal producers and power producers (most of which are state owned), the ultimate sufferer would be the consumer who has to bear the cost.

[106] http://coal.gov.in/cpddoc.htm

[107] Daily News and Analysis, “Coal India board okays 80% trigger, not the penalty”, Sumit Moitra, August 1, 2012 http://www.dnaindia.com/money/report_coal-india-board-okays-80pct-trigger-not-the-penalty_1722435

[108] The Economic Times, “NTPC ends row with Coal India over fuel supply agreement; accepts changes proposed by PMO”, Debjoy Sengupta, June 26, 2012 http://articles.economictimes.indiatimes.com/2012-06-26/news/32424986_1_fuel-supply-agreement-coal-india-cil

Importance of Coal in India and Maharashtra

Coal India Limited produces 81% of the total coal produced in the country. Almost all the state owned power plants buy coal from CIL and its subsidiaries. Maharashtra buys coal from Western Coalfields Limited (WCL). WCL produces around 43MT of coal per year. Thermal power plants in Maharashtra require an average of 39.6 MT coal per year, if we extrapolate coal linkages per day on to coal requirement per year[109]. Several private (CPPs and IPPs) and captive power producers buy coal from various sources including CIL.

Thermal plants of MSPGCL and private producers contribute largely to the power requirement of Maharashtra. It has been observed and MSPGCL also claims that they are supplied with poor quality coal[110] whereas fine quality coal is supplied to private producers. The problems associated with coal that pose major impediments in power plant performance are indicated below.

- Supply default – 100% contracted quantity is not supplied, results in more outages
- Wet coal – Coal is often transported in open containers and stored in open spaces. Wet coal or moist coal reduces the calorific value of coal.
- Coal found in India is of low quality and has a low gross calorific value[111]. It also has high (30-35%) ash content which reduces Specific Coal Consumption (SPCC).
- Adulteration – Mixing of sand, shale, stones and other impurities damage the power generation equipment esp. the coal pulverizer (crushers).

Though there is 112 billion tons of proven coal reserves in the country, problems related with quality, supply and transport deter growth of energy sector which hampers development on social and economic fronts. Poor quality of coal is problematic as it increases auxiliary consumption, operation and maintenance costs and time, and reduces overall efficiency. Hence, use of better quality coals, including washed coals, would improve efficiency.

Coal-gate scam

Popularly called as Coal-gate by critics, the report by the Comptroller and Auditor General (CAG) of India on coal sparked widespread protests-in-print in response to the estimated loss of Rs. 1.86 lakh crore to the exchequer of India.

[109] Government of India, Ministry of Power, Central Electricity Authority, Multiplied linkages per day for thermal power stations by 365 to get the annual requirement http://www.cea.nic.in/archives/coal_monthly/jul12.pdf -

[110] LiveMint, "WCL supplying inferior quality coal: MahaGenCo", Makarand Gadgil, October 14, 2011 http://www.livemint.com/2011/10/14220042/WCL-supplying-inferior-quality.html

[111] http://www.fe.doe.gov/international/Publications/Coal_Beneficiation_Workshop/coal_beneficiation_paper_zamuda.pdf

Coal, like water and oil is a natural resource. The ownership of such resource naturally goes to the state, whose beneficiaries are its people. India has fifth largest coal reserves in the world. State must take care – by law – that the beneficiaries of the revenue generated from the natural resources its people own, must be passed on to them.

From 1993 till 2005, 41 private companies and 29 state-owned companies got coal blocks "for free". This exponential acceleration can be attributed to the post liberalization era. It must be taken into account that even if less number of coal blocks were allocated to state-owned companies, the amount of coal to be mined was far more. After 2005, improvements were made in coal block allocation. Newspaper advertisements with separate advertisements for different sectors were introduced to accelerate the process and stop the delays that impede sectoral growth.

CAG Audit: In 2010, parliament passed the amendment bill of Mines and Minerals (Development and Regulation) Act (MMDR Act), and auction was made compulsory. Till then from 2006 to 2009, 135 captive coal blocks were allocated freely to government and private companies. Competitive bidding would have got the highest bidder to the forefront and the state would have received a justified market price for the coal blocks sold.

By giving away captive coal blocks freely to private companies, the state deprived itself of the money it owned. The money remained with the parties from whom it should have been ideally transferred to Government of India. The ultra-fast coal block allocation was done as a necessity for higher growth, and to minimize the need for expensive coal imports, asserts the Coal Ministry.

Clarification by Ministry of Coal: If the coal blocks were not made available, it would have resulted in higher imports causing outflow of foreign exchange or no large investments in these crucial sectors. Allocation of coal blocks has resulted in investment in these sectors which was the need of the times. 195 blocks with reserves of 44.23 billion tonnes of coal stand allocated, out of which 96 blocks with 26.93 billion tonnes of reserves have been allocated to Government companies / UMPPs. 27 blocks with 5 billion tonnes of coal reserves are allotted to private companies in the power sector, which is a regulated sector.

Solution 2

Reduce T & D losses

Goal: To strengthen the power transmission and distribution system

Introduction

Electricity once generated must be moved to areas where it will be used. This is known as transmission – moving large amounts of power over sometimes very long distances. It is separate from distribution, which refers to delivering electric energy from the high voltage transmission grid to specific locations such as residential streets, commercial organizations, etc. Distribution is considered to encompass substations and feeder lines that take power from the high voltage grid and progressively step down the voltage. The transmission and distribution system includes everything between a generation plant and an end use site. Along the way, some of the energy supplied is lost due to the resistance of wires and equipment that the electricity passes through. Most of this energy is converted into heat. The amount of energy that is lost in T&D depends on the physical characteristics of the system as well as how it is operated[112].

The central transmission utility (CTU) and state transmission utilities (STUs) are responsible for interstate and intra-state transmission in India. The STUs develop, operate and maintain the state transmission system to facilitate transmission of electricity from its source to load dispatch centres. MSEDCL is the distribution company of Maharashtra and MSETCL is the transmission company. The transmission network is used for electricity trading, providing open access and transfer of electricity. Electrical losses are an inevitable consequence of the transfer of energy across electricity distribution networks. Almost 100% of electricity transmission in India is owned by the public sector while about 13% of electricity distribution in India is owned by the private sector[113].

The transmission and distribution (T&D) losses in our country, which were around 15% up to 1966-67, increased gradually to 23.28% by 1989-90. After a brief spell of reduction in T&D losses to 21.13% (1994-95), there has been an upswing and the losses reached a level of 33.98% during 2001-02. Since then, a reducing trend has been observed as T&D losses have come down to 32.54% during 2002-03, 32.53% during 2003-04 and 31.25% during 2004-05[114].Over 21% of the total electricity generated in India is lost to transmission and distribution[115]. The T&D losses in the advanced countries of the world have been ranging between 6 to 11%[116]. T&D losses in India are among the highest in the world. These losses result in reduction of the State revenue and have drastic implications on profitability and commercial viability of the operations of transmission and distribution companies.

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[112] Energy efficiency in the power grid - http://www.nema.org/prod/technologies/upload/TDEnergyEff.pdf
[113] The Political Economy of India's Climate Agenda, CEPS Working Document No. 325/March 2010, Noriko Fujiwara
[114] http://www.ignou.ac.in/schools/soet/acpdm/BLOCK%204%20BEE-001/Part%203.pdf
[115] Journal of Computer Science 3 - Performance Monitoring of Energy Flow in the Power Transmission and Distribution System Using Grid Computing, (5): 323-328, 2007 http://www.scipub.org/fulltext/jcs/jcs35323-328.pdf
[116] http://www.ignou.ac.in/schools/soet/acpdm/BLOCK%204%20BEE-001/Part%203.pdf

MSEDCL suffers heavy financial losses due to theft/ pilferage of electricity, unmetered use and ineffective practices of billing and collection. In addition, the distribution system is often characterized by inefficiency, low productivity, frequent interruption in supply and poor voltage.

System losses increase the operating cost of power utilities and typically result in higher cost of electricity.

Electricity consumption

Domestic, industrial, commercial and agricultural consumers comprise the key customer segments. Besides these power is also supplied in bulk to railways for traction as well as to service utilities for public lighting and water works, among other. The total power consumption in 2010-11 is 87,397 MU (million kWh). Power consumption has grown at an average rate of 9.48% over the period from 2005-06 to 2010-11. The following table gives the consumption of electricity in the state by customer type.

Table 41: Consumption of electricity in Maharashtra by consumer type

Consumer Category	05-06 mkWh	06-07 mkWh	07-08 mkWh	08-09 mkWh	09-10 mkWh	10-11 mkWh	Annual % change (10-11)	Average % change
Agriculture	11094	9749	12676	12733	13925	16257	16.75	9.3
Industry	25692	26535	30323	28850	30866	34416	11.5	6.8
Commercial	4841	6940	6661	9102	10546	11571	9.72	27.8
Domestic	13572	14284	15553	16878	18171	19547	7.57	8.8
Administrative purposes								
Railways	1861	1987	2024	2110	2119	2707	27.75	9.1
Public works	2148	2272	2520	2560	2658	2310	-13.1	1.5
Miscellaneous	79	318	82	761	854	589	-31.0	129
Total	**59287**	**62085**	**69838**	**72994**	**79139**	**87397**	**10.43**	**9.48**

Of the estimated total power consumption of 87,397mkWh in 2010-11, the industrial sector consumed the majority share at 39.38%. This was followed by domestic (22.37%) and agriculture (18.6%). These three sectors together, account for 80% of the total electricity consumption in the state. Further, the agriculture segment has recorded the highest annual growth rate of 16.75% (2010-11) and the commercial segment has recorded highest average growth rate of 27.8% in electricity consumption.

The agricultural consumption has shown a modest average growth rate of 9.3% over the period 2005-06 to 2010-11, however it has increased by a staggering 16.75% from 2009-10 to 2010-11. Taking into consideration the consumption from 2005-06 till 2008-09, the share of agriculture consumption as a proportion of total power consumption, decreased from 18.71% (2005-06) to 18.6% (2010-11). In the year 2006-07 and 2007-08, agricultural consumption was 15.70% and

18.15% as a proportion of total power consumption respectively. Agricultural consumption has remained between 15-20% of total consumption for the past 6 years. The agricultural consumers are a heavily subsidized class of consumers.

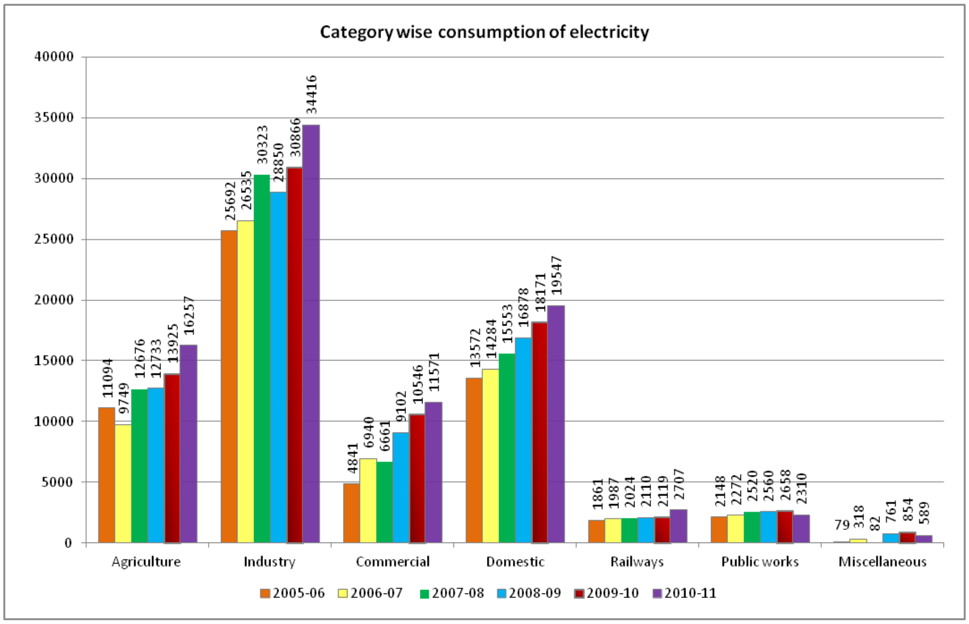

Figure 47- Electricity Consumption across various economic sectors and for administrative purposes

The agriculture consumption is not metered and tariffs are based on the pump size or unit horsepower (HP) of the motors. Such power loads get sanctioned at lower load declarations. Once the connections are released the consumer gets into the habit of increasing their connected loads, without obtaining necessary sanction for increased load from the utility[117]. Further, meter-less connections have made theft easier. Even if the distribution company has the record of total electricity consumed by agricultural consumers, it does not get recorded in front of the actual consumer because of the absence of meter. Drawing electricity from poles or from transmission lines illegally thus goes unnoticed. This has created several inefficiencies in the entire system – pumps are inefficient, price signals for crop selection are limited, water tables are falling rapidly, and poor farmers who do not have access to irrigation face water scarcity. As per the CEA, estimated ultimate groundwater potential in terms of electrical pump sets is 24.49 lakhs for Maharashtra as on July 31, 2012, however, 38.01 lakh[118] agricultural pumps were energized at the end of July 2012.

The precise estimation of unmetered consumption by the agricultural sector greatly depends on the cropping pattern, ground water level, seasonal variation, hours of operation, etc.[119]. Thefts get a safe environment with unmetered connections. Metered connections for agriculture will reduce the AT&C loss to a great extent.

[117] http://www.teriin.org/upfiles//pub/papers/ft33.pdf
[118] http://www.cea.nic.in/reports/monthly/dpd_div_rep/pumpset_energisation.pdf
[119] http://www.teriin.org/upfiles//pub/papers/ft33.pdf

Transmission and Distribution

The generated electric power is stepped up to a higher voltage for transmission on the *transmission grid*. The transmission grid moves the power over long distances to substations. Upon arrival at a substation, the power will be stepped down from the transmission level voltage to a distribution level voltage. As the power exits the substation, it enters the *distribution grid*. Finally, upon arrival at the service location, the power is stepped down again from the distribution voltage to the required service voltage(s).

Maharashtra State Electricity Transmission Company Limited – MSETCL

MSETCL is the wholly Maharashtra Government owned transmission entity under MSEB Holding Company Ltd. providing electricity service in most parts of Maharashtra. It has built 559 substations with a variety of voltage levels as per the requirement and technological progress which transfer electricity from source to the distribution company.

The electricity grid infrastructure is built in Maharashtra predominantly by MSETCL. At national level, Government of India owned Power Grid Corporation of India (PGCIL) builds and manages the national grid. The transmission network of MSETCL is constantly growing to meet the ever growing needs of a developing state.

MSETCL is the only transmission company in India among state transmission utilities to build HVDC (high voltage direct current) transmission line. MSETCL operates 752 km long, 1500 MW, 500 kV bipolar HVDC line from Chandrapur to Padghe. Other than this transmission line the rest of the transmission network operates on HVAC (high voltage alternating current).

Table 42-Transmission Network in Maharashtra, MSETCL

Voltage level	EHV Substations	Transformation Capacity (MVA)	EHV Lines (ckt km)
500 kV HVDC	2	3582	1504
400 kV	22	18180	7405
220 kV	171	39383	13209
132 kV	260	21633	12073
110 kV	34	2674	1724
100 kV	36	2587	686
66 kV	34	1139	3270
Total	**559**	**89178**	**39871**

Transmission System Availability which is a measure of availability of the transmission grid is improving year on year.

Table 43-Transmission System Availability[120]

HVAC System (MERC Benchmark 98%)							
Year	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12
Availability	98.72%	98.82%	98.99%	99.29%	99.48%	99.62%	99.72%
HVDC System (MERC Benchmark 95%)							
Availability	63.48%	91.73%	92.29%	93.55%	94.96%	97.62%	96.55%

Maharashtra State Electricity Distribution Company Limited – MSEDCL

MSEDCL is the wholly Maharashtra Government owned transmission entity under MSEB Holding Company Ltd. which distributes electricity to its variety of consumers *viz.* domestic, industrial, agricultural, commercial, public works, railways and other miscellaneous consumers. MSEDCL accepts electricity from MSETCL and dispatches it through State Load Despatch Centre.

MSEDCL has its own infrastructure consisting of distribution transformers, distribution lines, and sub-stations. The growth in distribution infrastructure is shown in the table below.

Table 44 - Distribution Network (Cumulative)[121]

Year	No. of sub stations	No. of distribution transformers	Distribution lines (ckt. Km.)
2006-07	1827	2,72,231	7,07,067
2007-08	1889	3,00,957	7,28,754
2008-09	1947	3,27,314	7,58,093
2009-10	2033	3,51,243	7,92,785
2010-11	2234	3,91,574	8,33,470

[120] http://www.mahatransco.in/wps/wcm/connect/b8a373004a56d5bda8cbbaf57b420b69/Technical+Perfoemance+05-2012.pdf?MOD=AJPERES
[121] Government of Maharashtra, Department of Planning, Directorate of Economics and Statistics: Economic Survey of Maharashtra, 2011-12

Transmission and Distribution losses in Maharashtra

T&D losses during 2010-11 were 21.60% as against 25.20% in the previous year. T&D losses in the state for the past six (2006-07 till 2011-12) years have been presented graphically below[122]. Though the losses have declined over the years they still remain very high. Losses beyond 18% are primarily due to theft of energy[123].

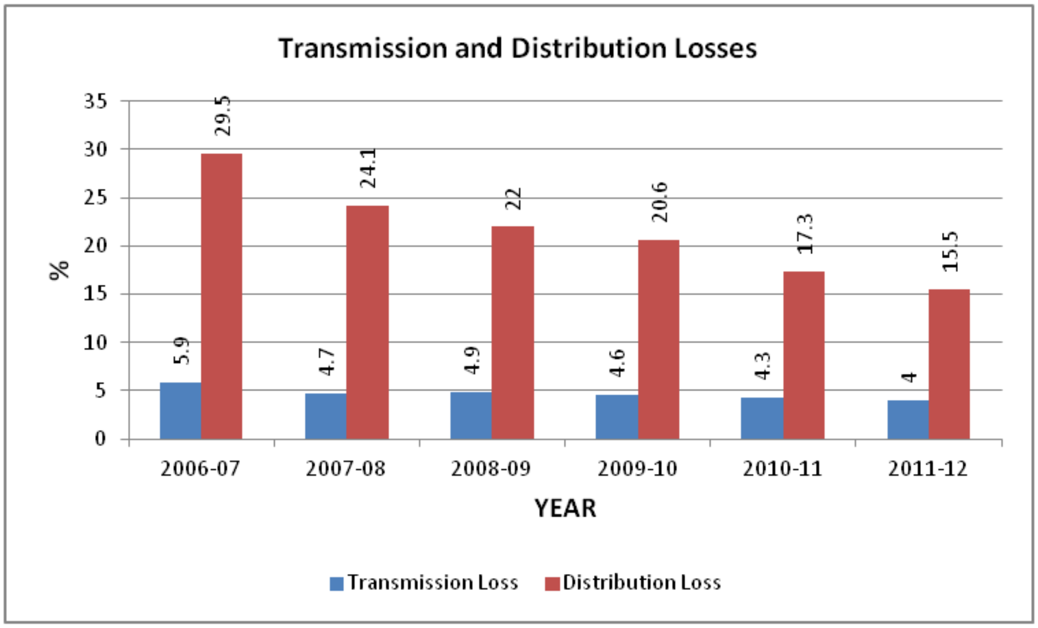

Figure 48 – Transmission and Distribution Losses for past 6 years[124]

To get a picture of the geographical variations in the T&D Losses, circle wise distribution losses in the state (for a six-month period from January 2012 to June 2012) are presented below in the graph[125]. The average distribution loss for MSEDCL circles in the state is 17.75%. Osmanabad has highest distribution losses of 38%, followed by Nandurbar (35%) Fifteen circles have losses of more than 20%.

[122] Government of Maharashtra, Department of Planning, Directorate of Economics and Statistics: Economic Survey of Maharashtra

[123] http://www.cag.gov.in/html/cag_reports/maharashtra/rep_2006/com_chap_2.pdf

[124] Government of Maharashtra, Department of Planning, Directorate of Economics and Statistics: Economic Survey of Maharashtra, 2011-12

[125] http://www.mahadiscom.in/consumer/Distribution-Losses-circle.pdf

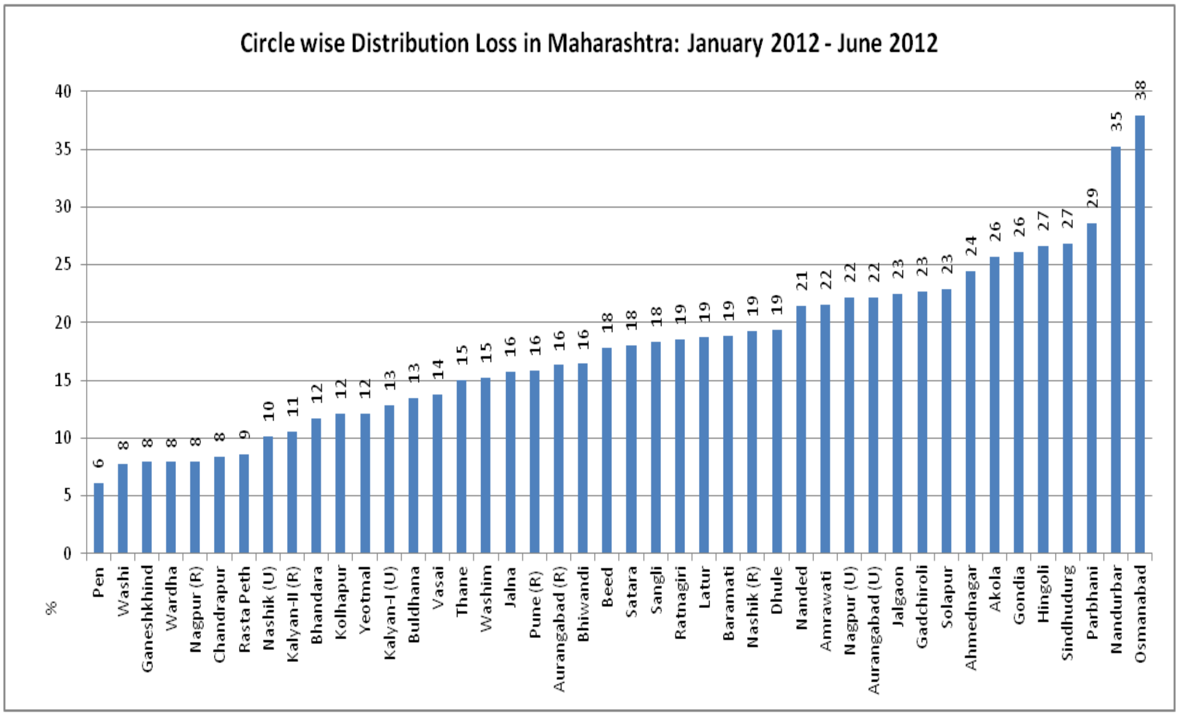

Exhibit 1- Circle-wise Six Monthly Sliding Average Percentage Distribution Loss

By increasing quality of metering, feeder separation and various such measures to curb losses, several circles have reduced their distribution losses by more than 33%.

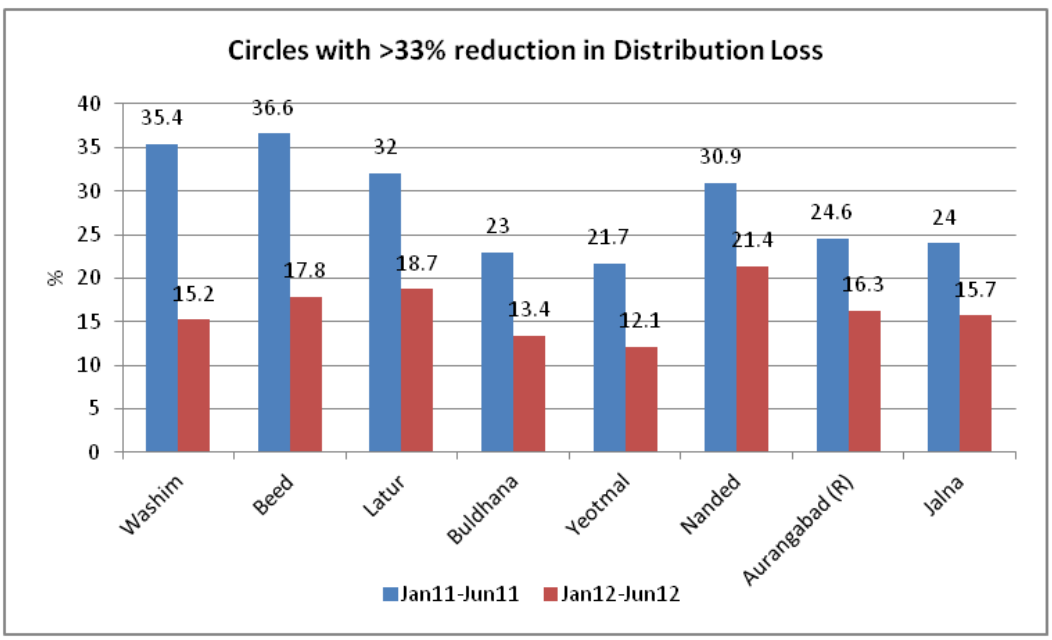

Figure 49 - Circles with > 33% reduction in distribution loss

Table 45-AT&C Loss, Billing & Collection Efficiency of Distribution Utilities[126]

Year	AT&C Loss (%)	Collection Efficiency (%)
2001-02	46.34	88.77
2002-03	44.25	87.6
2003-04	26.62	111.16
2004-05	38.95	96.34
2005-06	26.53	102.01
2006-07	NA	NA
2007-08	31.32	90.47
2008-09	31.19	88.19
2009-10	25.02	94.42

Transmission loss

Electricity generated at power stations is given to the Power Grid for transmission to different places. Power is required to be transmitted at very high voltage levels in order to transmit it efficiently. It is transmitted at voltage levels ranging from 33kV to 500 kV.

Power is dissipated into the transmission lines as it is transferred from one place to another. Transmission lines have their own resistance where voltage drops as a result of Ohm's Law. When distances are long, the magnitude of dropped voltage naturally increases. Using excellent quality materials and design for the cables and wires in transmission lines, transmission losses can be controlled.

Old worn-out and poor distribution network leading to frequent outages; skewed tariff structure; huge transmission & distribution (T&D) losses are largely attributed to outright theft & unmetered supply; uneven low transmission/high transmission line ratio, overloaded distribution transformer/lines; lack of accountability at feeder level and in distribution setup of state electricity boards etc.

Distribution loss

It refers to the difference between the amount of energy delivered to the distribution system and the amount of energy customers is billed. The distribution loss figures at 22/11kV and LT levels; the distribution loss estimation is not accurate, as these involve meters at the consumer level. These meters can sometimes be defective. Also, the estimation of distribution loss of unmetered energy for agriculture and other unmetered consumers like single point lighting is quite difficult[127].

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[126] Government of India, Power Finance Corporation, Performance of State Power Utilities 2001-02 to 2005-06

[127] Economic and Political Weekly, V Ranganathan: "Determining T&D losses in India-Their Impact on Distribution Privatization & Regulation", pp. 658, February 12, 2005

These losses occur on both sides of the energy meter - the utility side as well as the consumer side. On the utility side, the main causes for the energy losses are non-standard and antiquated distribution engineering practices, inefficient and overloaded distribution equipment, faulty and poor maintenance practices, a lack of investment in system upgrade, faulty meters and poor commercial management and accounting practices. At the consumer end, the problems leading to avoidable energy and revenue losses are lack of meters, prevalence of flat rate tariffs over metered tariffs, non-payment, theft, illegal connections, and lack of consumer education in the rural sector, rampant political interference and inefficient electricity use[128]. Distribution system therefore comprises two types of losses: technical as well as commercial losses. System losses increase the operating cost of electric utilities and distinctly result in higher costs of electricity.

T&D networks are supposed to

- Reach all consumers that want to be connected
- Meet their demands
- Provide satisfactory power supply reliability
- Provide power supply quality

Calculation of T&D losses: T&D loss accounts for the loss of energy from the point of generation to the point of billing. It is the difference between units injected into the system and units billed to the ultimate consumer, and generally expressed as percentage of units injected.

T&D Loss (%) = (Energy input – Energy billed) x 100/ Energy input

Technical losses

They are naturally occurring (caused by actions internal to the power system) and consist mainly of heat dissipation in electrical system components. Technical losses occur during transmission and distribution and involve substation, transformer and line related losses. High technical losses in the system are primarily due to inadequate investments over the years for system improvement works, which has resulted in unplanned extensions of the distribution lines, overloading of the system elements like transformers and conductors, and lack of adequate reactive power support. The following are the major reasons for technical losses in India:

- Inadequate investment in transmission and distribution, particularly in sub transmission and distribution. The investment in T&D sector (11th FYP) is 1:0.5 as against the ratio of

[128] India Electricity Distribution Reform, Review and assessment, Volume I: Main Report Submitted By CORE International, Incorporated
U.S.A, September 18, 2002

1:1[129]. Low investment has resulted in overloading of the distribution system without commensurate strengthening and augmentation.

- Haphazard growths of sub-transmission and distribution system with the short-term objective of extension of power supply to new areas.
- Large scale rural electrification through long 11kV and LT lines.
- Overloading of existing lines & substation equipment.
- Poor quality of equipment used in agricultural pumping in rural areas, cooler air conditioners and industrial loads in urban areas.
- Absence of up gradation of old lines and equipment.
- Low HT: LT ratio.
- Poor R&M of equipment
- Non-installation of sufficient capacitors.

Commercial or non-technical losses

Commercial or non-technical losses are caused by actions external to the power system or are caused by loads or conditions that the technical computation fails to take into account. These are difficult to measure as most of these losses are unaccountable. These losses are mainly due to low metering efficiency, unmetered supply of energy, theft and pilferages. This may be eliminated by improving metering efficiency, proper energy accounting & auditing and improved billing & collection efficiency[130].

Theft of power is energy delivered to customers that is not measured by the energy meter for the customer. This can happen as a result of meter tampering or by bypassing the meter. Losses due to metering inaccuracies are defined as the difference between the amount of energy actually delivered through the meters and the amount registered by the meters. All energy meters have some level of error which requires that standards be established. The drivers for commercial losses are listed below.

- Low metering/billing/collection efficiency;
- Low accountability of employees;
- Errors in meter reading - Avoid meter reading due to various reasons like house locked, meter not traceable, etc.; manual error in meter reading; data punching errors; lack of validation checks[131];
- Absence of Energy Accounting & Auditing;
- Theft, Pilferage and tampering of meters: Theft or pilferage by existing consumers is the predominant cause of loss of revenue to the utility. Almost all categories of consumers

[129] International Conclave on key inputs for accelerated development of Indian power sector for 12th plan and beyond - Capacity building for transmission system-Supply & Execution, - http://www.cea.nic.in/more_upload/conclave/24.pdf
[130] http://www.powermin.nic.in/JSP_SERVLETS/internal.jsp
[131] The IGNOU Report, sub source PFC

are involved in this. The following can be considered as practices of theft that directly affect the power distribution

- Theft (by SEBs) where meters are installed unofficially, off the records[132].
- Theft (by the consumer):
  - Direct hooks on HT/LT lines: This practice of direct tapping by non-customers is followed mainly in domestic and agricultural categories.
  - Tampering the meter, using devices to reverse the meter reading and damaging the instrument to prevent correct reading[133]. This results in slowing down of the meter and losses to the utility. There are various ways of tampering with the meters and slowing them down.
  - Unmetered connections: The agricultural consumers are not metered and charged on a flat rate basis. This arises in arriving at incorrect estimates in consumption in this category resulting in losses. Excessive use of electricity through unmetered connections goes unchecked and there is a potential to steal large amounts of electricity.
  - Industrial or commercial units consume power on using residential or agricultural power connections. This type of theft does not get reflected as losses in the books of records.
- Another aspect of theft by consumers is non-payment of bills for the electricity consumed. Though this is not accounted for in the distribution losses, it results in financial losses for the distribution utilities.

Apart from T&D losses which occur due to technical or commercial reasons, there are losses which occur due to the gap between the billing and the collection. In the year 2007-08, 46,260.05 million units (MUs) power was generated at a cost of Rs. 9,417 crore and 79,871MUs were purchased at a cost of Rs. 18,515 crore. Thus 126,131.05 MUs were available in the state, however only 104,430.95 MUs were billed. Thus 21700.1 MUs of power was lost either due to technical and commercial reasons. Even out of the total amount billed Rs. 23,483 crore only Rs. 22,687 crore was collected creating a deficit of Rs. 796.08 crore. Thus 17.20% of the units are lost and 3.4% of the billed amount is not collected[134]. The MSEDCL have quoted their circle wise average distribution losses as 17.75%.

The aggregate of T&D loss and loss due to non-realization of billed demand is termed as Aggregate Technical and Commercial loss (AT&C loss). The T&D losses have always been computed taking into account electricity bills issued to consumers as accrued income and not on actual collection. Therefore, T&D loss figures do not capture the major gap between the billing and the collection, apart from the large amount of theft not captured in billing. AT&C

[132] Economic and Political Weekly, V Ranganathan: "Determining T&D losses in India-Their Impact on Distribution Privatization & Regulation", pp. 658, February 12, 2005

[133] http://www.cag.gov.in/html/cag_reports/maharashtra/rep_2006/com_chap_2.pdf

[134] Government of Maharashtra, Department of Finance, Medium Term Fiscal Policy –Fiscal Policy Strategy Statement and Disclosures for Maharashtra, 2010-11, pp. 20

loss to the utility is the sum total of technical losses, commercial losses and loss due to non-realization of total billed units. AT&C loss for a year is also expressed as percentage of Energy Input. It is the difference between units injected into the system and the units for which the payment is collected. The AT&C losses take this gap into account.

Losses due to Unmetered (Agriculture) Consumption

In the year 2010-11, the agricultural sector (LT) consumed 15,813 MUs of electricity which was a staggering 40% of LT sales (22% of the total sales). Of the total units consumed by agricultural LT consumers, 8476 MUs were unmetered. This unmetered electricity is either consumed through pumps or other agricultural equipment.

Table 46 - Percentage Consumption and Revenue from LT Agriculture (metered & unmetered)

Year	Consumption	Revenue
2010-11	22%	9.4%

Total revenue generated by sale of electricity by MSEDCL in the FY 2010-11 was Rs. 33238 crore. The contribution of agricultural consumers to the total revenue was a meager Rs.3131 crore (9.4% of the total revenue).

Government of Maharashtra announced free power to farmers in the state in 2004. After incurring huge losses, the free power scheme was converted to a scheme with concessional rates in 2005. Electricity connections available for farmers are bifurcated in two types - metered and unmetered. Tariff for unmetered agriculture connections is based on 'HP' rating of the pump set used to draw water. This is a part of an indirect subsidy to farmers where a monthly charge based on the power rating is levied upon the farmer. MERC has directed MSEDCL to install meters for all unmetered agricultural connections. However the MSEDCL officials are facing stiff opposition from the beneficiaries (well-off farmers who actually corner the subsidies).

Table 47- Unmetered Agriculture connections (2008 to 2011)

Category	Particular	FY 2007-08	FY 2008-09	FY 2009-10	FY 2010-11
Ag. Unmetered consumers	No. of consumers	1,491,514	1,441,319	1,407,668	1,535,159
	Load in HP	6,286,356	6,086,496	5,940,885	7,252,058
Ag Metered consumers	No. of consumers	1,091,519	1,227,228	1,393,567	1,621,818
	Load in HP	4,607,505	5,200,299	5,885,311	7,650,990

Unmetered connections have increased in 2010-11 from the previous years (table 6 above). He reason for the tremendous Over 1 lakh new unmetered agricultural connections were released in the year 2010-11 due to shortage of meters[135].

[135] Government of Maharashtra, Maharashtra Electricity Regulatory Commission, Order for Truing Up of FY 2009-10 and APR of FY 2010-11, December 30, 2011, Case no. 100 of 2011

Initiatives taken by the Government to reduce T&D losses

The government has initiated two key programs to modernize distribution systems and increase supply networks - the Accelerated Power Development & Reform Program (APDRP) for urban areas and towns, and Rajiv Gandhi Gram Vidyutikaran Yojana (RGGVY) for rural areas and villages.

The government launched Accelerated Power Development and Reform Program (APDRP) in 2000-01 to bring about commercial viability in the distribution sector. Subsequently, the APDP was revamped to APDRP during 2002. The program had objectives such reducing AT&C losses to 15% in five years, decreasing power outages and interruption in supply, increasing the reliability and supply of power, adopting a systematic approach with management information systems, and improving consumer satisfaction through greater transparency[136].

The program, along with other initiatives of the Government of India and of the States, has led to reduction in the overall AT&C loss from 38.86% in 2001-02 to 34.54% in 2005-06, and further reduction to 28.56% in 2009-10[137]. The commercial loss of the State Power Utilities reduced significantly during this period from Rs. 29,331 crore to Rs. 19,546 crore. The loss as percentage of turnover was reduced from 33% in 2000-01 to 16.60% in 2005-06[138].

The Centre provided financial assistance to states for strengthening and upgrading sub-transmission and distribution networks. Till 2005-06, the government funded 50% of the project cost, half of which was in the form of grant and the rest in the form of loan. The loan component was discontinued in 2005-06. The rest of the funding comes from either the utilities' own resource generation or as counterpart funding from Rural Electrification Corporation (REC) and Power Finance Corporation (PFC). As on March 2008, in Maharashtra the APDRP project cost was Rs. 1643 crore out of which of Rs. 480 crore was under central assistance. The total amount utilized was Rs. 1148 crore which was 70% of the project cost. For FY 2010-11, although the sanction target was Rs. 9000 crore, Power Finance Corporation, the nodal agency for APDRP (now Restructured – APDRP) was able to sanction schemes of Rs. 13665 crore. Also, the entire amount of Rs. 2256.79 crore as released by Government of India (Central assistance) for disbursement under the Programme was disbursed by PFC to various state utilities.

The list of works undertaken by MSEDCL under APDRP I and II is provided in *Annexure VI*[139]. Phase I was undertaken in Pune city, Aurangabad, Jalgaon, Pimpri city, Nasik, Solapur, Sangli city, Ahmednagar, Osmanabad, Malegaon City, Amravati city, Latur, Ratnagiri, Kolhapur city, Nagpur, Sindhudurg, Nanded city, Amravati, Nagpur city and Nasik city at an estimated cost of Rs. 1136 crore. Phase II was undertaken in Akola, Buldhana, Khamgaon, Malkapur,

136 Power in India, Power distribution, pp. 228-229
137 Government of India, Power Finance Corporation, Performance of State Power Utilities 2007-08 to 2009-10
138 http://www.powermin.nic.in/distribution/distribution_overview.htm
139 http://www.mahadiscom.in/Apdrp_Project-02.shtm

Shegaon, Yavatmal, Bhandara, Dombivali, Ulhasnagar, Mulund-Bhandup and Thane districts. The estimated cost of the works undertaken was Rs. 237 crore.

MSEDCL has also undertaken 'Gaothan feeder separation scheme' in two phases in order to provide un-interrupted power supply to rural consumers as well as reduce T&D losses. The data on types of works undertaken under the Gaothan feeder separation scheme is tabulated in tables 10 & 11 in *Annexure VI*[140]. Works in phase I were undertaken in Nanded, Beed, Osmanabad, Latur, Nasik, Dhule, Jalgaon, Ahmednagar, Solapur, Kolhapur, Satara, Sangli, Pune, Aurangabad, Jalna, Parbhani, Amravati, Akola, Yavatmal and Buldhana districts. The cost was Rs. 943 crore. Rural Electrification Corporation (REC) had sanctioned a loan of Rs. 714 crore. Phase II works were implemented in Nasik, Dhule, Jalgaon, Ahmednagar, Wardha, Bhandara, Chandrapur, Gadchiroli, Gondia, Nagpur, Solapur, Kolhapur, Satara, Sangli, Pune Rural, Aurangabad, Jalna & Parbhani, Amravati, Akola, Buldhana and Yavatmal districts. The estimated cost of the project was Rs. 1446 crore and loan sanctioned from REC was Rs. 1301 crore.

Measures taken by MSETCL and MSEDCL to reduce losses

MSETCL has initiated various measures to reduce the transmission losses by modernization of Extra High Voltage (EHV) sub-stations. During 11th Five Year Plan, an addition of 134 EHV sub-stations of 39,575 MVA transformation capacity and EHV line length of 20,142 circuit km is expected.

In 2010-11, the work of 16EHV sub-stations of 8,827 MVA transformation capacity and EHV line length of 935.27 circuit km has been completed. As on 31st March, 2012, the Company had 559 sub-stations having transformation capacity of 89,178 MVA and EHV line length of 39,871 ckt. km[141].

The Transmission System Availability of MSETCL for HVAC System was 99.72% while that for HVDC System was 96.55% in 2011-12. Maharashtra Electricity Regulatory Commission (MERC) benchmark for HVAC system is 98% while that for HVDC system is 95%.

MSEDCL has undertaken measures like replacement of faulty meters, load reduction on overloaded HT & LT circuits by providing additional transformers, erection and commissioning of new sub-stations and lines under various schemes[142]. A massive drive has also been

[140] http://www.mahadiscom.in/Gaothan_Feeder_Separation_Scheme_Project-01.shtm

[141] http://www.mahatransco.in/wps/wcm/connect/msetcl/menu/transmission+network/network+at+glance/current+infrastructure

[142] Government of Maharashtra, Department of Planning, Directorate of Economics and Statistics: Economic Survey of Maharashtra 2009-10, Ch.9 Infrastructure

undertaken against unauthorized use of electricity. MSEDCL has also completed metering of all feeders. The initiatives taken by MSEDCL to reduce distribution losses are enlisted below[143]:

- Monthly Energy Accounting at Division level / Feeder level / DTC level;
- Giving target for each Division / Subdivision for LT loss reduction;
- Photo Meter Reading as well as DTC & feeder meters reading through digital camera;
- Collection for feeder wise energy audit;
- Massive theft control drive
    - In order to detect and curb the unauthorized utilization of electricity, there were 40 flying squads and 120 special squads (division level) operating during 2008-09 at different places in the State. During 2008-09, these squads detected 57,065 theft cases. MSEDCL has recovered Rs. 44.48 crore from these unauthorized consumers. During 2009-10 up to the end of October, 32,887 theft cases were detected and an amount of Rs. 36.02 crore was realized[144].
    - In the Pune division there are 15 squads to detect power theft of large quantum. The squad detected power thefts to the tune of Rs. 24 crores but recovered only Rs. 16 crore. In Mumbai division out of Rs. 30crores of thefts detected Rs. 17crore have been recovered; whereas out of Rs. 39.436 crore thefts detected from the Nagpur division only Rs. 13.46 crore have been recovered[145].
- MSEDCL police stations for efficient handling of theft of energy/other cases;
- Checking of doubtful energy intensive consumers;
- Capital investment plans;
- Accelerated Power Development Reforms Program (APDRP) schemes;
- Registrar General, Bombay High Court has designated all courts of additional districts & Session Judge at district headquarters for trial of Cases under EA 2003;
- Strict disciplinary action against delinquent employees;
- Speedy disposal of vigilance cases and strict action against defaulters; and
- Creation of more number of distribution franchisees in MSEDCL areas for improvement in metering, billing and revenue collection. *E.g.* Franchisee appointed in Bhiwandi circle (Details of Bhiwandi franchisee model is provided in *Annexure VI*)
- Maharashtra has 35 districts and 44 distribution circles. The distribution losses are calculated circle-wise on a six monthly sliding average percentage.

[143] Government of Maharashtra, Maharashtra Electricity Regulatory Commission, Order on APR of MSEDCL for FY 2008-09 & tariff determination for FY 2009-10, Case No. 116 of 2008
[144] Government of Maharashtra, Department of Planning, Directorate of Economics and Statistics: Economic Survey of Maharashtra 2009-10, Ch.9 Infrastructure pp. 133-134
[145] Sakal, August 18,2010

Solutions for improving efficiency of the grid

In the T&D sector, energy losses are essentially through transformers and cables. According to a study carried out by EPRI, USA, the overall losses between power plant and consumers could be between 8 and 15%, which indicates that efficiency of transmission and distribution system could be improved, thereby reducing CO_2 emissions[146]. Losses in various elements of the T&D system usually are of the order as indicated below.

Table 48: Losses in different elements of transmission and distribution

System element	Power losses (%)	
	Minimum	Maximum
Step up transformers & EHV transmission system	0.5	1.0
Transformation to intermediate voltage level, transmission system & step down to sub transmission voltage level	1.5	3.0
Sub transmission system & step down to distribution voltage level	2.0	4.5
Distribution lines & service connections	3.0	7.0
Total losses	7.0	15.5

The losses in any system would, however, depend on the pattern of energy use, intensity of load demand, load density, and capability and configuration of the transmission and distribution system that vary for various system elements.

Though energy efficiency is more focused on end users however there are several prospects in the T&D sector for efficiency improvement. Improving efficiency does not merely focusing on reducing losses but the primary focus is on reliability. A reliable network is crucial for economic development. There are several indices used to measure power quality and reliability. These indices are based on sustained outages *i.e.* interruptions that last for more than five minutes.

- **SAIDI** (System average interruption duration index) represents the sum of customer-sustained outage minutes per year divided by the total customers served.
- **SAIFI** (System average interruption frequency index) represents the number of customer.
- **CAIDI** (Customer average interruption duration index) for group of customers that actually had one or more interruptions and how long (on average) the interruptions lasted. The figure represents the total number of customer interruption durations divided by the total number of customers interrupted.

Table 49-Performance indices (2009-10)

Distribution Co.	SAIFI (No.)	SAIDI (Minutes)	CAIDI (Minutes)
TPC-D	1.77	44.33	25.18
MSEDCL	12.28	307.19	25.01

[146] International Electro-technical Commission (IEC) - Efficient electrical energy transmission and distribution - http://www.iec.ch/about/brochures/pdf/technology/transmission.pdf

Table 50-Quality of Supply (2010-11)[147]

Total No. of Incidences/ Events.	
Voltage variation outside the specified range	18362
Harmonics beyond control level, at the point of supply	250

Following steps would help curb T&D losses

- Energy audit should be conducted at all levels of feeders and transformers.
- Due to growing urbanization, the distribution lines in urban areas carry excess load, leading to power losses and breakdowns. On the other hand the rural lines are overextended. The losses can be reduced by realigning the lines to reduce line mileage and by using small distribution transformers to reduce the length of low tension lines.
- Installation of tamper proof meter boxes and tamper proof numbered seals.
- Statistical analysis of electricity meter readings must be done so that the sample data from electricity meters can be analyzed statistically over time to estimate significant deviation from usual meter reading. This will help keep track the energy usage of consumers and a benchmark will be available, in case of significant meter reading deviation.
- Installation of online prepaid meter: This is a device which can be interfaced with a static electronic meter. It is a micro controller based application. This device will accept the number of units recharged by the concerned department person, count the number of units consumed by the customer. As soon as the customer exceeds the recharged amount, the power supply will be disconnected until the next recharge. When the number of units consumed matches with the number of units the consumer has paid for, the microcontroller sends a signal to the contact maker/breaker circuit and the power supply to the consumer is cut off until the next recharge. The figure below represents a block diagram of an online prepaid energy meter. This system can be used effectively for preventing power theft, non-payment of electricity bills, can reduce the cost of manpower and the entire billing process can be centralized.
- Energy audit of energy received and energy sold in each area, which should be the responsibility of the Executive Engineer. These audits should be held on a biannually.
- Existing distribution network can be converted to a high voltage distribution system (HVDS) which covers reduction of LT lines, taking high voltage line up to the load centre and supplying power through smaller capacity energy efficient distribution transformation, re-conductoring of over loaded lines, power factor correction, Geographic Information System (GIS) mapping, pole wise consumer information, etc. This would require energy audit and accounting studies, analysis of the data using software for developing component aided network model[148].

[147] http://www.mercindia.org.in/pdf/Order%2058%2042/SoP%20of%20MSEDCL%20FY2010-11.pdf
[148] http://www.cea.nic.in/god/special_reports/Guidelines

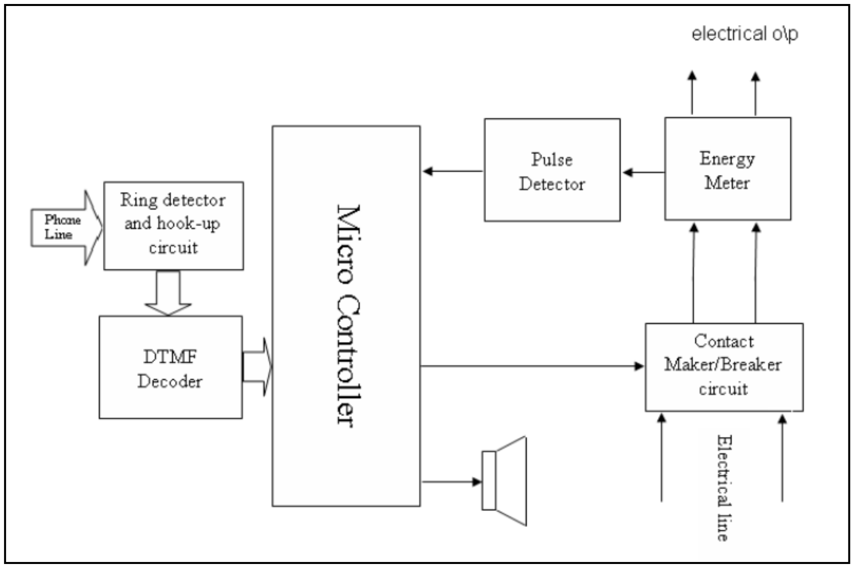

Figure 50-Block diagram of an online prepaid energy meter

- Smart grid is one of the solutions to the critical and persistent problems facing the T&D sector. These grids contain sensors and load control switches that can monitor, preemptively detect and repair defects in the T&D network. Such technologies can be used to reduce interruptions and outages while minimizing maintenance expenditure. The losses can be considerably reduced with the introduction of smart energy meters-high-accuracy electronic meters with tamper detection, remote billing, disconnection and reconnection features. This can be done in a phased manner starting with industrial and high end commercial users[149] (malls and multiplexes) followed by residential complexes.
- Commercial action includes tamper proof metering at all level of transformation and for all the consumers; operationalizing energy accounting up to feeder level; de-centralized computerized billing & collection; development of MIS and proper duties & responsibilities up to the line man. Commercial activities target reduction of commercial losses and improvement of revenue[150].

High voltage distribution system (HVDS)

Reduction of LT lines reduces line losses considerably and also reduces probability of power theft by hooking. HVDS suggests an increase in installation of small capacity single-phase transformers in the network which again save considerable energy. The existing distribution network can be converted to a high voltage distribution system (HVDS) which covers reduction

[149] LiveMint, "Being smart about electricity", Gulzar Natarajan, April 6, 2010

[150] http://www.cea.nic.in/god/special_reports/Guidelines%20for%20Formulation%20of%20Report%20on%20Strengthening%20and%20Improvement%20of%20Sub-transmission%20and%20Distribution%20Network%20under%20Accelerated%20Power%20Development%20&%20Reform%20Programme/status_of_distribution_sector_in.htm

of LT lines, taking high voltage line up to the load centre and supplying power through smaller capacity energy efficient distribution transformation, re-conductoring of over loaded lines, power factor correction, Geographic Information System (GIS) mapping, pole wise consumer information, etc. This would require energy audit and accounting studies, analysis of the data using software for developing component aided network model[151]. HVDS helps to reduce the length of LT lines and makes power available at site close to the users. It also reduces the probability of power theft by hooking and can be an ideal step to reduce line losses.

Smart Grid

Smart grid technologies could contribute to greenhouse gas emission reductions by increasing efficiency & conservation, facilitating renewable energy integration, and enabling plug-in hybrid electric vehicles.

The traditional grid is a network of transmission lines, sub stations, transformers and more that deliver electricity to the consumers. Smart grid is an intelligent network that uses two-way flow of electricity and information to create an automated and distributed advanced energy delivery network[152]. It is a concept referring to the application of digital technology to the electric power sector to improve reliability, reduce cost, increase efficiency, and enable new components and applications. A smart grid thus extends from the generation, through the transmission and distribution systems, to the consumer. It incorporates the entire value chain. The benefits associated with smart grids are as follows:

- Increased integration of large scale renewable energy systems- Compared to the existing grid, the smart grid promises improvements in reliability, power quality, efficiency, information flow, and improved support for renewable and other technologies.
- More efficient transmission of electricity and improved security - Smart grid technologies, including communication networks, advanced sensors, and monitoring devices, form the foundation of new ways for utilities to generate and deliver power and for consumers to understand and control their electricity consumption. This also helps in quicker restoration of electricity after power disturbances
- Reduced peak demand – In home energy management systems and intelligent controls in appliances, giving consumers more choice and control over how and when electricity is used, which can save money and help the grid operate its electricity network more efficiently and reliably benefitting all consumers.
- Reduce T&D losses - Smart grid will reduce losses occurring in transmission and distribution systems to a large extent as the grid will be interactive and easily 'readable' at any point of time from many operating servers.

[151] http://www.cea.nic.in/god/special_reports/Guidelines
[152] IEEE, "Smart Grid – The New and Improved Power Grid: A Survey", Xi Fang, Satyajayant Misra, Guoliang Xue, Dejun Yang http://optimization.asu.edu/~xue/papers/SmartGridSurvey.pdf

- Minimize thefts to a great extent - Consumers having illegal connections, drawing excess electricity, and tampering with the meter would be traced easily. Also, the consumers who default in payment can be easily traced. The whole spectrum of T&D losses consists of theft, illegal and tampered meters, and inefficient collection. Smart grid will curb all these when all the essential installation components of the Smart Grid are in place.

Total Inter-regional transmission capacity by the end of 10th Plan was 14,050 MW which is expected to grow to about 25,650 MW by 11th Plan end. An inter-regional transmission capacity of 37,800 MW has been planned for the 12th Plan. Transmission line capacity addition of about 100000 ckt. km. (circuit kilo metre), HVDC terminal capacity of 13,000 MW and AC transformation capacity of 270000 MVA has been planned for the 12th Plan. The country has initiated steps to evolve smart grid with a view to improve the reliability & efficiency of the power sector as a whole.

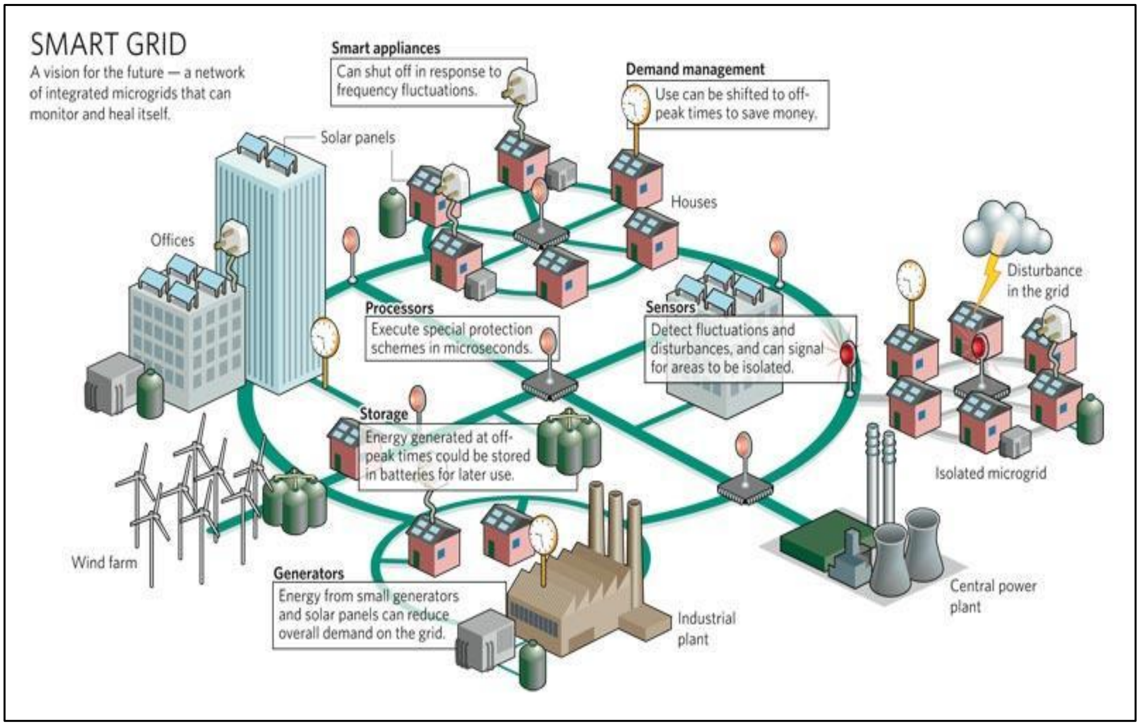

Figure 51 - Pictorial representation of Smart Grid Technology[153]

An inter-ministerial group on smart grid, the India Smart Grid Task Force (ISGTF) has already been set up. It will serve as government focal point for activities related to smart grid. The main functions of ISGTF pertaining to smart grid are[154]:

[153] www.energyinformative.org

[154] Government of India, Ministry of Power, India Smart Grid Task Force http://www.isgtf.in/Forms/About_ISGTF.aspx

- To ensure awareness coordination and integration of diverse activities related to smart grid technologies.
- Practices & services for research & development of smart grid.
- Coordination and integrate other relevant inter-governmental activities.
- Collaborate on interoperability framework.
- Review & validate recommendations from India Smart Grid Forum, etc.

Policy framework to promote use of smart grids in India would be developed after pilot implementation. An outlay of Rs.500 crore has been estimated for various pilot projects to be executed during the plan. The total outlay of Rs 9,500 crore has been estimated, which includes pilot projects and scaling up of pilots, phased installation of smart meters, extending mechatronics (Supervisory Control and Data Acquisition - SCADA technology) system to 100 more towns and integration of renewable energy power into the grid[155].

The fundamental difference between traditional grid and smart grid that will radically change the transmission and distribution of electricity is the 'interactive' nature of smart grid. Consumers will be able to interact with the electricity distributor about the quality of electricity they receive; they will be able to lodge complaints through the network and advanced security mechanisms would be put in place. Sensors would be present (PMU – Phasor Measurement Units) at regular intervals along the grid which will give feedback to the load despatch centre about over loading, under loading, attempt of theft, etc. Consumers will also be able to add electricity to the grid.

Smart Transmission and Distribution

New technologies *viz.* new materials, electronics, sensing, communication, computing, and signal processing are incorporated in transmission network. Real-time monitoring of transmission lines can transform the entire monitoring process of transmission and distribution. Introduction of DC (direct current) power dispatch system using high frequency switching techniques can make power distribution systems more efficient (loss minimization) and easier to control energy flow.

Intelligent meters and field devices (devices other than meters which are a part of distribution system) will replace current devices. These will offer failure protection to the consumers which are the other end of the distribution system. Moreover, they will be equipped with protection from tweaking, by using handling protection and monitoring based on high speed communication mechanism. It would not be easy to manipulate energy meter.

[155] Government of India, Planning Commission, Report of the Working Group on Power for Twelfth Plan (2012-2017)

Micro-grid and Macro-grid

Micro-grid will essentially be a part of Macro-grid, unless otherwise specifically put into application. The users in a Micro-grid can generate low voltage electricity using distributed generation, such as solar panels, wind turbines, and fuel cells. The single point of common coupling with the Macro-grid can be disconnected, with the Micro-grid functioning autonomously[156]. The multiple distributed generators and the ability to isolate the Micro-grid from a larger network in disturbance will provide highly reliable electricity supply (islanding).

Renewable Energy

Renewable energy generation and distribution will become increasingly simple in the Smart Grid. Renewables like solar energy and wind energy are dependent on intensity and duration of solar radiation and wind respectively. Being entirely dependent on renewables thus may not yield uninterrupted power and the outcome of using renewables may defy the whole purpose of using them. Smart Grid can have provisions that will enable electricity distributors to switch from one power source to other; while keeping electricity supply to the end user uninterrupted. Incorporation of green energy thus becomes easier which will ultimately contribute to environmentally stable high growth.

Large scale deployment is not at all an easy task. But it can be divided into smaller regional modules where the modules can be designed autonomously.

[156] IEEE, "Smart Grid – The New and Improved Power Grid: A Survey", Xi Fang, Satyajayant Misra, Guoliang Xue, Dejun Yang

Conclusion

The existing T&D system is a centralized grid system. However in future we need to change this grid network so that it does not solely rely on large conventional plants but also on clean energy generators distributed throughout the grid.

The new grid will bring down losses to a large extent. Current T&D losses are 25% and after the realization of the presented solutions, T&D losses will come down to 10%, which the transmission and distribution utilities should strive to achieve. Developed countries have T&D losses in the range of 6-11%[157].

Improvement in transmission and distribution network by using advanced robust technologies, 100% metering and computerization of the power grid can save installation of 10000 MW of coal based power in 2025. In 2025, 34000 MW of coal based capacity needs to be added if the power sector maintains its performance as it is right now. Improvement in transmission and distribution and reducing T&D losses to 10% will reduce the addition of coal power to 24000 MW.

Capital expenditure of Rs. 50000 crore[158] will be saved till 2025.

[157] http://www.ignou.ac.in/schools/soet/acpdm/BLOCK%204%20BEE-001/Part%203.pdf

[158] 5 crore per MW of coal based power

Case studies on smart grid technology

Japan

Japan had not seen much value in smart grid technology in the past, but that changed in March 2011 due to the disaster at the Fukushima Daiichi nuclear power station. Along with bolstering its own power infrastructure, Japan is looking to create business opportunities by tapping its technology leadership with the so-called "smart community" concept, which embraces renewable energy sources and central energy management systems for monitoring and controlling power flows. Along with smart homes and EVs, smart communities apply IT and sensor networks to create intelligent transportation systems. Social healthcare systems are also part of this effort to make cities smart. Interestingly enough, Japan will deploy this new "smart city" concept in the Tohoku region, which was affected by the tsunami disaster in 2011. Constructing a more energy- efficient power infrastructure also less vulnerable to natural disaster is a crucial goal for Japan, and smart meter deployments have increased accordingly.

China

China made major strides in installing high-voltage transmission lines, and within the next few years it will continue to develop its grid. State Grid has announced an investment plan for 2009–2020 with provisions for 384.1 billion Yuan (US$58.5 billion) worth of investment in smart grid technology (split between 30.8% for smart use, 23.2% for smart distribution, and 19.5% for substations)[159].

University of California, San Diego (UCSD)[160]

The University of California, San Diego's 1,200-acre, 450-building campus, with a daily population of 45,000, runs two 13.5 MW gas turbines, one 3 MW steam turbine and a 1.2 MW solar-cell installation that together supply nearly 80% of the campus' annual power, said a paper released last year by three computer science professors. The turbines produce 75% fewer emissions than conventional gas power plants, the university said on its website. For HVAC, it uses a 40,000 ton/hour, 3.8 million-gallon capacity thermal energy storage tank, plus three chillers driven by steam turbines and five driven by power. The balance of campus power - up to 10 MW - is bought on the open market under California's deregulated market and served by SDG&E (San Diego Gas & Electric)[161].

The University of California at San Diego can't claim to be a smart grid but it most definitely is a micro-grid, with its own power generation, monitoring and security. UCSD has only one

[159] Nuclear Sneak Attack, pp. 11; Power – Vol. 5, No. 5, May 2011
[160] Smart Power Generation at UCSD
[161] Smart Grid Today: UC San Diego gears up for smart micro-grid - http://www.poweranalytics.com/pa_articles/pdf/ucsd_smart_grid.pdf

connection to the SDG&E grid at the transmission level, and it owns the high-voltage substation, which gives the campus greater reliability. The campus also owns and maintains all of its distribution wires and meters.

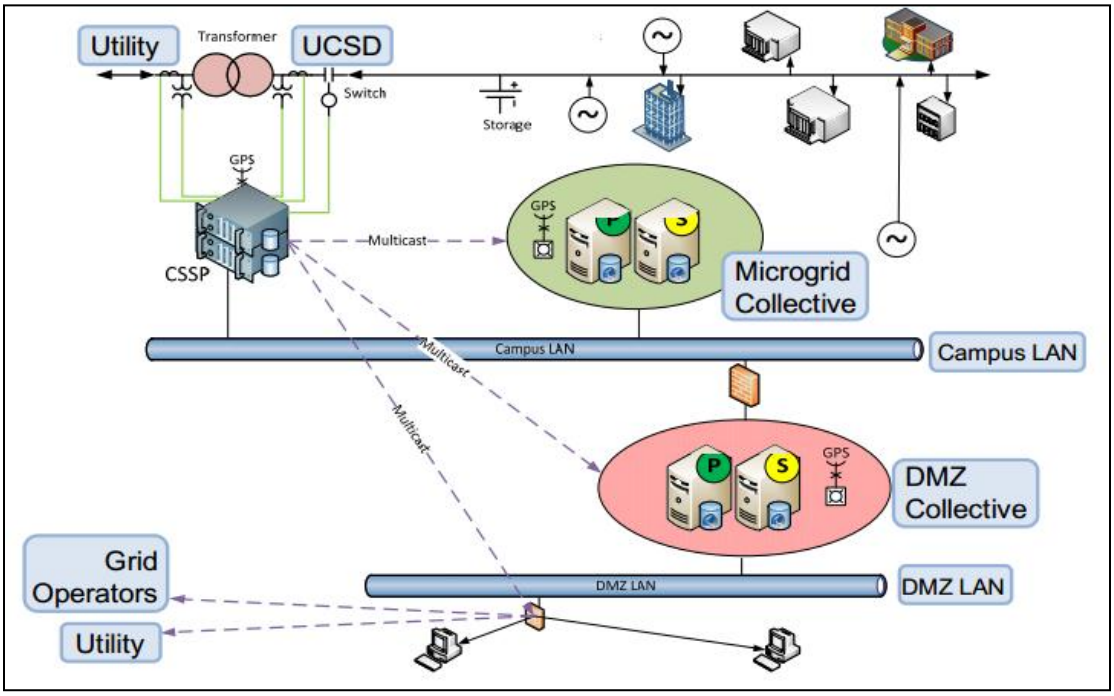

Figure 52- UCSD micro-grid[162]

At UCSD, the micro-grid provides the ability to manage 42 megawatts of generating capacity, including a central cogeneration plant, an array of solar photovoltaic installations and a fuel cell that operates on natural gas reclaimed from a landfill site. The central micro-grid control allows operators to manage the diverse portfolio of energy generation and storage resources on the campus to minimize costs. The micro-grid is connected to the utility grid but can disconnect and operate in islanded mode if conditions (such as a cascading blackout) warrant, as in the case of the power blackout that struck parts of Southern California, Arizona and Mexico in September 2011[163].

The UCSD micro-grid case study demonstrates the success of the integration and management of local resources in conjunction with the ability to be parallel with the grid, independent from the grid, the ability to go back and forth based on data driven decisions as well and responding to grid stability issues. This action with the grid can be viewed as a throttle instead of a switch, giving the ability to continuously process make/buy decisions for energy.

[162] http://www.energy.ca.gov/research/notices/2011-12-16_workshop/presentations/06_UCSD_AM-Kleissl.pdf
[163] http://www.glennmosier.com/2012/01/video-the-uc-san-diego-microgrid-a-living-laboratory/

US Department of Agriculture (USDA)[164]

The U.S. Department of Agriculture (USDA) has reached its $250 million goal to finance smart grid technologies. Agriculture Secretary Tom Vilsack announced nine rural electric cooperatives and utilities in 10 states would receive loan guarantees to make improvements to generation and transmission facilities and implement smart grid technologies.

The funding is based on the Obama Administration's Blueprint for a Secure Energy Future, a framework for a modernized electric system that specifies a number of public and private initiatives. It includes a goal of $250 million in loans for smart grid technology deployment as part of the USDA's Rural Utility Service, which is focused on upgrading the electric grid in rural America. $250 million investment in loan funds for smart grid technologies means "infrastructure investment at virtually no cost to the taxpayer." Following is a list of rural utilities that will receive USDA funding, which is contingent upon the recipient meeting the terms of the loan agreement.

Colorado/ Nebraska/ New Mexico/ Wyoming: Tri-State Generation and Transmission Association, Inc. – $140,483,000 loan. Funds will be used to build 50 miles of transmission line and make upgrades to existing generation and transmission facilities. The loan amount includes $21,756,000 in smart grid projects and $808,780 in environmental improvements.

Kansas: The Ark Valley Electric Cooperative Association, Inc. – $6,130,000 loan. Funds will be used to build and improve 355 miles of distribution line and make other system improvements. The loan amount includes $2,014,500 in smart grid projects.

Minnesota: Stearns Cooperative Electric Association – $23,654,000 loan. The cooperative will improve 147 miles of distribution line and make other system improvements. The loan amount includes $974,085 in smart grid projects.

Agralite Electric Cooperative – $5,159,000 loan. Funds will be used to build and improve 61 miles of distribution line and make other system improvements. The loan amount includes $180,968 in smart grid projects.

Missouri/Iowa: Northeast Missouri Electric Power Cooperative – $30,093,000 loan. Funds will be used to build and improve 24 miles of transmission line, build three new substations, and make other improvements. The loan amount includes $500,000 in smart grid projects.

North Carolina: Edgecombe-Martin County Electric Membership Corporation – $6,410,000 loan. The cooperative will build and improve 310 miles of distribution line and 2 miles of transmission line and make other system improvements. The loan amount includes $1,084,728 in smart grid projects.

[164] Power Magazine, Sonal Patel: "USDA Reaches $250M Goal for Smart Grid Technologies", September 11, 2012 http://www.powermag.com/smart_grid/USDA-Reaches-$250M-Goal-for-Smart-Grid-Technologies_4956.html

Piedmont Electric Membership Corporation – $30,000,000 loan. Funds will be used to build and improve 108 miles of distribution line and 5 miles of transmission line and make other system improvements.

Brunswick Electric Membership Corporation – $21,500,000 loan. Funds will be used to build and improve 220 miles of distribution line and make other system improvements.

Wisconsin: Chippewa Valley Electric Cooperative – $6,000,000 loan. Funds will be used to build and improve 88 miles of distribution line and make other system improvements. The loan amount includes $255,833 in smart grid projects.

Also some of the largest utilities in the US including Florida Power and Light, Xcel Energy, Pacific Gas and Electric, and American Electric Power, have undertaken initiatives to deploy smart grid technologies.

Solution 3

Increase green energy sources

Goal: To explore all sources of green energy in the state and increase their share in the electricity market by providing power efficiently, cost effectively and on a large scale.

Introduction

Efficient and reliable supply of energy is critical for economic growth. The increasing demand for electricity is not being met and shortfall remains. The availability of conventional energy sources is limited and may not be sufficient in the long run to sustain the process of economic development[165]. Renewable energy sources are currently insufficiently exploited though the potential exists.

Before India's independence, electricity was decentralized. It was generated and supplied locally by private entrepreneurs, enterprising municipalities and provincial governments. Most of the installed capacity was located in West Bengal and Bombay states which were under strong British influence and contained major urban and industrial areas. The emphasis was on supply to large urban concentrations, and there was little coordination or cooperation between the different suppliers. Various legislations were formed in the pre as well as post-independence era. In the post-independence period, private companies providing electricity was considered unacceptable, as they would focus on areas with greatest demand – cities and urban areas – and neglect rural areas due to meager return on their investments. Eventually state electricity boards (SEBs) were established, which led to the gradual domination of the electricity sector by government enterprises. To promote regional coordination and operation of power supply, Regional Electricity Boards were also formed. Central sector in due course established several centrally owned public sector corporations to supplement generation activities of the SEBs. In the financial crisis of 1991, the sector was opened for private investment. Regional Load Dispatch Centers were also established at the same time to operate the power system in a region, ensure regional grid security and to integrate with power systems of other regions and areas. Amendments in 1998 opened transmission to private investment, subject to the approval of Central Transmission Utility (CTU)[166].

Thus electricity in the pre-independence era was decentralized and privatized, and was available to those who could afford it. After independence this attitude changed as electricity was viewed as a crucial instrument for social development and a rigid control by the government was considered essential. However, later the electricity sector was opened for private investments. However, private companies generate power and sell the power to SEBs through power purchase agreements or trade it at the electricity market. Even with the various reforms and experiments with the electricity sector, electricity is still unavailable to most of the rural areas. Industries and commercial establishments in rural as well as urban areas have to rely on power back up systems in hours of load shedding. This scenario prevails in the state of Maharashtra as well.

There are 41,095 inhabited villages in Maharashtra. 36 villages still remain un-electrified in Maharashtra as on July 31st 2012. Barring these which are termed as unfeasible and

[165] http://planningcommission.nic.in/reports/genrep/intengpol.pdf
[166] Economic and Political Weekly: S L Rao: The Political Economy of Power; Vol. - XXXVII No. 33, August 17, 2002

inaccessible by Rural Electrification Corporation (REC), 100% villages in the state have been electrified[167]. The 36 remaining villages are set to be electrified using non-conventional energy through MEDA, as per CEA report on village electrification. (36,010 are electrified as per the criteria laid down in the Rural Electrification Policy of 2004. 86.5%[168] of the villages are electrified[169]).

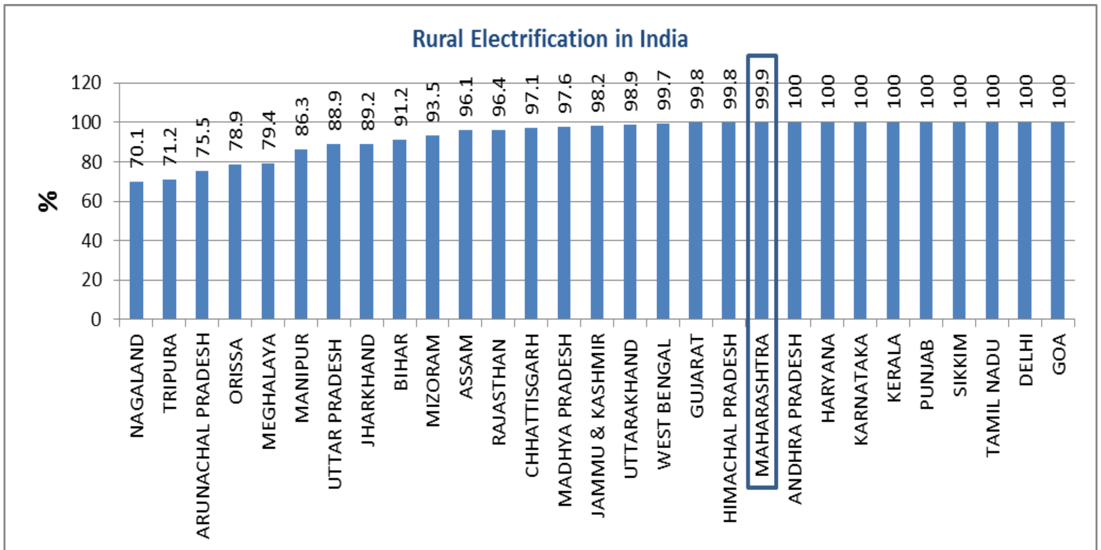

Figure 53-Status of Rural Electrification in India[170]

Even if it is seen that 100% of villages in the state are electrified, it is not so. The Ministry of Power has two terms to indicate the electrification of a village *viz.* UEV – Un-electrified village and PEV – Partially Electrified Village. 36 villages are UEV that means most of the villages have been electrified, completely or partially. The number of partially electrified villages is large[171].

Those who have access to electricity suffer from shortages and poor quality of supply. Unscheduled outages, load shedding, fluctuating voltage and erratic frequency are common. Consumers and the economy bear a large burden of this poor quality supply. Motors are overdesigned and consume more electricity; voltage stabilizers are needed for more expensive equipment; diesel generators provide backup power to industrial and commercial consumers; and inverters have become a household phenomenon. Equipment gets damaged; motors and

[167] http://www.recindia.nic.in/download/Maharashtra.pdf
[168] Government of Maharashtra, Department of Planning, Directorate of Economics and Statistics: Economic Survey of Maharashtra 2009-10, Ch.9 Infrastructure, pp. 240,
[169] Government of Maharashtra, Department of Planning, Directorate of Economics and Statistics: Economic Survey of Maharashtra 2009-10, Ch.9 Infrastructure, pp. 134; Government of India, Ministry of Home Affairs, Census of India 2011
[170] Government of India, Ministry of Power, Central Electricity Authority, Village Electrification http://www.cea.nic.in/reports/monthly/dpd_div_rep/village_electrification.pdf
[171] Government of India, Ministry of Power, Bharat Nirman http://powermin.gov.in/bharatnirman/pdf/Progress_on_electrification_of_villages_households.pdf

pumps are often burnt out. In addition to this is the cost of the idle manpower and loss in production when power supply is interrupted[172]. 44% of rural households depend on kerosene for domestic lighting and another 55% on electricity, while in urban areas dependency is 89% on electricity and 10% on kerosene[173].

The expense on back-up power generation apportioned across the total power consumption by a consumer can be viewed as the 'premium' above the grid power cost borne by the consumer for choosing to have backup power. The amount of premium borne depends on several factors[174]:

- Duration of back-up equipment usage – The premium increases with increase in the typical daily outage duration as a larger number and/or a larger capacity of battery storage units have to be used to accommodate the outage.
- Load/Power consumption to be supported on back-up equipment – The premium increases with increase in the number and especially the type of appliances that a consumer chooses to run. Higher the load to be supported on back-up, higher is the capacity rating of the Inverter to be used thus resulting in an increased initial investment.

The premium paid by residential consumers varies widely across cities because this premium depends on the duration of usage of back-up power which in turn depends on the severity of the daily outage and the duration of the peak outage season in a given city.

- A consumer with a typical monthly consumption level of 400 units with an 800 VA Inverter back-up pays a premium of ~80% above the grid power cost when faced with a severe outage of 6 to 7 hours throughout the year. A similar consumer will pay a premium of ~17% above grid costs when facing a 1 hour daily outage for only 3 months a year and a less frequent lower duration outage for the rest of the year. With the use of an inverter of the above mentioned capacity, the consumer will be able to run only limited appliances in the house. The premium will increase if the consumer chooses to run all appliances; this will however require a shift from inverter to generator set.
- Commercial consumers choosing to opt for back-up systems end up paying an even higher amount of premium as compared to residential consumers.

For a commercial establishment with a typical consumption of 1500 units and a diesel generator power back up, faces a premium of ~150% above the grid power cost when faced with a severe outage of 6 to 7 hours throughout the year. A similar establishment will pay a premium of ~11% above grid costs when facing a 1 hour daily outage for only 3 months a year and a less frequent lower duration outage for the rest of the year.

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172 http://planningcommission.nic.in/reports/genrep/intengpol.pdf
173 Reality Checks, "Rural Energy Security in India", Bikramjit Sinha & Indranil Biswas
174 The Real Cost of Power, Wartsila

Power plants require fuels. India is not well endowed with reserves of oil, uranium and gas. While coal is abundant, it is with low calorie and high ash content, though with low sulphur content and is regionally concentrated[175]. Moreover in Maharashtra most of the power plants are concentrated in areas where coal reserves are found. This has resulted in the shortage of water for generating power. At Chandrapur Super Thermal Power Station only one unit of 210MW was functional due to water shortage in March 2010[176]. The installed capacity Chandrapur Super Thermal Power Station is 2340MW. After the monsoon the situation has slightly improved and at present 1840MW of power would soon be generated. Since the coal had also become wet due to rains the units could not be operated due to lack of fuel.

Electricity requirement can be met by alternate fuels which include renewables like bagasse, biomass, wind, solar, etc. Green Energy is any energy system that does not severely impact the health of humans or the environment in the short or long term. It is also defined as any energy source whose by-products can be readily reintegrated back into the environment by the existing biological systems of the Earth. These energy sources have less ecological impact than conventional energy sources.

Green / alternative / renewable energy plays a significant role in the global efforts to combat climate change and develop new energy system. In the light of pressures to reduce carbon emissions, there is a need to increase renewable energy technologies and solutions and thereby promote development of sustainable energy systems. Renewable energy systems contribute to saving the planet by reducing greenhouse gas emissions.

It is not completely necessary for green energy sources to come from places like solar or wind, which are examples of green "power plants." A green energy source can be a building that is designed in a way that it keeps itself cool in the daytime and heated in the night through its architectural design rather than having air-conditioning or a heating system. The conservation of energy through architectural design becomes, itself, a green energy source. Similarly, many sources of green energy can come directly from the area in which the energy is needed rather than from an outside source. A residence, for example, can be covered with solar panels for the purpose of collecting energy to be used for electricity. When utilized properly, surplus energy is often produced in this manner, which can be sent back through the local power grid and used at other destinations[177].

Given the present trends of increasing energy demands, rapid economic growth, availability of fuel supplies, environmental impact particularly climate change, health impact no single resource or technology is the solution. It is necessary to explore and harness all possible sources of green energy and get them into the mainstream supply of power at economical

[175] http://planningcommission.nic.in/reports/genrep/intengpol.pdf
[176] Maharashtra Times, October 13, 2010
[177] http://www.wisegeek.com/what-is-green-energy.htm

prices. Development of clean, renewable energy sources to replace carbon based fuels is underway on many fronts. The key drivers for renewable energy are as follows:

- Demand supply gap, especially as population increases,
- Large untapped potential,
- Concern for the environment,
- Need to strengthen energy security,
- Pressure on high emission industry sectors from their shareholders,
- Viable solution for rural electrification.

Renewable Energy Scenario

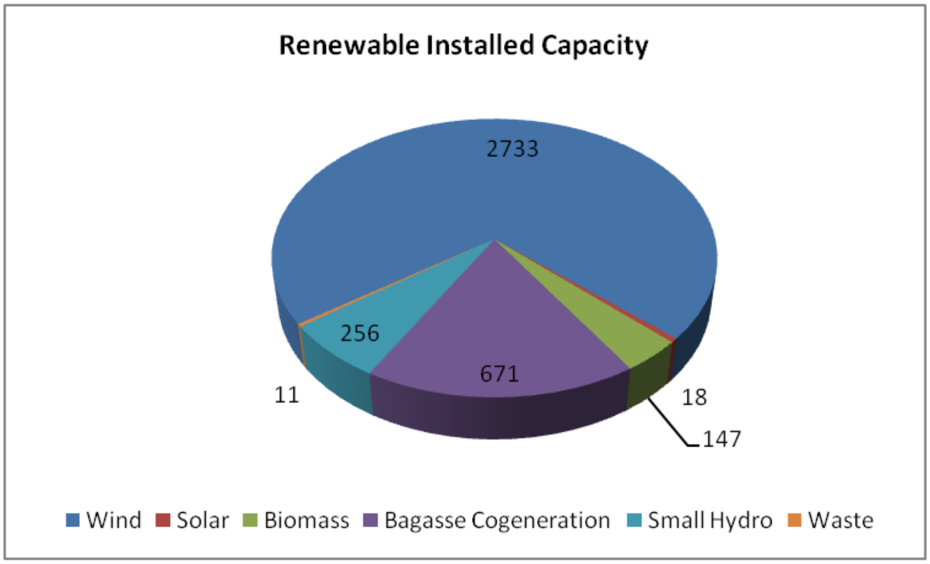

Figure 54- Breakup of Renewable Energy Capacity in India[178]

India

The total installed capacity of renewable energy stood at 13,310 MW. Wind energy had a large share of 10,000MW and the balance was of micro hydro, co-generation, solar and biomass. Thus in the renewable energy sector, wind occupied a dominant position having 69% share in the installed capacity followed by small hydro (16%) and biomass (14%)[179]. Solar power is still in its nascent stage of development due to high costs, but this sector will receive a boost with the Jawaharlal Nehru National Solar Mission (JNNSM).

The economic crisis that started in United States of America in 2008 and slowly swept the world for a brief period of time induced a slowdown in capacity addition of power renewable sources[180]. In 2006, the grown of solar energy capacity addition dropped to 31% from 34% the previous year. It did jump to 60% in 2008 but again the solar PV market contracted by 17% in 2009.

Maharashtra

Total installed capacity of renewable energy has increased from 1955 MW in March 2008 to 3630 MW in March 2012. There has been a rise of close to 100% in the renewable energy installed capacity in the state in the past 4 years. It has further increased to 3726 MW in July 2012.

[178] Government of India, Ministry of Non Renewable Energy, 2010
[179] Tata Power - Policy incentive for Wind and Biomass Power Generation, Dec 17,2009
[180] PowerLine Volume 14, April 2010, p.78

The largest component of renewable generation is the wind power sector having a total installed capacity of 1997MW. Several private players *viz*. Suzlon Energy Pvt. Ltd., Enercon India Pvt. Ltd., Acorn Properties Pvt. Ltd., Theolia Wind, Shri Ram EPC Pvt. Ltd. and RRB Pvt. Ltd. are developing wind farms across the state currently. As on 31st March 2012, wind power capacity increased to 2733 MW[181].

Bagasse cogeneration has shown a significant growth of 14.5% in 2009-10 from the previous year whereas growth registered by wind power is 3.4%. Biomass capacity has registered no growth in 2009-10 from the previous year. Urban waste disposal has become a major problem with no towns and villages ready to spare land for landfills. Urban waste has can be put to use for generating electricity. This will also reduce the amount of waste entering a landfill.

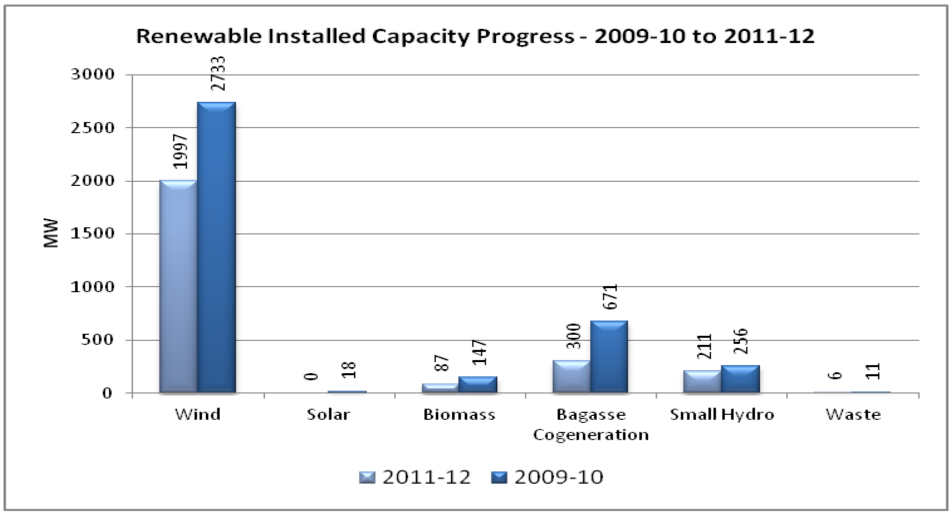

Figure 55-Installed Capacity (Renewable Energy) in Maharashtra

Targets set by Central & State Governments

India is blessed with an abundance of non-depleting and environment friendly renewable energy resources such as solar, wind biomass and hydro power. Recognizing this potential, the Indian government has accorded a high priority to exploring and harnessing the potential. Ministry of New and Renewable Energy (MNRE) was set up with the aim to develop and deploy new and renewable energy for supplementing the energy requirements of the country. In fact India initiated its renewable energy program in 1981 with the establishment of the Commission for Additional Sources of Energy, which was later converted into the Ministry of Non-Conventional Energy Sources (MNES) in 1992 and renamed the Ministry of New and Renewable Energy (MNRE) in 2006.

[181] Government of India, Ministry of Non Renewable Energy, 2010

Ministry of New and Renewable Energy (MNRE) has set aggressive targets with projections touching 25,000 MW by 2012 which would require investment to the tune of $12billion. MNRE has also set up provisions for subsidies of $650 million. By 2012, the government expects renewable energy to contribute 10% of total power generation and have a 4-5% share in the fuel mix[182]. Globally, renewable energy technologies and industries have been growing at rates ranging between 20-60%[183].

The National Action Plan on Climate Change (NAPCC) launched in 2008 envisages renewable energy to constitute around 15% of India's energy mix by 2020. The Prime Minister had also announced providing subsidies worth a whopping Rs. 82,000 crore to produce 200,000 MW of solar power by 2050[184]. Following are eight missions under NAPCC.

- National Solar Mission
- National Mission for Enhanced Energy Efficiency
- National Mission on Sustainable Habitat
- National Water Mission
- National Mission for Sustaining the Himalayan Ecosystem
- National Mission for a "Green India"
- National Mission for Sustainable Agriculture
- National Mission on Strategic Knowledge for Climate Change

The National Solar Mission has been approved as one of the eight missions under the NAPCC. It aims to promote development and use of solar energy for power generation and other uses with the ultimate objective of making solar competitive with fossil-based energy options.

In line with the central government policy, Maharashtra Energy Development Agency (MEDA) was established as a state nodal agency under the umbrella of the MNRE. The main objective is undertaking development of renewable energy and facilitating energy conservation in the Maharashtra. MEDA has envisaged the addition of the following renewable technologies by 2012[185].

Table 51- Envisaged addition of renewable energy technologies by MEDA

Renewable based grid connected power	2450MW
Solar water heating systems	4,35,000m^2
Solar concentrators for medium temperature applications	15,000m^2
Solar cookers	1,10,000
Solar PV systems for homes	65,000

[182] India Infrastructure Research – "Power in India Renewable Energy", 2009, pp. 166-169
[183] India Infrastructure Research – "Power in India Renewable Energy", 2009, pp. 174
[184] Power Line, Vol. 14 – "Road to Copenhagen", Nov 2009, pp. 24
[185] http://www.usaid.gov/in/Pdfs/Maha%20_EC_Action_Plan.pdf

Energy conservation in industrial units (No)	3819
Electricity demand saving in different sectors (Total)	3000MW

For the year 2010-11, wind generation projects by various private developers are being set up in districts Dhule, Nandurbar, Beed, Nasik, Ahmednagar, Aurangabad, Kolhapur, Satara, Sangli and Pune. The total proposed wind generation is 5273MW, but considering a PLF of 25 % of the total capacity to be installed, it turns out to be 1318MW[186].

Policy Support and Incentives

There is an urgent need to promote renewable sources of energy for power generation as these are the most environmental friendly sources. The central and state governments have announced a package of fiscal incentives. One of the cornerstones of the government's policy has been a competitive market based structure for those segments of the power sector that are commercially viable.

The Electricity Act, 2003 enjoins the State Electricity Regulatory Commissions to promote cogeneration and non-conventional energy sources through appropriate measures of grid connectivity, sale of electricity as well as specifying the purchase of electricity. The central and state governments also extend a support through a number of measures like generation based incentive (GBI), prompt clearances, preferential tariffs, open access, etc. incentives are also granted to encourage equipment companies to manufacture renewable energy equipment, or private and government entities to undertake R&D relating to renewable energy[187].

- ***Direct Tax Benefits*:** The income of industrial undertakings or enterprises engaged in infrastructure development including renewable energy based power projects is exempt from direct taxes for a period of ten year. This benefit is under section 80-1A of the Income Tax Act and can be availed for any ten consecutive assessment years out of the first fifteen years of operation.
- ***Accelerated Depreciation Benefit*:** (Any method of depreciation used for accounts or income tax purposes that allows greater deductions in the earlier years of the life of an asset is Accelerated Depreciation). For projects commissioned before September 30 of a financial year, investors can take advantage of accelerated depreciation of up to 80% of the project cost for income tax calculations subject to a minimum utilization of six months in the year in which the deduction is claimed. For projects commissioned before March 31 of the financial year, the accelerated depreciation can be claimed on 40% of the project cost.
  For biomass power generation projects, 80% depreciation can be claimed in the first year for the following equipment required for cogeneration systems: back pressure, pass out, controlled extraction, extraction cum condensing turbines for cogeneration

[186] Government of India, Ministry of New and Renewable Energy
[187] Captive Power in India-2010, Captive Power from Renewable Sources, pp. 120-122

with pressure boilers; vapor absorption refrigeration systems; organic rankine cycle power systems; and low inlet pressure small steam turbines.

- ***Concessional Loans and Easy Clearances*:** GoI has incentivized investment in wind power projects by providing soft loans through Indian Renewable Energy Department (IREDA). Industrial clearance is not required for setting up a renewable energy project. For generation projects upto `1billion, no clearance from Central Electricity Authority (CEA) is required.
- ***Clean Development Mechanism (CDM) Benefits*:** The renewable energy projects set up in the country are allowed to register and reap benefits under the Kyoto Protocol's CDM. The CDM framework was developed under the United Nations Framework Convention on Climate Change (UNFCC) to help industrialized countries meet a part of their emission reduction requirements through the purchase of emission reduction credits from projects in developing countries.
- ***Renewable Purchase Obligations (RPO):*** Under the Electricity Act 2003, the National Electricity Policy 2005 and the Tariff Policy 2006, it is obligatory upon SERCs to fix a certain percentage for purchase of power from renewable energy sources in the area of a distribution licensee. In Maharashtra, the RPO is 6%.
- ***Renewable Energy Certificate (REC):*** REC would help create a national market for renewable energy. Under this mechanism, renewable energy generators will have the option to either sell the renewable energy at preferential tariffs fixed by the concerned SERC or to sell the electricity generation and environmental attributes associated with renewable energy generation separately. The environmental attributes can be exchanged in the form of RECs in case of latter option.
  Central Electricity Regulatory Commission (CERC) has asked state counterparts to notify REC regulations in order for utilities to meet their renewable purchase obligation (RPO). Those who hold the certificates will be able to sell green energy to states, individuals or other trading entities. MERC has notified the final regulations.
- ***Generation Based Incentive (GBI):*** This scheme is based at rewarding actual generation rather than mere capacity addition. the incentive provided is `0.50 per unit of electricity fed into the grid, over and above the specified SERC tariff, for a period not less than 4 years and a maximum period of 10 years with a cap of `6.2 million/MW. The total disbursement in a year will not exceed one fourth of the maximum limit of the incentive (`1.55 million/MW) during the first four years. The scheme will be applicable to a maximum capacity limited to 4000MW during the period of the 11th plan.
- ***Customs Duty Concession:*** A standard customs rate of 5% is charged on imports of key wind energy equipment and components. These include wind operated electricity generators and battery charges up to 30kW, special bearings, gear boxes, yaw components, wind turbine controllers, sensors, brake hydraulics, flexible couplings, brake calipers, blades for rotor, as well as parts and raw materials for the manufacture of blades and rotors.
- ***Excise Duty Exemption:*** Wind operated electricity generators, components and parts thereof, water pumping mills, wind aero-generators and battery chargers are exempted from excise duty.

Several financial incentives and grants have been announced under the National Policy on bagasse based cogeneration and biomass generation in the country. The table below summarizes the details regarding capital subsidy and central financial assistance.

Table 52 – Financial incentives and grants for bagasse cogeneration and biomass generation

Projects	Special category states (North East, Sikkim, J&K, Himachal Pradesh & Uttarakhand)	Other states
Biomass	Rs. 2.5 million x ('C'MW)^0.646	Rs. 2 million x ('C'MW)^0.646
Bagasse cogeneration	Rs. 1.8 million x ('C'MW)^0.646	Rs. 1.5 million x ('C'MW)^0.646
Bagasse cogeneration projects by cooperative /public/ joint sector	Rs. 4 million/MW for 40 bar & above* Rs. 5 million/MW for 60 bar & above Rs. 6 million/MW for 40 bar & above	Rs. 4 million/MW for 40 bar & above* Rs. 5 million/MW for 60 bar & above Rs. 6 million/MW for 40 bar & above
	(maximum support is Rs. 80 million per project)	
Biomass power projects using advanced technologies	`12 million x ('C' MW)^0.646	`10 million x ('C' MW)^0.646

- Note: 'C' is the variable used for the capacity of the power plant; for new sugar mills which are yet to start production and which are employing the backpressure route/ seasonal/ incidental cogeneration, subsidies will be half of the level mentioned above
- **Eligibility: For biomass power-Minimum 62 bar steam pressure, maximum of up to 15% use of fossil fuel of total energy consumption in kCal or as per DPR, whichever is less; For only new boilers and turbines (capacity limited to in accordance the estimated potential in a state). For cogeneration: Minimum 40 bar steam pressure; maximum of upto 15% use fossil fuel of total energy consumption in kCal or as per DPR, whichever is less, during crushing season.

Ministry of New and Renewable Energy (MNRE) mix of fiscal and financial benefits[188]

- $2/3^{rd}$ of the project cost subject to a maximum of `2 crore /100 KW for procurement of modules, structures, power conditioning units, cabling etc. to the implementing agency. The balance cost on land, extension of grid lines, transformers, civil works, foundation and erection and commissioning, etc. is met by the implementing agency.
- Up to `1.0 lakh for the preparation of Detailed Project Report (DPR) for grid interactive SPV power projects.
- 2.5% of its share of project cost, subject to a maximum of `5 lakhs for performance evaluation, monitoring, report writing, etc. to the State Nodal Agency.
- Interest subsidy of up to 4% to financial institutions including IREDA, nationalized banks, etc. for captive power projects of maximum capacity 200 KW by industry.

[188] Overview of Sustainable Energy Potential of India- http://www.geni.org/globalenergy/research/renewable-energy-potential-of-india/Renewable%20Energy%20Potential%20for%20India.pdf

Jawaharlal Nehru National Solar Mission[189]

The Jawaharlal Nehru National Solar Mission (JNNSM) is one of the eight missions under the NAPCC, which has set an ambitious target of achieving 20,000MW in three phases by 2022. The JNSSM's target is to increase the country's grid connected solar capacity to 1000MW by 2013 (Phase I), to 4000MW by 2017 (Phase II) and to 20,00MW by 2022 (Phase III). It is further aiming for off-grid solar power of 200MW in Phase I, 1000MW in Phase II and 2000MW in Phase III. 87.8 MW of capacity was installed in the Batch-I of the Phase-I of JNNSM (till June 2012)[190].

Table 53-JNNSM targets as set by the Ministry of New and Renewable Energy[191]

Application	Target Phase-I (2010-13)	Cumulative Target Phase-II (2013-17)	Cumulative Target Phase-III (2017-22)
Grid connected Solar power including roof-top	1100 MW	4000-10000 MW	20000 MW
Off-grid installations including rural solar lights	200 MW	1000 MW	2000 MW
Solar collectors	7 million sq.m.	15 million sq.m.	20 million sq.m.

Phase I which ends in 2013 has a target of 1000MW, to be equally divided between solar photovoltaic (PV) and thermal, making the scheme totally technologically neutral. The modules for PV should be 100% manufactured in India while for solar thermal, 30% of the cost would come from domestic sources, which would eventually increase to 100% in the second phase. In the first phase, the maximum limit for a single PV project is 5MW and that for solar thermal is 15MW. Solar projects that have come up under state policies and the MNRE's generation based incentives have been allowed to migrate to the JNSSM.

The Ministry of Power is supporting the implementation of first phase, whereby costly solar power would be allocated with the unallocated power of the central generating stations, to make solar power an attractive proposition for purchase by distribution companies that are not financially sound. This would help in significantly reducing the unit cost of solar power. NTPC's trading arm, NTPC Vidyut Vyapar Nigam Ltd (NVVNL) has been appointed as the nodal agency for the same.

Under the JNNSM, the MNRE has announced guidelines for off-grid applications and small grid connected projects at the 33kV level. For off-grid projects of less than 100kW, capital subsidy at 30% of the benchmark cost or soft loans at 5% interest rate have been made available. For grid connected rooftop solar projects ranging from 100kW to 2MW state utilities can purchase

[189] Power Line, Volume 14-No.12 – "Solar Power in India", August 2010; pp. 84
[190] http://mnre.gov.in/file-manager/UserFiles/commissioning_status_spv_batch1_phase1.pdf
[191] Power Line Volume 14, April 2010, p.71; http://www.mahaurja.com/PDF/PG2_solar_JNNSM.pdf

power at a feed-in-tariff set by the respective state electricity regulatory commissions. JNNSM aims to create an enabling environment for solar technology penetration, both at a centralized and decentralized level.

In the one year since the launch of the JNNSM, 37 projects totaling 650 MW have been allotted. By November, 2011, bidding process for 350 MW under second batch of projects of first phase of National Solar Mission has also been completed. As against the average tariff of Rs. 12.20 /kWh in the first batch of solar projects in 2010, the tariff offered in the second batch of projects were in the range of Rs.7.49/kWh to Rs. 9.44/kWh, with weighted average of the offered tariff at Rs. 8.78/kWh. The steep decline in solar power tariff affirms Ministry's aim to achieve the grid parity in the shortest possible time frame[192].

Government of Maharashtra has announced various policies for attracting private investment in generation through wind, biomass, bagasse, waste to energy and hydro. MERC has announced attractive tariff for each of the sectors for private investment. Government of Maharashtra has also provides following policy support for renewable energy[193].

- ***Green Energy Funds*** have been created to support renewable energy projects on wider scale partly through subsidy and partly by providing finance on commercial terms. Amendment to the Maharashtra Tax on Sale of Electricity Act, 1963 was made in December 2004 and notification dated 15th May 2008 was issued to levy the "Green Energy Cess" equivalent to 8 paise per unit on the sale of electricity to commercial and industrial consumers.
- ***Urjankar Nidhi*** has been created to provide seed money initially to support renewable energy projects. To manage the proposed funds, the public trust under the name of Urjankar Fund Trust has been established under the Indian Trusts Act, 1882.
- ***Comprehensive Renewable Energy Policy:*** Approval to the comprehensive energy policy was accorded by the cabinet on 4 September 2008, by which target of commissioning 2000 MW capacity wind energy projects, 1000 MW capacity bagasse projects, 400 MW capacity biomass projects and 100 MW capacity small hydro projects has been finalized.
- ***Renewable Purchase Obligation:*** Maharashtra Electricity Regulatory Commission (MERC) had put forth a criterion to be implemented from 2007-08, that of all the power being distributed by distribution companies, at least 4% should be from renewable sources. The MERC has also set solar Renewable Purchase Obligation (RPO) targets of 0.25% for 2010-11 till 2012-13[194]. Till 2015-16, 0.50% RPO in solar and 8.50% RPO in

[192] Government of India, Ministry of New and Renewable Energy, Annual Report 2011-12
[193] Government of Maharashtra, Department of Planning, Directorate of Economics and Statistics: Economic Survey of Maharashtra 2009-10, Ch.9 Infrastructure, pp. 137
[194] Power Line, Volume 14-No.12 – "Stellar Support-Regulatory incentives and guidelines", August 2010; pp. 88

other renewables totaling 9% RPO, for entities owning captive plants or having open access[195].

- ***Evacuation arrangement:*** MEDA and MSEDCL/MSETCL will undertake the survey for installation of LV, HV and EHV sub-stations, and will also supervise the erection of sub-stations[196].

  After the evacuation arrangement is transferred to MSEDCL/MSETCL, MEDA will reimburse 50% of the approved expenses to the developer.

State level incentives for bagasse and non-bagasse based (biomass) captive power generation

State level incentives for bagasse and non-bagasse (biomass) based captive power generation are tabulated below. Maharashtra state has also promulgated favorable policies which include wheeling and banking and third party sale. Maharashtra has also announced preferential tariffs for biomass power generation[197].

Table 54 - State level incentives for bagasse and biomass captive generation

Source	Tariff	Tariff validity	3rd party sale	Wheeling	Banking
Bagasse	`4.98/ unit	5 years	Allowed	Allowed	Allowed
Biomass	`4.79/ unit	5 years	Allowed	Allowed	Allowed

Third party sales generally lead to shorter payback periods and are therefore more attractive to private investors.

Evacuation arrangement

- For installing HV / EHV substation for Bagasse Based Cogeneration Power Project / Energy Generation Project capital subsidy of Rs. 1 crore per project will be given; only if minimum 80% PLF is achieved for minimum one year.
- For the cooperative sugar factory that installs bagasse based cogeneration project, 100% exemption for 10 years on 3% purchase tax on sugarcane purchase.

State level incentives for wind based captive power generation

Wheeling charges levied for captive use wind generated power are much less in comparison to other conventional sources of energy. These are in the range of 2-10%, but buy back tariffs are in the range of 3-5%. Banking and open access facilities have also been provided.

Table 55 – State incentives for wind based captive power generation

[195] Government of Maharashtra, Maharashtra Electricity Regulatory Commission, Regulations 2010
[196] http://www.ireda.gov.in/Compendium/index%20copy.htm
[197] Captive Power in India, "Captive Power from Renewable Sources", 2010, pp. 122-123

Wheeling (% of energy fed into the grid)	Banking	Buy-back	Open access	RPO (%)	Capital subsidy	Reactive power charges
2+5% transmission loss + grid support charges	12 months	`4.98/ unit (escalation of `0.15/ unit per year for 13 years from date of commissioning of project)	Allowed	6	Power evacuation, approach road, electricity duty, loan to co-operative societies	`0.25 / kVARh

Evacuation arrangement-

- MEDA shall get the approach roads constructed.
- Electricity Duty will not be levied for the first 10 years.
- 100% refund of Octroi from the Green Energy Fund

State level incentives for small Hydro Power Project

Evacuation arrangement

- Capital subsidy will be applicable up to 5 MW Capacity Small Hydro Projects based on Kolhapur type weir, waterfall, and run of the river. (only if 80% PLF achieved)
- Up to 5 MW. Small Hydro Power Projects subsidy of Rs.50, 000 per KW will be given.
- Maximum limit for subsidy will be Rs.1.5 crore per project.

Benefits of Renewable energy[198]

Tackle rising carbon emissions

The energy mix is dominated by coal fired plants in the state and in our country. By 2017 India will be the fourth largest emitter of greenhouse gas emissions. The power sector is alone for more than 40% of those emissions. Aggressive use of renewable, clean energy sources can help alleviate this problem.

Addresses energy security challenges

India has fourth largest coal reserves in the world, but Indian coal has a high ash and low heat content[199]. Coal is being imported and significant imported coal capacity is now being built in coastal regions. The fuel for the proposed nuclear power plants will also have to be imported.

198 Mckinsey Report, Renewable Energy: Bridging India's power gap
199 Resources for the Future, Discussion Paper, "Options for Energy Efficiency in India and Barriers to their adoption: A Scoping Study", Soma Bhattacharya and Maureen L. Cropper, April 2010

Fuels for renewable energy sources are not import dependent and can help address energy security concerns.

Provide electricity to rural villages

Instead of relying on the slow extension of electricity distribution grid to remote villages, renewable enable distributed generation. This will also accelerate the pace of rural electrification. It will also reduce the consumption of kerosene. These subsidies can be redirected towards promoting renewable energy for remote villages.

Economically competitive

Technological improvements will ensure that cost of power generated through renewable sources will decline, especially for solar energy. Renewable energy is already competitive compared to peak power prices of or retail prices for commercial and high end consumers in cities like Mumbai. In Maharashtra, the peak power deficit was 4941MW in 2008-09, which is likely to worsen in the near future. Up to December 31, 2010 the peak power deficit was 4106MW already (A part of this deficit was given relief with the Agricultural Load Management Scheme). Meeting peak demand through distributed renewable sources like solar panels on residential rooftops or commercial buildings or from hybrid renewable plants can prove economically viable.

Employment Generation

Providing electricity in rural areas will generate employment. Rural energy needs are not just agricultural and cooking and lighting needs. Electricity is needed for schools, micro, small and medium enterprises (MSME) as well. In India, there are around 87% of schools are located in rural areas. Among MSME, around 44.52% of the registered units and around 54.68% unregistered units are in rural areas. There are thousands of rural artisans such as weavers who operate as Own Account Enterprises[200]. Their productivity will be enhanced by supply of clean energy and moreover due to availability of electricity, number of hours of work will also increase.

Cost of various sources of renewable energy

Electricity production is based on coal fired plants, with 68% share in the state's total electricity production. 1 kWh of electricity generated at a thermal power plant emits waste heat, carbon dioxide, nitrogen oxide, carbon monoxide, sulphur dioxide and fly ash.

Thermal power generation using coal and gas involves exploited burning of fossil fuels and consequently carbon and greenhouse gas emissions. Although it is not feasible to completely

[200] India Science and Technology: 2008 - "Rural Energy Security in India: Reality Checks", Bikramjit Sinha & Indranil Biswas, May 2009

discard power from fossil fuel sources, we can reduce dependence on fossil fuels by catering to renewables. The capital cost per MW of various sources of renewable energy is tabulated below.

Table 56 – Capital cost and typical cost of generated electricity from renewable options[201, 202]

Renewable energy source	Capital Cost (Rs. Crore /MW)	Estimated cost of generation per unit (Rs./kWh)
Wind	4.50-5.50	2.00-3.00
Small hydro projects	5.00-6.00	1.50-2.50
Bagasse cogeneration	3.5	2.50-3.00
Biomass	4.00	2.50-3.50
Biomass (Gasifier)	0.94	2.50-3.50
Solar (PV)	10-15	7.49-9.44[203]
Urban waste Industrial waste	2.5-10.0	2.50-7.50

Decentralized Distributed Generation

The cost of a decentralized distributed generation (DDG) for a village with 240 households, having a demand of 150W per household is tabulated below. DDG is a transitional solution for remote rural areas, depending on the type of fuel availably. It can be installed in these remote locations by the Gram Panchayats with subsidies and incentives provided by the government. If these models are locally owned, rural communities can take responsibility of pricing and collection, operation and maintenance of the plant. Private players can provide technical and management support[204] with the government playing a critical role. Other than providing subsidy, the government shall also regulate and monitor the process till the DDG becomes operational. The model once successful can be implemented in other rural places too.

[201] http://planningcommission.nic.in/reports/genrep/intengpol.pdf
[202] Government of Maharashtra, Maharashtra Electricity Regulatory Commission, Renewable Energy Tariff order FY 2012-13
[203] Government of India, Ministry of New and Renewable Energy, Jawaharlal Nehru National Solar Mission
[204] Confederation of Indian Industry – "Bharat Nirman Plus: Unlocking Rural India's Growth Potential", May 2007

DDG IS ECONOMICALLY FEASIBLE

DDG options

ESTIMATES

		Grid extension	Small hydro	Biomass	Diesel	Wind	Solar
Capital expenditure* (Rs lakh)		6	15-17	20-22	10-12	18-20	90
Cost (Rs per KWh)	Variable	3.5	0.25	1.5-2	8-9	0.1	0.25
	Lifecycle	4	1.9-2.9	2.6-3.2	8.6-10	5.8-8.7	17
Power availability (hours per day)		No power during peak hours; limited supply during off-peak hours	Up to 24 Depends on nature of water source	Not constrained	Not constrained	5-8 Will vary with seasons	5-6 Depends on battery backup
Comments		Suitable for villages close (<5km) to the grid in power surplus states	Cost-effective for regions with steady water sources	Requires source of biomass	Fuel availability can be an issue	Effective only with grid back-up	Expensive solution; should be used only in remote areas

- **Hydro, biomass have low variable costs of power generation with reasonable capital costs and are best suited for both basic lighting and livelihood usage**
- **Cost of generation from diesel is high and may be suitable only for livelihood usage (and not basic lighting)**
- **Solar and wind are expensive options and should be used depending on availability of alternatives**

* Demand of about 36 KW assumed per village (240 households with 150W demand each)

Figure 56 - Economics of Decentralized Distributed Generation

The government provides incentives, tax concessions, subsidies and various other incentives for setting up renewable energy plants. The Electricity Act, 2003 removed licensing requirement for all power generation plants including those based on renewable energy.[205] Off / on grid captive power plants can be best suited for rural electrification. It is a cost effective route of power, especially with the emerging renewable technologies such as biomass projects. The appropriate DDG can be chosen depending on the local fuel availability as well as demand in the area. A pilot DDG project was set up in village Bahrabari in Bihar by Desipower, a nonprofit organization. National Thermal power Corporation (NTPC) also took up distributed generation for rural electrification of remote villages through non-conventional energy sources in order to assist Government of India in achieving the goal of "electricity for all". Two pilot projects at village Jemara in Chhattisgarh with biomass (woody) for 100 households and at village Jaraha-Chetwa in Uttar Pradesh for 200 households, were successfully commissioned in 2004-05[206].

[205] Captive Power in India-2010, "Fuel Outlook", pp. 110

[206] https://www.ntpc.co.in/annualreports/2004-05/DirectorsReport05.pdf

Renewable Energy Potential of Maharashtra

Over 14% of the rural households in Maharashtra still do not have access to electricity. There are many regions which have access to grid connected electricity but suffer from power outages, fluctuating power supply or no power at all, *e.g.* Melghat forest in Akola district. The tribal villages like Melghat are located in such remote locations that the cost of wheeling power will not be economically feasible. Moreover there are several tribal villages located in the buffer zones of Tiger Reserves and National Parks. These regions can be supplied with electricity through renewable power generation sources. There are various villages particularly the tribal villages which have remote locations. Wheeling power to such large distances would not be feasible economically as in such villages the power consumption will be less than 30 units.

The unit cost of power for a consumer is same whether the consumer is near the generating station or whether he is in a remote location. The cost of providing power to far off communities is hidden in this pricing mechanism. Moreover, transfer of electricity to large distances also involves losses – commercial and technical. Since grid extension is technically and economically challenging, decentralizing electricity systems are a feasible option for rural electrification. A combination of renewable energy technologies can be used for rural electrification as well as remote villages in the state. Thus decentralized renewable energy technologies can penetrate in locations where it is not economically feasible by MSETCL and MSEDCL to transmit and distribute power at larger distances due to the remoteness of many regions in Maharashtra. Billing, collection, maintenance and monitoring thefts would also be difficult in such remote areas.

In such regions off grid applications or decentralized distributed generation has a lot of relevance. Off-grid and decentralized generation proves to be a viable option in such regions. The key drivers for renewable energy are the following[207]:

- Demand-supply gap, especially as population increases
- Large untapped potential
- Concern for the environment
- Need to strengthen energy security
- Pressure on high-emission industry sectors from their shareholders
- A viable solution for rural electrification

As demand has always outstripped supply, it is necessary that urban areas should also make a transition towards renewable energy. Maharashtra has 3005MW of grid connected renewable power as on March 2011, which is mainly on account of wind power[208]. The renewable energy

[207] Global Energy Network Institute – "Overview of Renewable Energy Potential in India", Meisen, Queneudec, Avinash, Timbadiya; October 2006
[208] http://mospi.nic.in/mospi_new/upload/Energy_Statistics_2012_28mar.pdf

potential of India and Maharashtra, installed capacity and untapped potential in the state and the capital cost required for setting up various renewable energy plants is tabulated below.

Table 57–Renewable energy potential in India & Maharashtra and untapped potential in Maharashtra[209]

Renewable energy source	India potential (MW)[210]	Maharashtra Potential[211] (MW)	Maharashtra Installed Capacity (MW)	Maharashtra Untapped Potential (MW)	Maharashtra % untapped (2011-12)
Wind	48000	5439	2733	2706	49.75
Small hydro projects	15000	732	256	476	65.03
Bagasse cogeneration	5000	1250	671	579	46.32
Biomass	16881	781	403	378	48.40
Solar	-	-	21	NA	NA
Waste					
Urban waste	2700	287		0	0
Industrial waste		350	11	339	96.86
Total	**87581**	**8839**	**4095**	**4765**	**50.66**

NA-Not available

Small hydro means hydro power projects with a station capacity more than 1MW and up to & including 25MW

Out of total potential of 8839 MW of renewable energy in the state, 50% is untapped. Wind power is the only resource that is largely utilized so far. Investments in solar power are picking up with the JNNSM. One of the major benefits of renewable energy sources is that the power plants from these sources can be off-grid decentralized plants catering to the needs of a single household (except small hydro power) or a village, or larger MW scale power plants connected to the grid.

Wind power

Wind power is one of the most promising sources of renewable energy today and the most developed so far. India's installed wind power capacity stood at 17,351 MW as of March 31, 2012 and accounted for around 70% of the total grid connected renewable capacity. India is currently the world's fifth largest wind producer. The government has set a target of 10,500MW for the Eleventh Plan period. Karnataka, Gujarat, Rajasthan and Maharashtra together account for 70% of the country's total wind capacity.

[209] Government of Maharashtra, Department of Planning, Directorate of Economics and Statistics: Economic Survey of Maharashtra 2009-10, Ch.9 Infrastructure, pp. 135
[210] Power in India, Renewable Energy, pp. 169
[211] Government of Maharashtra, Maharashtra Energy Development Agency

The cost of setting up a 1MW wind power plant is also reasonable costing around Rs. 4.5-5.5 crore/MW. Wind energy has a drawback that it cannot act as a peaking station and cannot produce power on demand.

Projected wind capacity and generation (2025)

Assuming tapping the entire Maharashtra wind energy potential of 5439 MW in 2025

Wind power generation @ PLF 30% - 14294 MU

% wind capacity of total installed capacity - 12.75%

% generation of total generation - 6%

Small hydro power (SHP)

SHP schemes have little or no environmental impact and can provide a range of energy services particularly in rural areas. SHP projects avoid issues such as deforestation and submergence. In areas with hydro-power potential, this form of renewable energy is the most cost-effective opportunity to energize on/off-grid areas. Small hydro-power can satisfy low to medium electric needs such as lighting or telecommunication and power for small industries. SHP projects are further classified as:

Table 58 - Classification of small hydropower projects[212]

Class	Station Capacity in kW
Micro Hydro	Up to 100
Mini Hydro	101 to 2000
Small Hydro	2001 to 25000

SHPs typically have an inherent ability for immediate starting, stopping and load variations (solar and wind have similar flexibility but not so with biomass and co-generation). These plants usually have limited poundage capacity. Thus in off seasons when they are generating less than full capacity, water can be stored during off-peak hours and utilized during peak hours, making them suitable as peaking plants. In peak season they usually run as base loads.

[212] http://www.mnre.gov.in/schemes/grid-connected/small-hydro/

Projected SHP capacity and generation (2025)

Assuming tapping the entire Maharashtra SHP potential of 732 MW in 2025

SHP generation @ PLF 30% - 1923 MU

% SHP capacity of total installed capacity – 1.8%

% generation of total generation – 0.83%

Bagasse based cogeneration

Bagasse based cogeneration is extensively used by the sugar industry, where the fuel sugarcane residue is available virtually free for the captive unit. In this process the sugar mills generate sufficient power to sell the surplus to the grid after meeting their own requirement. 5000MW of power could be supplied to the grid if all the 550 sugar mills in the country switch to modern techniques of cogeneration[213]. In Maharashtra, 76% of bagasse cogeneration remains untapped. There are around 163 sugar factories in Maharashtra. Nearly 76% of the cogeneration potential from the sugar mills is yet untapped. If the all the factories switch to cogeneration, Maharashtra will have a total of 1250 MW of power available from bagasse based cogeneration.

Projected Bagasse capacity and generation (2025)

Assuming tapping the entire Maharashtra bagasse based cogeneration potential of 1250 MW in 2025

Bagasse based co-generation @ PLF 50% - 3285 MU

% bagasse capacity of total installed capacity - 3 %

% generation of total generation – 1.5%

Biomass projects

These are significant from the socioeconomic perspective as they have potential for employment generation and asset creation as they are linked to agriculture. According to the IEA, the share of global electricity from biomass is expected to increase from 1.3% at present to

[213] http://mnre.gov.in/annualreport/2007_2008_English/Chapter%205/chapter%205_1.htm

about 3.5% by 2050. This is based on the 120-150 million tons of surplus biomass available from agriculture and forest residues. The current net availability of biomass in India is estimated at 540 million tons, of this almost three four this is used as fodder for cooking and for other economic activities. Being linked to agriculture, biomass projects have a tremendous potential for employment generation. The technology for biomass gasification is reasonably matured.

Biomass energy includes fuel wood, charcoal and agricultural residues as fuel. Biomass fuels comprise of both woody and non woody mass. The first comes from trees and shrubs; the latter from crop residues and other vegetation. Biomass includes rice husk, bamboo, cane, straw, cotton stalk, coconut shells, soya husk, de-oiled cakes, coffee waste, jute wastes, groundnut shells, saw dust, market waste, house waste, etc. Biomass plants are generally small sized plants with captive capacities of 25MW and below. Punjab has the highest installed capacity accounting for 32% of the total biomass based captive capacity. This is followed by Andhra Pradesh (18.5%) and Tamil Nadu (17.3%)[214]. As of now only 88.9% biomass potential in Maharashtra remains untapped, but growing scarcity of fossil fuels is likely to necessitate its growth in the future. Biomass generation is ideal for rural and remote areas as it is flexible to integrate biomass with other sources such as wind and solar.

There are several advantages of this route for village electrification, a few of which are listed below[215]:

- Biomass is available almost everywhere.
- Power will be available on demand at any time of the day or year. The device can be used for 24 hours continuously or for limited period of the day.
- Different capacities from a few kilowatts to megawatt scale gasifiers are available.
- The power can be used for multiple applications like lighting, drinking and irrigation water supply, small scale industries, etc. Since the device can be used any time of the day, service can be conveniently sequenced.
- Production cost of power from gasifier systems range from `2.5/kWh to `5/kWh depending on capacity utilization, biomass cost, etc.
- Socially beneficial electricity production, as it is linked to agriculture.

Biomass is an important energy source in Indonesia, Malaysia, Philippines, Thailand and Vietnam[216]. Developed nations like Finland, Sweden and Austria also have biomass power generation. Sweden also has a higher share of biomass generation. Biomass surpassed oil to become the number one source for energy generation in 2009, accounting for 32% of the total energy consumption in Sweden. It is projected that biomass consumption will continue to

[214] Captive Power in India, Captive Power from Renewable Sources, pp119
[215] The Economic Times, “Lighting up rural India, naturally”, Paul P J, August 20, 2010
[216] Biomass: More than a Traditional form of Energy- FAO/RAPA

increase by another 10% in 2011[217]. A total of 147 MW of biomass capacity has been installed in Maharashtra till 2010-11[218].

Table 59: Anticipated future of biomass power

Parameter	Now (2010)	Future (2020)
Distributed electricity generation	Biomass has a minor contribution	Biomass will be a major contributor
Use in co-firing in power plants	Fewer than 1% of power plants use biomass	A much larger % of utility power will be from biomass
Use of feedstock	Primarily waste biomass and assorted	Dedicated energy crops
Related revenue streams	Some additional revenue streams already present	A more established end user market for co-products
Standalone renewable electricity source?	Primarily standalone mode	Will be used in conjunction with other renewable electricity sources

Projected Biomass capacity and generation (2025)

Assuming tapping the entire Maharashtra biomass potential of 780 MW in 2025

Biomass based co-generation @ PLF 68% - 2050 MU

% biomass capacity of total installed capacity – 1.8 %

% generation of total generation – 0.94%

Solar energy

Data on solar energy potential in the state is not available; however the present state of harnessing solar energy is insignificant[219]. Since Maharashtra has a temperature in the range of 25-27.5^{o}C, the state has a huge solar potential. Solar energy at present is being used only for water heating in residential complexes. However, it can also be used to meet peak demands through solar panels on residential rooftops and commercial buildings. Solar PVs are best suited for urban buildings. The high end commercial and residential consumers can go off the grid and have their own solar installations rather than paying higher tariffs.

217 http://www.renewableenergyworld.com/rea/news/article/2010/06/biomass-generates-32-of-all-energy-in-sweden
218 http://www.mahaurja.com/PDF/Biomass_Proj_StatusC.pdf
219 India Science and Technology: 2008 - “Rural Energy Security in India: Reality Checks”, Bikramjit Sinha & Indranil Biswas, May 2009

India's grid connected capacity currently stands at around 143 MW[220]. Most projects are small sized demonstration projects set up by MNRE. The installation of MW scale projects are very few as cited below.

- 95 MW of solar power is installed in the states of Gujarat and Rajasthan.
- 2 MW grid connected – West Bengal, Green Energy Development Corporation at Asansol
- Two projects of 3MW each commissioned by Karnataka Power Corporation Ltd
- 2 MW project Azure Power at Amritsar in Punjab
- 1 MW solar PV thermal power project is being developed at Chandrapur by MahaGenCo
- NTPC plans to establish solar power capacities of over 300 MW (PV or thermal)
- Tata Power is independently exploring options for 300 MW worth of solar projects to be commissioned by 2013

From FY 2010-11, Maharashtra has seen the inception of Grid interactive solar power. A total of 25 MW solar power generating capacity has been added in two years. A 125 MW (5 X 25) solar power project at Sakri, Dhule is being undertaken by MSPGCL. It is going to be the biggest solar power project in the state. The table below shows location and commissioning details of solar power projects commissioned in Maharashtra.

Table 60- Grid Connected solar power plants in Maharashtra[221][222]

Company	Capacity MW	Location	Commissioned
MSPGCL	1	Chandrapur STPS	April 2010
MSPGCL	2	Chandrapur STPS	October 2011
MSPGCL	2	Chandrapur STPS	February 2012
Dr. Babasaheb Ambedkar Sahakari Sakhar Karkhana Ltd.	1	Osmanabad	July 2011
Tata Power	3	Mulshi, Pune	March 2011
Clover Solar Pvt. Ltd.	2	Supa, Baramati, Pune	October 2011
Videocon Industries Ltd.	5	Warora, Chandrapur	October 2011
Citra Real Estate Ltd.	2	Katol, Nagpur	November 2011
Sepset Construction Ltd.	2	Katol, Nagpur	November 2011
Firestone Trading Pvt. Ltd.	5		
Total (MW)	**25**		

Apart from grid connected system, solar power finds a wide application in decentralized and off grid applications. Some of the key decentralized applications using solar power include home

[220] http://mnre.gov.in/file-manager/UserFiles/powerplants_241111.pdf
[221] http://www.mahagenco.in/uploads/projects/projectCompletedInLast5Years.pdf
[222] http://mnre.gov.in/file-manager/UserFiles/commissioning_status_spv_batch1_phase1.pdf

lighting, street lighting, pumps, solar water heaters, solar cookers, etc. solar power plants have also been established as stand-alone off- grid installations for supplying power to railway stations, border outposts, hospitals, etc. The market for decentralized and off-grid power is huge. It also includes demand from areas such as rural electrification, backup power for telecom towers and for lighting billboards and tail end grid support, where solar power could effectively reduce dependence on DG sets as well as load from grid. Tabulated below is the installed capacity of decentralized solar applications in India and Maharashtra as of January 2012[223].

Table 61 – Installed capacity – India and Maharashtra (January 2012)

Source/System	Cumulative Capacity	
	India	**Maharashtra**
Solar home lighting systems (No.)	6,96,069	2431
Solar lanterns (No.)	8,50,375	8683
Solar street lighting systems (No.)	1,41,280	8420
Solar PV pumps (No.)	7571	228
Solar water heating – collector data (million sq.m)	3.25	
Solar cookers (No.)	6,72,000	58044

JNNSM's guidelines for off-grid projects provide multiple channels of contact between the suppliers through channel partners such as renewable energy service provider companies, financial institutions including micro-finance institutions, system integrators and program integrators. Incentives are available through renewable vouchers, capital and interest subsidy, viability gap funding and green energy bonds. Grid connected capacities are the main focus area of JNNSM though. Following are examples of off-grid solar power used for cooking, lighting and telecom towers[224]. Batch II of Phase I of JNNSM has just started (January 2013).

Through its Rural Village Electrification (RVE) program, MEDA has installed solar home lighting and street lighting in 362 villages and 805 hamlets in Maharashtra till July 2012[225]. 30,483 solar home lights and 3,508 solar street lights have been installed by MEDA. 56 kW solar photo voltaic SPV power plants have also been installed at 6 village places.

Solar steam cooking

Solar concentrators have been used for solar steam cooking systems. The world's largest solar steam system for cooking is set up at the Shirdi temple. It is designed to meet requirements of about 50,000 meals per day. Other examples include Mount Abu in Rajasthan designed for 10,000 people per day, Tirupathi and Satyabhama University, both in Andhra Pradesh each catering to 15,000 people per day. The world's highest solar cooker installation was in Ladakh

[223] Government of India, Ministry of New and Renewable Energy, Annual Report 2010-11, 2011-12,
[224] Power Line, Volume 14-No.12: "Off-grid Solutions-Needs and deployments", August 2010; pp. 92
[225] http://www.mahaurja.com/PDF/RE_RVE_Achivement.pdf

for the Indian Army. It involved 10 solar concentrators to cook for about 500 people. Solar concentrators have also been deployed for systems processing drinking water from sea water. Other emerging uses include solar crematoriums, waste water evaporation and solar air conditioning.

Solar lighting

Lighting solutions are among the most basic requirements addressed by off-grid solar systems. In remote rural areas to fulfill lighting needs, solar lamps have been introduced in most areas. Villagers spend around `150 every month on kerosene to fuel kerosene lanterns[226]. The people in remote areas are ready to shell out money for solar lamps. The United Nations Environment Program says that kerosene fumes are responsible for 64% deaths for children under the age of five in developing countries[227]. Even if these remote households get solar lanterns the health of women and children will improve. The children will have more hours for studying and the local artisans will also be benefitted as their productivity will increase. Several such installations have been installed and the impact has been that rural productivity from income generating activities has increased. This is particularly significant as access to power in rural areas remains a problem. This can just be the start, but in the long run, electricity is not just essential to fulfill lighting needs, but for the development of the area.

Figure 57- Solar streetlight

Figure 58 – Decentralized application of solar power for pumping water in Melghat, a tribal village

Telecom towers

The telecom industry has over 250,000 towers that are shared by various operators. The energy requirements of running the base station towers involve both utility supply and diesel

[226] Mint – "Solar lamps light up rural lives, dim use of oil lanterns", September 2010

[227] Wall Street Journal Online, "Solar lamps face subsidy shadow in rural India", December 7, 2009; http://online.wsj.com/article/SB125991486832876383.html

generator (DG) sets. Each tower requires a 15-20 kVA DG set and has an average run time of 16-20 hours per day. At an approximate diesel consumption of 1.9-2 liters per hour, the total annual diesel consumption is calculated to be approximately 12-14 kilo liters. Per unit cost based on DG sets ranges from `30-50. Hybrid solutions comprising solar and DG sets or solar power entirely can be harnessed to meet the energy requirements of the telecom base stations.

The typical PV array for a single operator base station tower is 3-3.5kWp (kilowatt-peak, a measure of the peak output of a photovoltaic system). The energy generated from a 3kWp PV array is 11-13kWh per day, and the array supports the load for about 10-12 hours in the day. Also reducing the DG set operation by 10 hours would reduce the CO_2 emissions by about 45kg per day. The installation of these systems faces challenges such as insufficient space for PV arrays, remote management sites and logistics issues.

Land is a key input in solar projects. Solar PV is generally regarded as suitable for Indian conditions where space is a constraint, especially for projects such as rooftop solar. Globally, solar PV is the fastest growing technology with PV production increasing by an average of 20% each year since 2002. At end 2009, the cumulative global PV installation surpassed 21,000MW, of which 90% consisted of grid tied systems. Grid parity, the point at which PV electricity is equal to or cheaper than grid power, has been achieved in California, Japan and Hawaii and other islands. The US is expecting to reach grid parity by 2015[228].

Solar energy can be harnessed by several applications such as photovoltaic (PV) cells placed on the roof top of houses or commercial buildings, and collectors such as mirrors or parabolic dishes that can move and track the sun throughout the day are also used. This mechanism is being used for concentrated lighting in buildings and called concentrating solar power (CSP). The capital costs of CSP projects are high. Globally the capital cost of projects based on parabolic trough technology (the most commercially deployed technology) range from `160 million/MW to `400 million/MW. The capital costs of upcoming projects coming up in India have been estimated to be over `140 million/MW. The costs are expected to decline with more competitive supply of components and as other low-cost technological options like CSP plants with storage and hybridization are explored[229].

Photovoltaic (PV) cells have a low efficiency factor, yet power generation systems using photovoltaic materials have the advantage of having no moving parts. PV cells find applications in individual home rooftop systems, community street lights, community water pumping, and areas where the terrain makes it difficult to access the power grid. The efficiency of solar

[228] Power Line,Volume14-No.12,“PV Promise-Solar photovoltaic dominates technology choice”,August 2010; pp. 88
[229] Power Line, Volume 14-No.8, “Cost trend-Economics of solar PV and CSP projects”, April 2010; pp. 74

photovoltaic cells with single crystal silicon is about 13-17%. High efficiency cells with concentrators are being manufactured which can operate with low sunlight intensities[230].

Solar Rooftop

Buildings can provide a unique opportunity to generate electricity by utilizing rooftops. These plain surfaces facing direct sunlight at most of the times of the year are a vast source of energy – these rooftops can come together to become a massive power plant – a decentralized one.

An example of solar PV installations in Pune city is considered to get a clear understanding of power that can be generated from cities through renewables. Utilizing the area of residential and commercial building roof tops in the city, Pune alone can provide an installed capacity of 1000 MW and generate upto 1000 MUs of electricity annually. This is calculated considering minimum efficiency of 10%.

Pune – A Giga Watt Solar City

Total area	243.87 sq.km.
Residential + Commercial Area - 44% of total	0.44
Residential + Commercial Area	107.30 sq.km.
Solar PV Installation possible on 50% buildings	0.50
Effective area	53.65 sq.km.
Rooftop Area Ratio (40% of land)	0.40
Final effective installation area	21.46 sq.km. *or* 21,460,560 sq.m.
Area required for 1MW generation	20,000 sq.m.
Installed Capacity	**1073.028 MW**
Capacity Utilisation Factor (CUF)	0.1
Annual Generation	**939.97 MU**

44% of residential area has been considered as per the City Development Plan Report prepared for JNNURM. It has been assumed that 50% of the buildings' residents agree and installation of solar power plant is possible on their rooftops. It has also been assumed that only 40% of the area of the total plant (building) can be actually utilized for installing solar panels.

230 Global Energy Network Institute – "Overview of Renewable Energy Potential in India", Meisen, Queneudec, Avinash, Timbadiya; October 2006

Projected solar capacity and generation (2025)

Maharashtra solar power potential of 905 MW in 2025231

Solar generation @ PLF 10% - 793 MU

% generation of total generation – 0.34 %

In addition, utilization of solar power potential on rooftops of buildings will provide more power from solar energy, which has a potential of generating 4 million units from a square kilometer of urban area.

Energy from Waste

Energy from waste which remains untapped altogether needs to be promoted on a large scale, particularly in the urban regions. Several initiatives have been taken up in various towns but these are minuscule. Municipal solid waste (MSW) generation ranges from 0.25 to 0.66kg/person/day with an average of 0.45kg/person/day. In addition, large quantities of solid and liquid wastes are generated by industries. Most wastes that are generated find their way into land and water bodies without proper treatment, causing severe water pollution. They also emit greenhouse gases like methane and carbon dioxide, and add to air pollution. The problems caused by solid and liquid wastes can be significantly mitigated through the adoption of environment-friendly waste-to-energy technologies that will allow treatment and processing of wastes before their disposal. These measures would reduce the quantity of wastes, generate a substantial quantity of energy from them, and greatly reduce pollution of water and air[232].

In most cities and towns in India, waste is disposed in an unregulated and unscientific manner in low-lying, open dumps on the outskirts of cities. Most of these dumping sites do not have systems for leachate collection, landfill gas collection or monitoring, nor do they use inert materials to cover the waste. As a result, ground and surface water get contaminated from runoff and lack of covering; air pollution is caused by fires, toxic gases, and odour; and public health problems due to mosquitoes and scavenging animals.

Though recycling waste is the best option so far but there are limits to recycling. If all the waste that is recyclable would have been recycled the problem of disposing waste would have been tackled by now. The waste that yields a high price is only recycled. Waste that is dumped is mixed, comprising all kinds of biodegradable, non-biodegradable and hazardous waste. This mixed waste leads to contamination of materials which limits the proportion of recoverable

[231] Government of India, Ministry of New and Renewable Energy
[232] http://www.eai.in/ref/ae/wte/wte.html

material and its value[233]. Since availability of land for new landfill sites is also a constraint and no one wants to have a landfill nearby due to health hazards. Generating electricity from waste can provide a solution to managing the waste. There is considerable scope for energy recovery from urban and industrial wastes.

Urban and Industrial Waste

Various technologies are available to harness energy by treatment of urban & industrial wastes. It is estimated that through adoption of technologies for recovery of energy from wastes over 1000MW of equivalent power can be generated from the above wastes in India[234]. About 42 million tonnes of solid waste (1.15 lakh tons per day) and 6000 million cubic meters of liquid waste are generated every year by our urban population[235].

A major advantage would be reduction in the quantity of waste and net reduction in environmental pollution, besides generation of substantial quantity of energy. Some Municipal Corporations have set up plants to recover energy from urban waste, the energy generated is used to light the street lights. The potential of 2700MW has been calculated for the country whereas Maharashtra has a potential of 270 MW.

MNRE has notified a scheme for Accelerated Program on Energy Recovery from Urban Wastes, with the following objectives:

- To accelerate the promotion of setting up of projects for recovery of energy from urban wastes;
- To create conducive conditions and environment, with fiscal and financial regime, to develop, demonstrate and disseminate utilization of wastes for recovery of energy; and
- To harness the available potential of MSW-to-energy by the year 2017

Wave Energy

Wind transfers tremendous amounts of power to waves. Heavy winds blow across the seas towards the land. This wave energy can be tapped by placing instruments to convert it into electrical energy.

The wave quality varies for different periods and seasons. It is possible to have a realistic formula to calculate the overall wave energy potential. A general study of the wave nature has shown that there is potential of 40,000 MW along the Indian coast.

A similar study along the coast of Maharashtra has shown that there are some potential sites such as Vengurla rocks, Malvan rocks, Redi, Pawas, Ratnagiri and Girye, possessing an average

[233] ILEX Energy Consulting UK, “Eligibility of Energy from Waste –Study and Analysis”, March 2005
[234] http://www.ireda.gov.in/homepage1.asp?parent_category=2&sub_category=29&category=106
[235] http://mnre.gov.in/energy-uwaste.htm#Recent%20developments%20in%20Municipal%20Solid%20Waste%20Management

annual wave energy potential of 5 to 8 kW/m and monsoon potential of 15-20 kW/m. Considering this, the total potential along the 720 km-stretch of Maharashtra coast is approximately 500 MW for wave energy power plants.

Table 62-Wave power at selected sites along Maharashtra coast[236]

Off Shore Avg. Wave Power kW/m			Coastal Avg. Wave Power kW/m		
Site	**Annual**	**(Jun-August)**	**Site**	**Annual**	**(Jun-August)**
Vengurla Rock	8.01	20.61	Girye	5.90	14.21
Square Rock	6.79	16.64	Vijaydurg	5.86	13.58
Redi	6.35	16.57	Ambolgarh	5.74	13.48
Malvan Rock	6.91	16.73	Kunkeshwar	5.64	13.35
Kura Inset	5.79	13.74	PawaPoint	5.36	13.10
			Wagapur	5.70	13.10

MEDA, the nodal agency appointed by the state government to take initiatives in nonconventional energy sources is set to float tenders for projects involving power generation through wave energy along Maharashtra coast.

236 http://www.mahaurja.com/PG_Wave.html

Conclusion

The current installed capacity of renewable in Maharashtra is 4095 MW. A large potential of 4747 MW yet remains untapped, of which the solar installed capacity would vary as we utilize potential areas of solar radiation. Solar potential is not included in total potential of renewable. MNRE has set a target of installing 905 MW of solar capacity in the 12th FYP. This would add to the existing renewable potential which would ultimately increase the renewable installed capacity to 9744 MW in 2025.

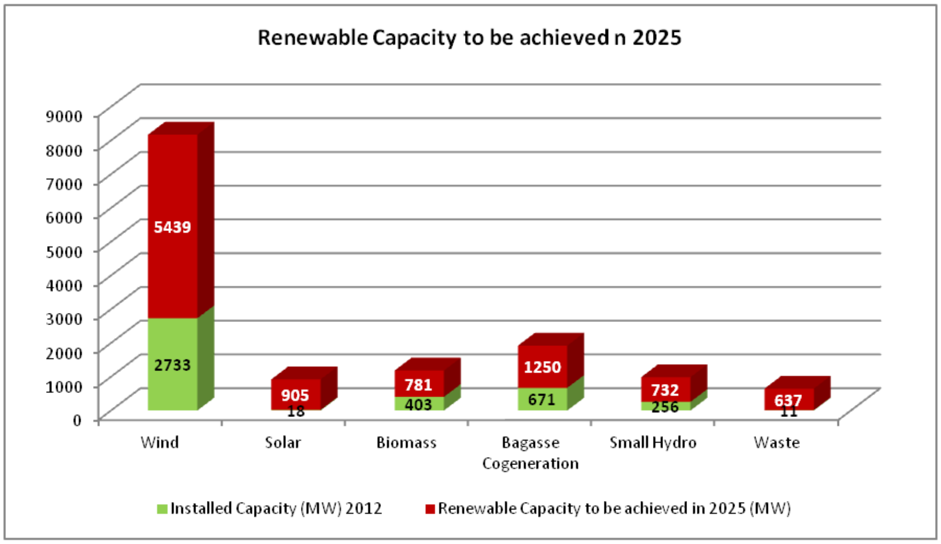

Figure 59 - Anticipated Renewable Energy Capacity Achievement (2025) –MEDA calculations

Table 63 - Anticipated renewable power generation in 2025

Source	Renewable Potential (MW)	Installed Capacity (MW) 2012	Proposed Capacity Addition in 12th plan (MW)	MEDA potential (MW)	PLF (%)	Target potential in 2025 (MW)	Anticipated yearly generation in 2025 (MU)
Wind	5439	2733	1500	5439	30	Scope in augmentation	14294
Solar	variable	18	525	905	10		793
Biomass	781	403	150	781	70		4789
Bagasse Cogeneration	1250	671	250	1250	50		5475
Small Hydro	732	256	50	732	30		1924
Waste	637	11	15	637	30	Scope in augmentation	1674
Sub total			2490				
TOTAL	**8839**	**4092**	**6582**	**9744**		**15000**	**28948**

9744 MW is the proven renewable energy potential that must be achieved with utmost urgency. However more areas for solar and wind energy will have to be identified. Roof top solar power generation is a viable option; its potential remains largely untapped. Considering the energy demand of around 40,000 MW in 2025, it is recommended that at least 35-40% (~15,000 MW) of power be generated from renewable sources in order to get closer to being sustainable in the electricity sector. 35-40% power in 2025 be generated from renewable sources

> Accelerating the growth of renewables in Maharashtra and taking the total installed capacity to 15000 MW in 2025 would generate around 45000 MU of electricity from renewables.

The country is faced with a dilemma of not only sustaining its economic growth but also with the global threat of climate change. India is the fifth largest emitter of greenhouse gases (GHGs) in the world, accounting for 4.7% of the total emissions. The principal energy-related challenge is access to energy, which has two distinct facets: ensuring energy supply to meet the growing demand of fuelling economic growth; and providing access to lifeline levels of clean commercial energy for the poor, chiefly electrification and cooking gas/kerosene[237]. 44% of rural households depend on kerosene for domestic lighting and another 55% on electricity, while in urban areas dependency is 89% on electricity and 10% on kerosene[238]. The disparity in access to energy between urban and rural areas and across income groups has stayed the same or widened. The grim reality is that in India almost half the population in rural areas has little or no supply of power. For long years, open ended subsidies in power have mostly been diverted and usurped by the undeserving non poor[239].

Electrification particularly in rural areas will greatly improve quality of life. Lighting alone brings benefits such as increase in study time and improved study environment for school children, extended hours for small businesses, and greater security[240].

Though the market share of renewable energy is small it holds a tremendous promise for meeting the future needs of electricity. As discussed several policy measures are being implemented; subsidies and incentives are being provided at the state and central level. Many such projects are coming up on a large scale in various parts of the country. The cost of renewable energy technologies has decreased substantially since the 1970s. Renewable/ green energy is a viable option for electrification particularly in the regions where people have no or

[237] CEPS Working Document No. 325, "The Political Economy of India's Climate Agenda", Noriko Fujiwara, March 2010

[238] India Science and Technology: 2008 - "Rural Energy Security in India: Reality Checks", Bikramjit Sinha & Indranil Biswas, May 2009

[239] The Economic Times, "Focus on power poverty- Innovate Rural Electrification", September 27,2010

[240] Independent Evaluation Group, World Bank, "The Welfare Impact of Rural Electrification: A Reassessment of Costs and Benefits"

little access to electricity. Distributed decentralized generation is the best viable option for remote villages.

Indigenous manufacturing holds the key to success of incorporation of renewable energy into the conventional energy system in India. Import of technology is proving costly and there are several other limitations in being dependent on imported technology. Also, economics of scale will play a major role to ensure lower costs[241]. In addition to subsidies in deployment of renewable energy technology, incentives for solar manufacturers are equally important.

- Solar lighting systems and kW scale off-grid solar systems can make a tremendous difference in the lives of the rural poor that have little or no access to electricity. Today, solar PV based lighting solutions (lanterns and home lighting systems) offer a cost-effective solution to quickly provide better quality lighting services to this population. Solar off-grid systems can provide lighting and power to Primary Health Centers, schools, drinking water systems, and for small income generating activities, significantly improving the quality of life in rural areas. The JNNSM has set a target to achieve 20 million solar lights by 2022, which is around 20,00,000 solar lights per day across the country. But this target seems to be minuscule for the mission which has set a massive target of 20,000MW by 2022. Nevertheless the subsidies and soft loans for the solar lights can be used to lighting for lighting up the rural households.
- In urban areas, renewable energy can be used in a different manner altogether. In the urban areas, private players are ready to invest as the return on investment is quicker and higher in comparison to rural areas. Moreover state of the art infrastructure is available in urban areas. Residential complexes are investing in solar water heaters, but this is not sufficient.
- In urban area power plants using urban and industrial waste should be considered. Municipal solid waste (MSW) poses hazard to health and environment, so using it to generate power would be feasible. The pace of setting up plants using MSW as a fuel should be intensified. Similarly industries are mostly clustered in MIDCs, or in specific areas and the industrial waste generated should also be put to better use by fuelling power plants based on industrial waste as fuel. Such plants should be located within MIDCs and depending on the quantum of waste generated; the capacity of the plant can be decided. Instead of connecting such plants to the grid, they can be used for street lights or other uses.
- Power can also be generated from sewage treatment plants, as is being done in several developed countries.
- Instead of taking up fertile lands from farmers, who rarely benefit due to the projects monetarily or in terms of electricity. The affected people are pushed into more poverty. Instead generation can be distributed through clean green energy, which would ensure power as well as cut down on the T&D losses as well.

[241] Power Line Volume 14, April 2010, pp. 72

- A policy decision/ reforms are needed wherein it would be made mandatory for all telecom towers and advertisements (hoardings) to harness solar power.
- Commercial, industrial and high end residential consumers who pay higher tariffs in order to cross subsidize the low end BPL consumers can switch to captive renewable technologies and generate their own power. A hybrid of solar and biomass technologies can be used to produce power, depending on the estimated usage. Depending on the type of industry, the waste can also be used to generate power. In fact, MIDCs can produce power from industrial as well as municipal waste. This would reduce municipal waste in the area considerably, and this electricity can be used by industries in MIDC.
- Renewable energy will also reduce greenhouse gas emissions and dependence on imported fuels. Moreover, setting up decentralized plants will also reduce T&D losses.

Envisaged total renewable capacity in 2025 - 15000 MW

Case Studies

San Antonio, Texas – Power generation from Sewage treatment Plants

San Antonio Water System (SAWS) has come up with an innovative technology of generating power from methane gas - a byproduct from the sewage treatment process, currently burnt off through the use of flares. 80% bio solids are already sold to recyclers for use in compost. Thus the sewage treatment plants (STPs) give a trifold benefit – power generation from methane gas, treated water used for irrigation and solid waste used for compost.

SAWS signed a 20-year lease and operating agreement with Massachusetts-based Ameresco that will allow the company to build a gas conditioning and distribution facility at the Dos Rios Water Recycling Center. Ameresco will be in charge of selling the gas on the open market. In return, SAWS will receive a 12 percent royalty off the sale of the gas.

Methane gas, which is a byproduct of human and organic waste, is a principal component of the natural gas used to fuel furnaces, power plants and other combustion-based generators.

About 140,000 tons of bio solids produced each year generate an average of 1.5 million cubic feet of gas per day on treatment which is enough to fill 1250 tanker trucks each year. AS per estimates calculated the contract could generate between $200,000 to $250,000 revenue for the utility each year.

Some communities are using methane gas harvested from solid waste to power smaller facilities like sewage treatment plants, but San Antonio is the first to see large-scale conversion of methane gas from sewage into fuel for power generation

Kearny, New Jersey – Power generation from Landfill site

Collection of methane gas is proposed in the 400 acre landfill at Kearny, New Jersey. This site is among 21 landfills in New Jersey where methane gas produced by decomposing garbage and used as fuel to generate electricity, according to the state Board of Public Utilities. Decades' worth of household trash, construction waste and assorted refuse buried in the landfill are providing electricity to thousands of homes. The Environmental Protection Agency has spotted 445 potential landfill sites through its Landfill Methane Outreach Program. The environmentalists envision making more use of landfill sites by installing wind and solar power to supplement methane. Thus these three sources could be combined to create a steady source of power. The new landfills need to be designed to accommodate methane gas collection whereas existing landfills can produce methane long after they've been shut down.

The Edgeboro landfill in East Brunswick, operated by the Middlesex County Utilities Authority, has been collecting methane since 2001 and currently generates about 13 megawatts of electricity, enough for about 13,000 homes for a year, according to Public Service Electric and Gas, the state's largest utility.

The Middlesex County agency uses the electricity generated by the Edgeboro landfill's methane to power the county's wastewater treatment plant in Sayreville. Last year, that saved the authority about $3 million, according to the executive director.

Long tubes with perforated bases are drilled down into a landfill to collect the methane gas, which then is used as fuel to drive generators. Inactive landfills are capped usually with a plastic or rubber covering that prevents excess gas from escaping.

Amanora Park Town Hadapsar, Pune - Electricity generation through Biomass gasifier system

Prosopis juliflora (Vedi Babhul) is used to generate electricity through Biomass gasifier system. This species is used as it is available in plenty and also thrives on less water. In the Amanora Township 11 kW electricity is supplied to the workers colony. The time required for installation is from 2 hrs. to 2 days. 1.3 kg per unit of *Prosopis juliflora* is used. Rs. 600,000 is the expenditure to generate 11 kW of electricity.

This project is also undertaken in villages Dhavlas, Valekhindi Dicholi and Yellur of talukas Mangalvedha, Jat, Patan and Valva respectively.

Dapoli Nagar Panchayat[242]

Dapoli is a small town in Ratnagiri district of Maharashtra. The local government Nagar Panchayat has installed renewable energy in its campus. Energy has been produce from solar, wind and waste. It is utilized for street lighting, running the local government buildings. It has set an excellent example of making peoples' (governmental) buildings autonomous of external power, at least for a part of their electricity needs.

- 53 kW power generation in the campus of Nagar Panchayat
- Supported by Maharashtra Energy Development Agency
- Funding from Central Government: Rs. 35.19
- 7 kW from solar PV panels atop the building
- 16 kW from wind in the Nagar Panchayat campus
- 30 kW from biogas produced from waste
- 23 kW will be utilized for Nagar Panchayat buildings
- 30 kW for street lighting

[242] http://72.78.249.125/eSakal/20120302/4996037045006219840.htm

Renewable Energy Facts

1. Europe DECOMMISSIONED more coal, fuel oil and nuclear capacity than it installed in 2009.
2. Solar energy is working at night on a commercial scale. A plant in Spain has seven hours of heat storage.
3. In a time period of just 5 years, Portugal's electric grid leapt from 15% to 45% renewables.
4. Iceland's power supply went from 75% imported coal to more than 80% local geothermal and hydro in 30 years.
5. China built (roughly) one windmill an hour in 2009.

Solution 4

Implement Energy Conservation Measures

Goal: To explore various energy conservation techniques for all segments of energy users in order to reduce the operational costs and enhance productivity.

Introduction

Energy is crucial for the development of modern society and so is energy conservation. Energy conservation is the practice of decreasing the energy used by using available energy in a smart and efficient manner. It involves the efficient use of energy in a way that will lead to use of less energy to achieve similar outcomes. Around two-thirds of the energy is lost while converting primary, secondary and final energy into useful energy services. Improving the energy efficiency of end-use applications would further reduce the energy intensity of the economy. Thus the end use is an area of high potential and needs to be largely explored. Higher end use energy efficiency *i.e.* providing technologically more desired service per unit of delivered energy consumed, is essentially the most easily deployable and certainly the most neglected[243] (in terms of implementation) way to conserve energy. End use energy refers to energy consumed in industrial, residential, agricultural and commercial settings.

Energy conservation is achieved through efficient energy use and it does not necessarily entail huge investments. It reduces energy consumption and energy demand per capita and thus offsets some of the growth in energy supply needed to keep up with population growth. This reduces the rise in energy costs and can reduce the need for new power plants. The reduced energy demand can provide more flexibility in choosing the most preferred methods of energy production. It further facilitates replacement of non- renewable energy with renewable energy. Thus energy conservation and efficiency immediately saves peoples' money, reduces outages and offsets the need for new power plants.

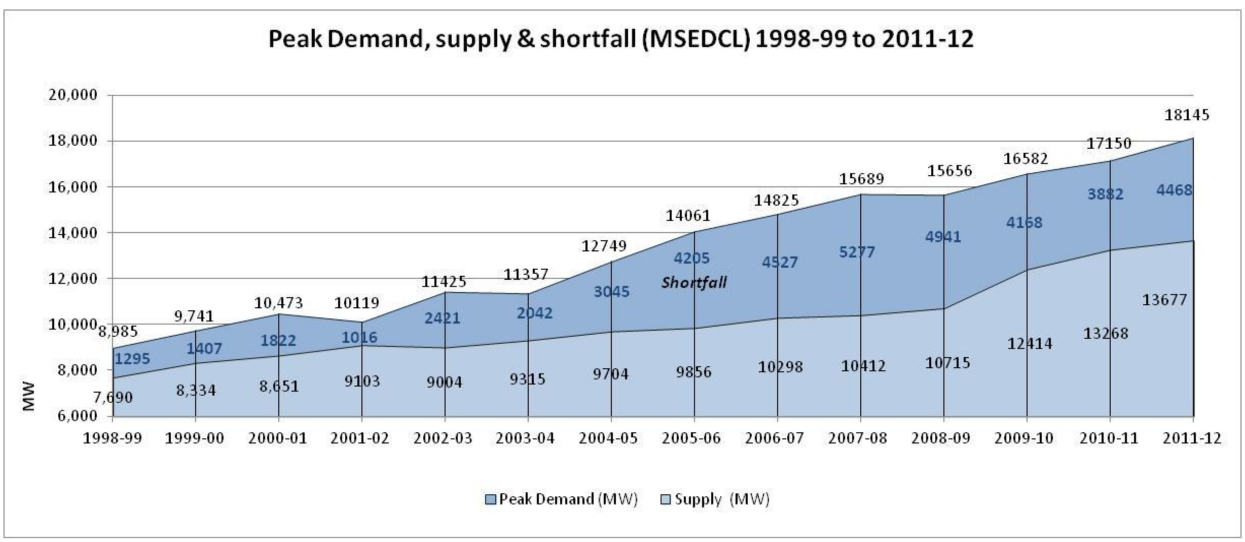

Figure 60-Peak demand, supply & shortfall in Maharashtra (MSEDCL distribution area)[244]

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[243] Rocky Mountain Institute, "Energy End-Use Efficiency", Amory B. Lovins, pp. 1; www.rmi.org

[244] Government of Maharashtra, Department of Planning, Directorate of Economics and Statistics: Economic Survey of Maharashtra 2009-10, Ch.9 Infrastructure

Electricity demand has consistently exceeded available supply. Peak demand, supply and shortfall at peak for the MSEDCL distribution from 1998-99 till 2011-12is plotted below. As can be seen, the demand supply gap has widened over the years. The average electricity deficit from 1998-99 to 2011-12 is 30% with the peak electricity deficit being 33% in 2011-12. Considering the severe power shortage in Maharashtra, growing demand and heavy distribution losses, huge investments in power sector are not sufficient to fulfil the energy gap.

Limited availability of finance and other legal and administrative barriers have constrained the construction of new power plant capacity in the country. As a result, under BAU scenario, India continues to face an electricity deficit beyond the end of the Twelfth Five Year Plan[245]. Moreover, resources such as land, water and fuel are limited. This has also posed a challenge to the construction of new power plants. Shortage of fuel (coal) has led to importing fuel at higher prices which has affected tariffs for consumers. Energy conservation and efficiency measures have the advantage to meet demand with the help of existing capacity at costs lower than that required for construction of power plants. It would also provide relief to the pressure on existing resources due to construction of new power plants.

Addition of new power plants is getting delayed due to land acquisition and environmental issues. There are widespread protests for constructing major power projects from thermal to nuclear. In Raigad (Konkan) - famous for *alphonso* mangoes, farmers are protesting against the 1200 MW thermal power project, which they say will damage their crops. Jaitapur nuclear project (9900 MW) in Konkan is also facing strong opposition from the locals, in spite of land being forcefully acquired by Government of Maharashtra under the emergency clause. Maharashtra is not the only state to face protests from the local population. Several proposed power projects across the country are in a similar crisis - the proposed 6000 MW Jasapara nuclear project in Bhavnagar and the Somepeta coal power plant site in Andhra Pradesh are also facing protests from the locals. Considering the overall hue and cry of populace protesting against major power projects, it is time to rethink our ways to deal with the looming power crisis because projects being planned may never be built. People will continue to oppose these projects, as they know their poverty will only be replaced by destitution, if and when these projects are built[246]. So even if the projects are built by force, by the time they are commissioned, electricity demand would have outpaced supply.

Electricity sector is dominated by coal fired power plants. Combustion of fossil fuels, especially coal to generate electricity is responsible for more greenhouse gas emissions than industry and transport combined. Unless the mix of fuels changes dramatically, greenhouse gas emissions will rise to unacceptable levels. Business as Usual projections will increase by two thirds over the same period, making power generation the fastest growing cause of climate change.

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[245] Lawrence Berkeley National Laboratory, International Energy Studies Group, "Eliminating Electricity Deficit through Energy Efficiency in India: An Evaluation of Aggregate Economic and Carbon Benefits", Jayant Sathaye and Arjun Gupta, April 2010

[246] Down To Earth, "See the Light", Sunita Narain, August 15, 2012 http://downtoearth.org.in/node/1631

Taking into consideration the problems discussed, indicates that a sustainable solution for meeting the increasing needs of electricity is imperative. It is not possible to keep on increasing production of electricity with potential increase in the severity of the problems. No matter which method is used there are limits set by technology, economics and resources. One apparent and obvious solution is to use electricity more efficiently. The initiative has already been taken by encouraging conservation and demand side management measures. Energy efficiency of appliances has vastly improved – with the same amount of electricity the output is much larger.

Energy conservation through efficient use of energy is the most economical and least cost option which contributes to sustainable development. It is a realistic choice to elevate pressures of energy shortage. Many opportunities exist to encourage the energy conservation and efficiency across various sectors. It is a realistic choice to alleviate the pressures of energy shortage. Energy efficiency and conservation measures can reduce peak and average demand. Energy conservation potential and possible energy savings for various economic sectors is tabulated below. The maximum potential is in the industrial, commercial and agricultural sectors[247].

Table 64 – Potential for Energy Conservation

Sector	Conservation Potential	Possible annual savings (mkWh)
Agriculture	Up to 30%	2619
Industrial	Up to 25%	4359
Domestic	Up to 20%	2380
Commercial	Up to 30%	1318

Globally, the anticipated growth in energy demand is on an unsustainable course, and energy efficiency and conservation will play a key role in slowing that growth[248]. Without focused efforts to reduce the energy consumption by appliances and equipment, residential and commercial building electricity demand will continue to grow rapidly, taxing energy supply and delivery systems, restraining economic growth, and resulting in significant global and local environmental damage[249]. The need of the hour is to develop more efficient systems and low energy technologies in high energy intensive industries and reduce consumption of energy intensive products. One unit saved avoids 2.5 to 3 times of fresh capacity addition[250].

> Energy conservation is any behavior that results in the use of less energy. Energy efficiency is the use of technology that requires less energy to perform the same function.

[247] http://power.indiabizclub.com/info/energy_conservation
[248] e-Journal USA Volume 14/Number 4, U.S. Department of State – "Energy Efficiency: The First Fuel", April 2009
[249] United Nations, Energy Case Studies, Market transformation through energy efficiency standards and labeling
[250] Infra line Energy, "Energy Efficiency: Prospects & Issues" sub ref: Asian Development Bank

Energy Conservation Initiatives

Bureau of Energy Efficiency (BEE)

BEE was set up in 2002 under the Energy Conservation Act, 2001, which aims at an integrated approach to energy conservation. BEE has wide ranging powers to promote the conservation of all forms of energy[251]. Prior to the Energy Conservation Act, 2001, the Government of India launched a voluntary appliance labeling scheme known as Eco-Mark in 1991. The aim was to increase consumers' awareness about environmentally friendly products in the market. However, the scheme did not succeed in attracting participation from most manufacturers. Two major reasons cited for the failure of manufacturers to participate were the cost of participation and lack of consumers' awareness. This scheme was re-launched a decade later as the Standards and Labeling Program to be monitored under the BEE[252]. The BEE launched Energy Conservation Building Code (ECBC) in 2007. According to BEE statistics, in 2008-09, energy savings generated through measures such as the standards and labeling scheme and green buildings resulted in 1505MW of avoided generation capacity up from 623MW in 2007-08. The target is to achieve 10,000MW in avoided capacity by 2012[253]. Various schemes launched by BEE are as follows

- Standards & Labeling Scheme in 2006 - BEE established a standard and labeling program for eleven household electronic appliances (refrigerators - Frost Free/No-Frost, Tubular Fluorescent Lamps, Room Air Conditioners, Direct Cool Refrigerator, Distribution Transformer, Induction Motors, Pump Sets, Ceiling Fans, LPG, Electric Geysers and Color TV) and is moving to gradually make them mandatory which would then become the de facto minimum efficiency performance standard (MEPS)[254].
- Energy Conservation Building Code (ECBC) was launched in 2007. The purpose of ECBC is to provide minimum requirements for energy efficient design and construction of buildings and their systems. It is applicable to buildings or building complexes that have a connected load of 500kW or greater or contract demand of 600 kVA or greater. Generally buildings or complexes having an area of more than 1000m^2 will fall under this category. The Code defines norms and standards for the energy performance of buildings and their components based on the climate zone in which they are located. It covers building envelope, heating, ventilation and air conditioning system, interior and exterior lighting system, service hot water, electrical power systems and motors. BEE has joined forces with the International Finance Corporation and Alliance to Save Energy, in a large-scale effort to improve the energy efficiency of municipal buildings.

[251] India Resident Mission (INRM) Policy Brief No. 6, "Energy Efficiency and Conservation", 2006
[252] Resources for the Future, Discussion Paper, "Options for Energy Efficiency in India and Barriers to their adoption: A Scoping Study", Soma Bhattacharya and Maureen L. Cropper, April 2010, pp21
[253] Power Line, Volume 14-No.3, "Road to Copenhagen", November 2009; pp. 24
[254] Prayas Energy Group, "Factsheet - Scaling-Up DSM to the National Level"

The Indian government introduced an Energy Conservation Code for commercial buildings in 2007 aimed at cutting their energy consumption by 25 to 40%[255].

- Star rating for office buildings: BEE launched the star rating for office buildings on February 25, 2009. The star rating program is based on the actual energy performance of a building, in terms of its specific energy usage.
- Bachat Lamp Yojana (BLY), launched on February 25, 2009- BLY was launched with an objective of replacing the incandescent lamps and cutting down the price of CFLs. Due to the high price of CFLs, which is 8-10 times the cost of incandescent lamps, CFLs haven't yet penetrated widely in households across the country. The share of incandescent lamp lighting in both residential and commercial sector is 80%[256]. BLY is also registered under the Clean Development Mechanism of the Kyoto Protocol part of the United Nations Framework Convention on Climate Change (UNFCC) on April 29, 2010. State level electricity distribution companies that join the program would distribute high quality CFLs at about `15 per piece to their consumers and in return take back a working incandescent lamp.
- Agricultural and Municipal DSM – Effective implementation of EC Act by Strengthening Institutional Capacity of State Designated Agencies (SDAs)
- Energy Efficiency in Small and Medium Enterprises (SMEs) Scheme
- Contribution to State Energy Conservation Fund (CECF) Scheme
- Institutional Strengthening of BEE

The benefits of electricity efficiency have been recognized in the 10th and 11th Plans as they both emphasize its importance and outline measures for its implementation. Schemes for promoting energy efficiency in India during the 11th Plan include the Bachat Lamp Yojana (promoting the uptake of CFLs), Standards and Labeling Scheme (covering all basic household appliances as well as motors, variable speed drives and agricultural pump sets), ECBC (for new commercial construction), Agricultural and Municipal DSM Schemes, and others.

National Mission on Enhanced Energy Efficiency

The National Mission on Enhanced Energy Efficiency (NMEE) has been approved as one of the eight missions under the National Action Plan on Climate Change (NAPCC). NMEE aims at rationalizing energy consumption without any adverse impact on economic productivity. The industrial segment which is the largest energy consumer gets a particular focus. BEE is responsible for planning and execution of this mission. In this regard it has already initiated the capacity building exercise required such as building a database of energy consuming industries in the economy[257].

[255] McKinsey Global Institute, "Fueling sustainable development: The energy productivity solution", October 2008
[256] http://moef.nic.in/downloads/public-information/bachat-lamp-yojana.pdf
[257] Power in India, Recent Developments, 2009, pp28

- Performance and achieve trade scheme (PAT) – Market based mechanism to enhance energy efficiency
- Market Transformation for Energy Efficiency (MTEE) – which would cover clean development mechanism roadmap, standards and labeling, energy service company (ESCO) promotion and capacity building
- Financing energy efficiency – tax exemptions, a revolving fund, and partial risk guarantee fund
- Power Sector Technology Strategy – which covers fuel-shifting, focus on new as well as old plants, integrated gasification combined cycle (IGCC) demonstration plants, and development of know-how for advanced super-critical boilers

The Government envisages improvement of energy efficiency of designated consumers under the NMEE. Nine notified energy intensive sectors are being covered in the 1st phase. These sectors include thermal power plants, cement, aluminum, iron & steel, pulp & paper, fertilizer, textile, chlor-alkali and railways. The sector wise energy efficiency targets and the unit-wise specific energy consumption (SEC) production targets for the nine notified energy intensive sectors are proposed to be established in 2011. The implementation period to achieve the specified targets by these designated consumers proposed is three years from the date the norms are established. The monitoring mechanism for designated consumers is also proposed to be ready by 2011. The Government envisages a saving of around 10 million tons of oil equivalent in the energy consumption of the designated consumers from the 9 energy intensive sectors and an avoided capacity addition of 5623MW[258].

Even though the Government has ongoing efforts such as standards and labels, and utility DSM programs, the changes in behavior are not rapid enough to ensure maximum efficiency gains. Because rapid implementation of these energy efficiency options will not only have financial and environmental benefits, but will also deliver results much faster than building GW power plants, it will reduce power shortages and achieve significant public benefits[259].

Maharashtra Energy Development Agency

Government of Maharashtra has designated the Maharashtra Energy Development Agency (MEDA) as the nodal agency for energy conservation with responsibility to coordinate, regulate and enforce the provisions of the EC Act in Maharashtra. In 2003, MEDA established a separate department for Energy Conservation. An action plan was drafted with the aim of peak demand saving of 1000 MW energy by 2012.

To provide guidance to MEDA on Energy Conservation Policy matter, Government of Maharashtra has constituted State Level Energy Conservation Committee under chairmanship

[258] Government of India, Ministry of Power, Rajya Sabha Question No 432 Answered on 26.04.2010 National Mission for Enhanced Energy Efficiency
[259] Prayas Energy Group, "Factsheet - Energy Saving Potential of Indian Household Appliance"

of Principal Secretary (Energy) in 2005. MEDA has developed 11 energy conservation programs to be implemented in cooperation with relevant state government agencies and private sector.

1. Home Bright: Residential high efficiency lighting program (Replacement of Incandescent Lamp by Compact Fluorescent Lamp (CFL))
2. Agricultural Efficiency: Energy efficiency improvement in agriculture (installation of Capacitors)
3. Bright Streets: Municipal Street Lighting Program using advanced technology
4. Municipal Energy Efficiency program: Improvement of energy efficiency in municipal pumping and street lighting
5. SME Program: Energy efficiency improvement in small and medium enterprises
6. Public Buildings Partnership Program: Energy efficiency implementation in public buildings using ESCOs as the implementing mechanism
7. Green Buildings Program: Cooperate with existing Green Buildings Center; construct one or two new Green Buildings in Maharashtra
8. Solar Water Heating: Solar Water Heating Program
9. Work Bright Program: Commercial High-Efficiency Lighting Program
10. Motor RE-Power: High Efficiency Motor Rewinding Program
11. EE Financing: Financing of energy efficiency improvement using the Energy Conservation Fund.
12. Awareness program: Awareness on Energy Conservation and Electrical Safety

MEDA also provides financial assistance to eligible organization for carrying out energy audits at their facilities through empanelled consultants. This promotional activity initiated by MEDA covered industries, commercial buildings and government/ government undertakings/ local self-government buildings/ MIDC. The details are tabulated in *Annexure VIII*[260]. MEDA also receives central and state grants for various conservation programs which are provided in *Annexure VIII*.

Several schemes have been introduced by the central and state governments for conserving electricity improving energy efficiency. It is necessary to undertake evaluation of the schemes that have been implemented till date. This would provide a better understanding of the energy saved due to energy conservation and efficiency measures taken by the government and would further help in forecasting new power addition requirements. It would be necessary to find out that of the various schemes launched how many of them have reached the end user? Has labeling promoted the purchase of more efficient appliances? How have the old appliances (non – starred) been phased out, or are they available for sale?

[260] Save Energy Program (Financial assistance for carrying out energy audit) [Valid from 1sstt July 08 to 31sstt March 10]

Energy Savings across Sectors

Total electricity consumption in Maharashtra during 2010-11 was 87,397 mkWh. Electricity consumption for various sectors for the years from 2004-05 to 2011-12 is tabulated below. As can be seen for the years tabulated below, industry is the largest consumer of electricity with an average consumption of 40% followed by domestic (22.81% average consumption) and agriculture (18.38% of average consumption). These three sectors account for 80% of the total electricity consumption in the state.

Table 65 - Electricity Consumption across sectors (mkWh)[261]

Category	04-05	05-06	06-07	07-08	08-09	09-10	10-11	11-12*
Industry	22515	25692	26535	30323	28850	30866	34416	26687
% consumption	40.43	43.33	42.74	43.42	39.52	39.00	39.38	37.13
Domestic	12916	13572	14284	15553	16878	18171	19547	16484
% consumption	23.20	22.89	23.01	22.27	23.12	22.96	22.37	22.94
Agriculture	10733	11094	9749	12676	12733	13925	16257	15515
% consumption	19.27	18.71	15.70	18.15	17.44	17.60	18.60	21.59
Commercial	5420	4841	6940	6661	9102	10546	11571	9047
% consumption	9.73	8.17	11.18	9.54	12.47	13.33	13.24	12.59
Administrative Purposes								
Public Works	2174	2148	2272	2520	2560	2658	2310	2260
Railways	1850	1861	1987	2024	2110	2119	2707	1657
Miscellaneous	76	79	318	82	761	854	589	217
TOTAL	55684	59287	62085	69838	72994	79139	87397	71867
% change		**6.5**	**4.7**	**12.5**	**4.5**	**8.4**	**10.4**	

* Upto December 2012

Energy Savings in the Domestic sector

Domestic electricity use accounts for a major impact on electricity demand because of complex attitudes towards use of electricity. New appliances are being added in the market, but their efficiency is not checked at the consumer end, due to lack of awareness and apathy towards energy savings.

The average growth in power consumption in domestic sector from 2004-05 to 2010-11 is 7%.

[261] Government of Maharashtra, Department of Planning, Directorate of Economics and Statistics: Economic Survey of Maharashtra 2005-06 to 2011-12

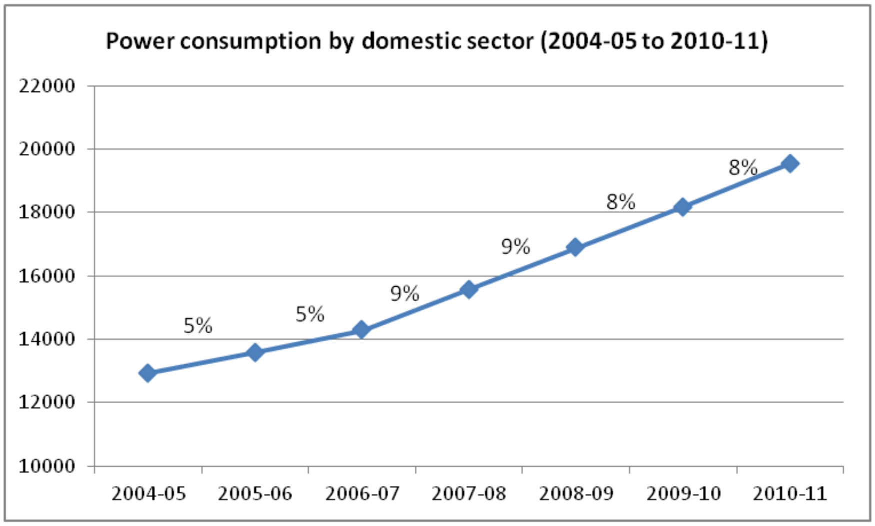

Figure 61 - Power consumption in domestic sector

Energy consumption by various household appliances is given below. It can be seen from the figure that lighting requirements consume maximum (20%) electricity followed by refrigeration followed by air conditioners. Major part of the consumption comes from fans, lighting, refrigerators, and televisions (active mode). A part of the consumption is contributed by ACs, air coolers, electric water heater, and stand-by power (including Set-Top-Boxes, DVD Players, TVs, and Computers). These nine appliances account for almost all the total consumption. The figure below graphically represents the consumption of nine household appliances. Out of these, only four end uses *viz.* lighting (incandescent bulbs and tube lights), fans, refrigerators and television sets contribute 80% of household consumption.

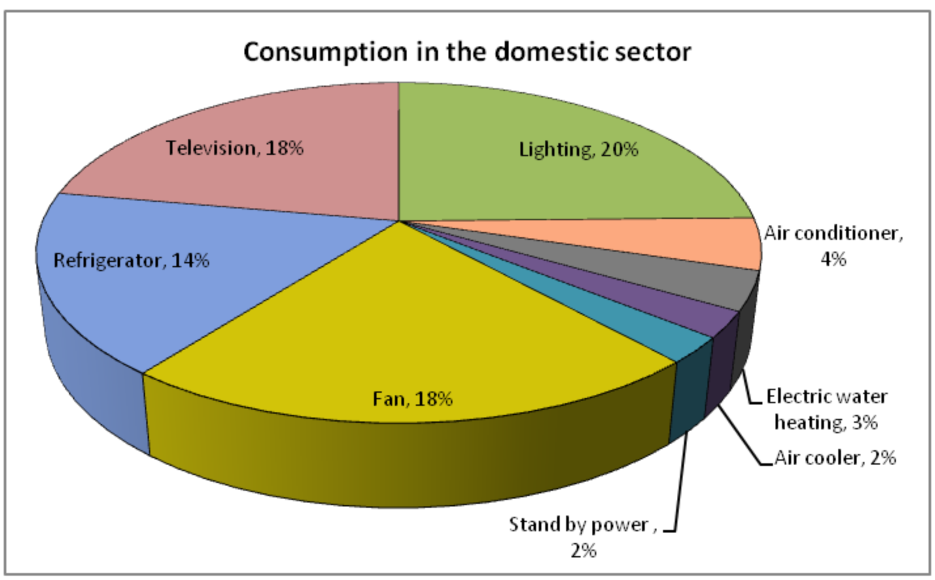

Figure 62 – Consumption of electricity in domestic sectors

With living standards rising, it is inevitable that the number of appliances in the market will inevitably and continuously increasing. Consequently introducing energy efficient appliances in the household sector is an important alternative to decrease the need for increasing generation capacity. This will make the society less dependent on fossil fuels and would also have an impact in reducing emissions of carbon dioxide into the atmosphere[262].

The focus of energy conservation is on five end uses *viz.* a) lighting, b) cooling, c) televisions, d) refrigeration and e) water heating. Energy conservation has been calculated for each of these end uses by replacement of conventional appliances with energy efficient ones (Table placed in *Annexure IX*).

The parameters considered for calculation are

- Power consumption
- Hours of Operation - daily, monthly and yearly
- Number of appliances per consumer
- Number of consumers

If new sales are restricted to energy efficient appliances for use in households, around 25% energy could be saved. The potential for energy conservation in the domestic sector is 20% that results in avoided capacity of 570 MW[263]. The energy that would be saved by transition to energy efficient appliances is tabulated below[264].

Table 66 – Energy savings from energy efficient household appliances

Appliance	Standard (W)	Energy Efficient (W)	Saved Watts (W)	Savings (%)
Tube light	36	28	8	22.2
Incandescent Lamp	60#	20#	40	66.7
Fan	70	55	15	21.4
Air Conditioner	2300	1900	400	17.4
Refrigerator	130-140	90-100*	45	36.0
Television	90	50	40	44.4
Geyser(boiler)	2500	0**	2500	100.0
Total saved watts			**3033**	

60W bulb is in use at large while 40W bulb is used on few instances. 20W CFL would replace the standard 60W bulbs.
* Operating wattage of the refrigerator.
** 100% savings as electric water heaters and geysers would be replaced with solar heaters.

[262] Resources for the Future, Discussion Paper, "Options for Energy Efficiency in India and Barriers to their adoption: A Scoping Study", Soma Bhattacharya and Maureen L. Cropper, April 2010
[263] Calculations based on energy consumption across urban and rural consumers in Maharashtra
[264] Energy efficient appliances calculations based on research from documents of BEE and Energy Saving Potential in Indian Household from Improved Appliances**,** Prayas Energy Group

Lighting needs

Lighting constitutes a major category of household energy use accounting for 20% of the energy consumption. Compact Fluorescent Lamps (CFLs) and energy efficient tube lights are an efficient alternative to traditional incandescent bulbs for provision of high quality lighting services. As can be seen from the table above, a transition from incandescent bulbs to CFLs will result in two thirds of (66%) energy savings. A 20W CFL can replace 60W incandescent bulb, still giving same amount of illumination. CFLs are more expensive than traditional bulbs, but the payback period is estimated to be 1.2 years, which is cost effective given the longer life of these lamps. The low acceptability of CFLs appears to be due to its high price and lack of warranty[265]. Use of efficient lighting can result in saving nearly 80-90% of energy savings.

Tube light

The energy efficient tube light that saves 8W, can give relief around of 390 MW in the evening peak.

Incandescent Lamp

Incandescent lamps are used as main lighting source in many rural households and as a secondary source in urban areas. In urban households, incandescent lamps are mostly used in toilets, bathrooms, passageways, backyard, etc. Replacement of all lamps by CFLs can provide relief of 1460 MW from the evening peak.

> Energy savings in household lighting - 1850 MW of relief in evening peak hours can be achieved, by switching over to energy efficient lighting in both urban and rural areas of Maharashtra.

Cooling needs

Fan

15W can be saved per fan if the existing fans are replaced by efficient fans with the following improvements[266]:

- Increase the height of the stator and rotor stack.
- Using thicker wires (more copper)
- Using smaller capacitor which will decrease the top speed of the fan

380 MW of reduction in summer peak can be achieved by using energy efficient fans.

[265] Resources for the Future, Discussion Paper, “Options for Energy Efficiency in India and Barriers to their adoption: A Scoping Study”, Soma Bhattacharya and Maureen L. Cropper, April 2010
[266] Prayas energy Group, “Fact sheet on ceiling fans”

Air conditioner

5% consumers can provide a relief of 160 MW in summer peak, by switching over to BEE star labeled air conditioners.

Energy savings in cooling (fan + Air conditioner) - Around 540 MW of relief can be obtained in the summer peaks.

Refrigeration

More efficient direct-cool refrigerators have a payback period of less than 3 years; more efficient frost-free refrigerators have a payback period less than 2 years. The more efficient direct cool refrigerators result in energy savings of 49%.

Though the energy labeling programs and star ratings have been introduced by BEE, there is lack of awareness among the consumers and the implementation process is slow. It is necessary to phase out inefficient cheap appliances from the market.

Energy savings in refrigeration - Around 114 MW round the clock relief can be achieved (Considering one refrigerator per two households).

Television

Televisions constitute 18% energy consumption in households. Nearly 44% energy can be saved by switching over to energy efficient televisions.

Energy savings in television - 366 MW of relief can be achieved by moving to energy efficient televisions.

Water heating

The energy efficient solution in this regard is to replace conventional electric water heaters and geysers in a phased manner and make way for solar water heating. Many consumers have already switched over to solar water heating due to rising cost of electricity. Replacement to solar water heaters needs to pick up rapid pace.

Energy savings in water heating - Considering 10% consumers in Maharashtra use geyser for water heating, replacement to solar water heater can provide a relief of 2000 MW in morning peaks.

Urban and Rural Domestic Electricity Savings and Peak Demand Relief

There is a remarkable difference in the energy requirement of urban and rural domestic consumers. With increasing urbanization, standard of living of population in urban centres, energy requirements in urban areas is higher than that in rural areas, and also not all households in rural areas are electrified whereas almost all the households in urban centres are electrified. Energy savings in both urban and rural areas is tabulated below based on the above criteria, by considering around 56% of the 143 lakh MSEDCL domestic consumers as urban and 44% as rural[267].

Table 67 - Domestic consumers of MSEDCL

	Urban	Rural
MSEDCL consumers	8000000	6300000

Table 68- Urban electricity savings

Appliance	Total Units saved/year (MU)	Peak Demand Relief (MW)		
		Summer	Morning	Evening
Tube light	561			256
Incandescent Lamp	350			960
Fan	788	240		
Air Conditioner	117	160		
Television	526	240 (afternoon & evening		
Refrigerator	1000		114 (RTC)	
Geyser (boiler)	365		2000	
Total	**3707**			

Table 69 - Rural electricity savings

Appliance	Total Units saved/year (MU)	Peak Demand Relief (MW)		
		Summer	Morning	Evening
Tube light	241			132
Incandescent Lamp	920			504
Fan	466	142		
Television	276	126 (afternoon & evening)		
Total	**1903**			

267 Government of India, Ministry of Home Affairs, Census of India, 2011

A significant impact of energy efficient appliances can be seen in the peak load relief that would be obtained daily.

Energy savings potential in domestic energy savings in urban and rural areas

In both rural and urban areas of Maharashtra, demand relief of around 2500 MW would be achieved in summer, while in monsoon and beginning of winter as demand is less, a relief of 1500 MW would be achieved. Energy saving lighting appliances have a potential of saving more than 2500 MW in the evening.

Energy Savings in the Industrial sector

There are 32,178 units under MIDC area having investment of around Rs.37025 crore employing almost 820,723 people. Small and medium enterprises (SME) form a vital part of the industrial sector and represent nearly 40% of the country's GDP[268]. Power consumption by industries has increased on an average by 8% from 2004-05 to 2010-11. The graph below shows power consumption of industries over the years from 2004-05 to 2010-11.

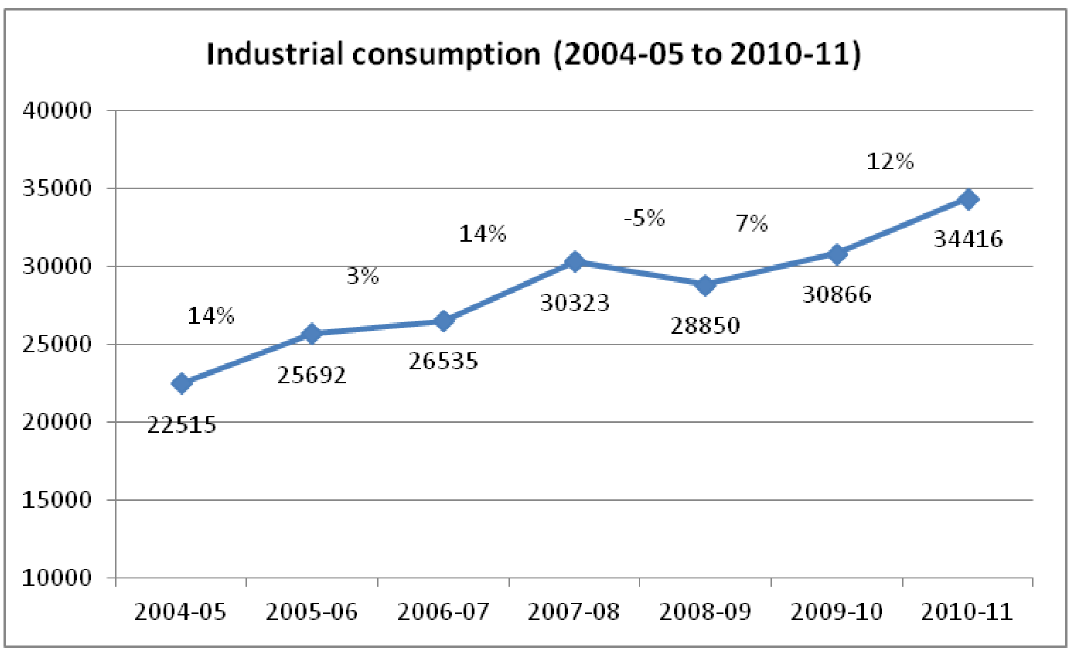

Figure 63 - Industrial electricity consumption (2004-05 to 2010-11)

[268] http://www.mahaurja.com/PDF/SMEProgram.pdf

The industrial sector is the largest consumer of energy, consuming 40% of the energy generated. It can be seen that energy consumption has decreased by 5% in the year 2008-09, which can be attributed to various factors like economic recession and also a shift to captive power plants due to power shortages and higher tariffs. Power shortages impact industries not only by way of loss of production and earning, but also in terms of huge investments made by users on standby systems.

The cost of energy constitutes a significant proportion of the production costs in several industries such as fertilizer, chlor-alkali, steel, aluminum, etc. As a result, managing energy costs becomes important for these industries to not only reduce energy expenditures but to also improve their overall productivity and competitiveness. Table below shows the energy costs as a proportion of the total production costs across key industries[269].

Table 70– Share of electricity in the total production cost

Industry	Share of energy in total production costs (%)
Aluminum	30 (rolled products), 40 (metal)
Cement	29-61
Chemicals	5-15
Chlor alkali	50-65
Fertilizer	65-87
Integrated steel	30-35
Paper and pulp	20-22

The chlor-alkali industry is the most energy intensive industries – it manufactures caustic soda for almost every other industry as a strong chemical base. This industry utilizes mercury in large amounts, although it has been prohibited from 1991 for use in industries by CPCB. The high energy cost (between 65 and 87%) of fertilizer industry is because the industry uses gas/naptha/furnace oil/low sulphur heavy stock not only as an energy source but also as process input.

Steel, cement and aluminum industries are required to maintain a continuous manufacturing process, so power is one of the most critical inputs for these industries. Any power interruption leads to loss of production, additional fuel consumption and wastage of energy. As can be seen from the table above, energy costs represents more the 10% of the production costs, these enterprises should consider conservation efforts. Most of the industries had also opted for captive power generation due to power shortages and power quality problems such as voltage fluctuations, frequency variation, generation spikes, surges and sags, etc. The quality of grid supply is a major cause of concern for most of the industrial consumers as power quality problems result in damage to equipment besides leading to downtime and production losses.

[269] Captive Power in India, India Infrastructure Research, “Captive Economics”, pp. 76-77

These result in significant problems not only in manufacturing industries but also in office buildings, malls, hospitals, hotels, etc. that rely on grid power[270]. The installed capacity of captive power plants in the state was 1273.209 in the 2005-06 which grew to 2926MW up to March 2010. Economic output is influenced by the size of the electricity savings and rate of penetration of energy efficient technologies, and that of self-generation equipment and inverters used by businesses faced with electricity cuts[271].

There are thousands of industrial processes, each depending upon a different amount and mix of energy for a variety of services (e.g., motor drive, process heat, steam and electricity generation, electrolysis, and product feed stocks). Moreover, industries vary greatly in their overall level of energy use, because of differences in industry scale and energy intensity. Unlike the domestic sector where replacement with energy efficient appliances saves energy, the industrial sector will have to undertake varied measures to tap the energy saving potential. The industrial sector nevertheless has a huge energy saving potential. It is possible to conserve energy through use of energy conservation measures, which include energy savings potential for motors, lighting, heating and ventilation systems, and industrial processing. Energy saved would result in economic benefits through reduced power consumption from the grid and the saved power can be used effectively in areas facing power shortages. Moreover this would also increase the revenue of the utilities as power would be wheeled to other companies. Industries in spite of knowing the benefits of energy efficiency consider it as a burden[272].

Table 71- Energy savings potential of SME clusters in Maharashtra[273]

Cluster Location	Cluster type	Total Units listed (nos.)	Estimated Total Energy Consumption	% Savings potential assessed	Annual energy saving Potential assessed
Bhandara	Rice Mills	160	16.52 MU	10	1.65 MU
Jalgaon	Dall Mills	160	23. 49 M U	10	2.35 M U
Pune / Kolhapur	Dairy Units	102	12460 TOE/ 42 MU	10	1250 TOE/ 4.2 MU
Ichalkaranji	Textile Units - Sizing & Processing	183	113760 TOE / 39.12MU	10	11400 TOE/ 4 MU
	Power Looms	~ 1.5 lakh	690 MU	5	34.5 MU
Total				**46.7 MU/12650 TOE**	

270 Captive Power in India, India Infrastructure Research, "Captive Economics", pp. 76-77
271 Lawrence Berkeley National Laboratory, International Energy Studies Group, "Eliminating Electricity Deficit through Energy Efficiency in India: An Evaluation of Aggregate Economic and Carbon Benefits", Jayant Sathaye and Arjun Gupta, April 2010
272 Mahratta Chamber of Commerce Industries and Agriculture, Energy Audit
273 Government of India, Ministry of Power, Bureau of Energy Efficiency, State-wise Electricity Consumption & Conservation Potential in India (prepared by National Productivity Council)

BEE has set targets for 478 commercial business units (including Reliance industries, Vedanta group, NTPC, Hindalco) that account for 1/3rd of 500 million tonnes of oil equivalent (MTOE) of energy consumption in the commercial sector. These units from eight sectors (iron and steel, chlor-alkali, cement, fertilizers, aluminium, pulp and paper, textile, TPS) consumed 166 MTOE of energy in 2009-10. The limit for electricity consumption is set for electricity consumed per unit of the product[274].

Table 72 - Energy savings potential in energy intensive Industries[275]

Industry	Conservation potential (%)
Pulp and Paper	25
Textiles	20-25
Sugar	20
Glass/ ceramics/ Ferrous foundry	15-20
Fertilizer	10-15
Petrochemicals	10-15
Cement	10-15
Iron and steel	8-10
Aluminum	8-10
Refineries	8-10
Chlor alkali	10-15
Ferro alloys	8-10

Initiatives by MEDA

MEDA has provided the following measures to conserve energy in industries[276]:

1. Conduct regular energy audits.
2. Plug all oil leakages.
3. Avoid incomplete combustion of fuel.
4. Keep insulation on the furnace walls to save heat, use optimum thickness insulation. 65 mm thick insulation on a 115 mm thick furnace wall can reduce the heat loss by 66%. (2650 Kcal/m^2 down to 850 Kcal/m^2)
5. For boilers,

Always check the soot deposits – a meager '3 mm' layer of soot on the heat transfer surface consumes 2.5% extra fuel.
Stop steam leakage – a single instance of a '3 mm' hole on a steam pipe carrying steam at rate of 7 kg/cm^2 would waste 32 kilolitre of fuel every year.

274 http://www.business-standard.com/india/news/govt-issues-mandatory-energy-norms-for-firms/469691/
275 Infra line Energy, "Energy Efficiency: Prospects & Issues", sub ref: ADB and MEDA http://www.mahaurja.com/PDF/POTEcon.pdf
276 http://www.mahaurja.com/PDF/TipIS.pdf

6. Refrigeration and Air conditioning - Utilize waste heat of excess steam or flue gases.
7. Proper selection of pump according to pumping requirement, and proper insulation, alignment, installation of pump is also important.
8. Cooling towers in thermal power plants - Installation of automatic on-off switches for cooling tower fans can save 40 % on electricity use.

Energy audits in industries

Periodic energy audits are mandatory for power intensive industries, under the Energy Conservation Act, 2001. MEDA has empanelled a group of energy consultants and auditors and has assisted industries and businesses in identifying energy efficiency opportunities by subsidizing energy audits. Till 2009, 475 energy audits have been conducted.

Table 73- Achievements of the Energy Conservation Program[277]

Particulars	Cumulative achievement (up to March 31, 2008)	Achievement (in 2008 -09)	Cumulative achievement (up to March 31, 2009)
Energy Audit (Nos)	445	30	475
Replacement of CFL at Gram Panchayat	2505	6008	8510
Waste Heat Recovery	0	6	6

Measures to be adopted for energy savings in few energy intensive industries

Cement industry[278]

- Comprehensive energy audits
- Waste heat recovery
- Use of Vertical Roller Mill (VRM) in the place of conventional ball mill.
- External re circulation systems for VRM
- Installation of pre-calcinators
- Use of Variable Frequency Drive (VFD) and Variable Speed Drive (VSD)
- Computerized maintenance system and Inventory Control

Fertilizers industry[279]

- Replace process equipment with high efficiency models
- Improve process controls to optimize chemical reactions
- Recover 'process' heat
- Maximize waste heat recovery

277 http://www.mahaurja.com/PDF/CummAchv.pdf
278 http://www.industry.siemens.com/datapool/industry/industrysolutions/cement/en/Cement-production-en.pdf
279 http://www.sswm.info/sites/default/files/reference_attachments/GELLINGS%20et%20al%202004%20Energy%20Efficiency%20in%20Fertiliser%20Production.pdf

Paper industry[280]

- Type of raw material used
- Size and vintage of the plant
- Variety mix
- Comprehensive energy audits
- Waste heat recovery
- Installation of pre-calcinators
- External re circulation systems for VRM
- Use of Variable Frequency Drive (VFD) and Variable Speed Drive (VSD)
- Use of Vertical Roller Mill (VRM) in the place of conventional ball mill.
- Computerized maintenance system and Inventory Control

1kWh saved at user end for normal industrial use is

- Saving of Rs. 30,000/- per year @ `5.5 per kWh and 5500 hours per year use saving 4500 kg of coal per year at power use
- 5T CO_2 emissions released to atmosphere per year

Energy savings potential in industries

The industrial sector overall has energy saving potential of 25% which means avoided capacity of 970MW[281].

Energy savings in Agricultural sector

Agricultural pumping consumes a fifth of electricity use in India. Political decisions made in individual states in the 1970s to provide subsidized electricity, and in the 1980s and 1990s to provide virtually free electricity for irrigation have had long-term negative impacts on the electricity sector as a whole. Since meters were removed during this period, agricultural rates in India for majority of agricultural consumers are based on the pump size, not metered consumption. This has created several inefficiencies in the entire system – pumps are inefficient, price signals for crop selection are limited, water tables are falling rapidly, and poor farmers who do not have access to irrigation face water scarcity. The effective subsidy, though

280 http://ies.lbl.gov/iespubs/41843.pdf
281 Calculated based on industrial consumption

partially compensated by the government, contributes to the financial plight of the electricity companies[282].

In Maharashtra too, the state utility (MSEB, now unbundled) suffered the same plight. Around 1977-78, MSEB started charging its consumers on a flat rate fixed on the basis of the pump capacity (horsepower) rather than actual metered consumption. During the time, number of agricultural consumers and the volume of electricity used by them were quite small. So the decision to stop metering their electricity consumption did not prove disastrous. The subsequent years saw a rapid increase in the number of agricultural pumps and also in their electricity consumption, which still was not metered. In the same period, like other SEBs, MSEB too suffered from various distortions such as technical incompetence, financial mismanagement, administrative lethargy, political interference, electricity theft and increasing arrears[283]. Energy audit conducted by BEE at Solapur brought forward the fact that for most of the unmetered consumers connected HP is much more than the sanctioned HP. This contributes to commercial losses for MSEDCL.

There is a strong nexus between electricity, water and agriculture. Since agricultural sector is provided with electricity at far cheaper rates which leads to exploitation of ground water resources. This not only creates stress on the water table but also is highly energy intensive. Energy intensity of pumping is increasing further because of falling water table. Groundwater potential for irrigation pump sets is such that it can sustain 2.4 million pumps. But, in reality 150% of sustainable pumps have been energized, as a result they suck out 50% more groundwater. If energized pumps draw groundwater beyond safe limits, the very purpose of energizing pumps will get defeated as there will be no water to draw.

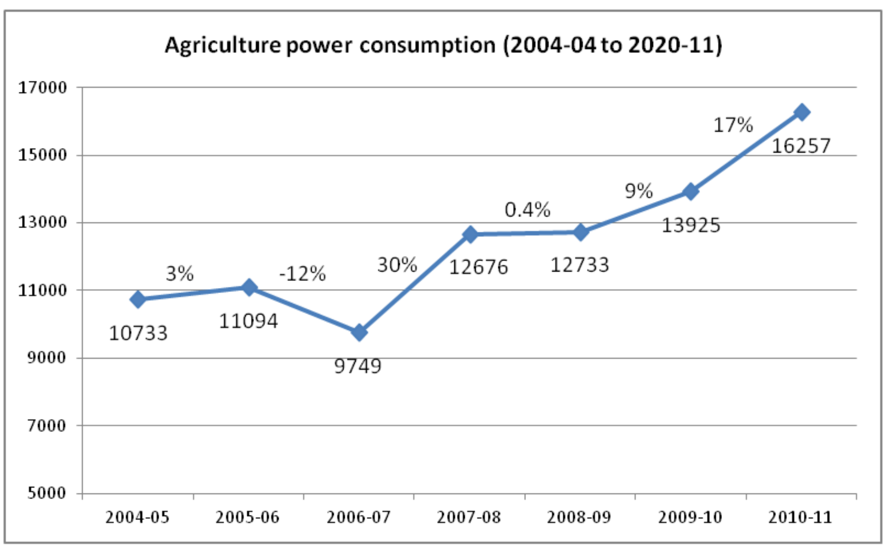

Figure 64- Consumption by agriculture sector (2004-05 to 2010-11)

[282] An Overview of Indian Energy Trends

[283] Prayas Energy Group, "Privatization or Democratization: The Key to the Crises in the Electricity Sector - *The Case of Maharashtra", 2001*

In the year 2010-11, the agricultural sector consumed about 17% of the total energy generated. Agricultural power consumption from 2004-05 to 2010-11 is depicted in the graph above.

A simple method to conserve energy in agriculture sector is using BEE star labeled pump sets.

- 5 HP pumps can be replaced by 3.7 HP pumps,
- 3 HP pumps by 2.2 Hp pumps.

These replacements can save 2800 MU of electricity, and give a load relief of around 580 MW from 2200 to 1400 hrs.; the hours for which energy for pumps is available according to Agricultural Load Management (Ag LM) scheme. Energy savings in the agriculture sector has been calculated by considering 3.6 million[284] energized pumps in Maharashtra. Around 16% electricity could be saved by shifting to energy efficient pumps.

Table 74- Average savings in Agriculture sector

Unit	Currently used pump rating	Energy efficient pump	Currently used pump rating	Energy efficient pump
HP	5	3.7[285]	3	2.2
kW	3.73	2.76	2.24	1.64
hrs./day	8[286]	8	8	8
hrs./yr	2000	2000	2000	2000
units/yr	7460	5520	4476	3282
saving	1940		1194	
No. of energized pumps	1800000		1800000	3600000[287]
Total energy savings (MU)	3490		2150	5640
Demand Relief (MW)				1175

Parameters affecting pump set efficiency performance:

- Improper pump selection and usage
- Undersized pipes
- Suction head Variations and large discharge lengths
- Inefficient foot valves and piping system
- Motor rewinding and low voltage profile
- Water table variations

[284] Government of Maharashtra, Department of Planning, Directorate of Economics and Statistics: Economic Survey of Maharashtra 2011-12, Ch.9 Infrastructure
[285] Prayas Energy Group, Agricultural Pumping Efficiency in India http://mahadiscom.com/emagazine/nov05/agri_pumping_eff_in_india.pdf
[286] As per the Ag-LM (Agricultural Load Management) scheme, only 8 hours of power is supplied to agricultural pumps, as pumps are not needed to be run for 24 hrs.
[287] Government of India, Ministry of Power, Central Electricity Authority, Progress Report, Pump set Energization

Analysis of the agricultural electricity supply system shows that a program replacing two components, undersized pipes and high friction foot valves, can save the utility company Rs.2.1/kWh due to reduction in fuel use and other short-run costs, even assuming a zero agricultural electricity tariff[288].

Initiatives by BEE

BEE has prepared an Agricultural DSM (Ag DSM) program in which pump set efficiency upgradation could be carried out by an Energy Service Company (ESCOs) or the distribution company. The Ag-DSM program for preparation of DPRs has already been initiated by BEE as pilot projects in 5 states *viz.* Maharashtra, Gujarat, Haryana, Punjab & Rajasthan. One DPR in Solapur district of Maharashtra is ready for implementation purpose. The result of the study is encouraging with the saving potential of 40% by replacement of inefficient pumps with Star rated pump sets. BEE is also developing a methodology for CDM in Ag-DSM project so that it becomes more attractive. The implementation for replacement of inefficient pumps with Star rated pump sets will be done through the ESCO/Utility who would invest in energy efficiency measures on a rural pump set feeder on which supply quality enhancements (such as feeder segregation & High Voltage Direct Supply [HVDS]) have already been carried out. The intervention would lead to lower energy supply on the feeder, and hence, could result in lower subsidy to be paid by the State Government. Part of the savings in the subsidy would be paid to the ESCO/Utility on an annual basis, over a period of time, to pay for their investment in pump set upgradation[289].

> Energy savings potential in agricultural sector
>
> Demand relief of around 1175 MW would be achieved.

Energy Savings in Buildings

Buildings account for over 40% of the world's energy use and the resulting carbon emissions are more than those in the transportation sector. Energy efficient buildings represent one of the primary opportunities to reduce electricity consumption and resulting carbon emissions and create new jobs[290]. The construction sector in India is witnessing a fast growth due to several factors. Some of the key growth drivers are, increased demand for housing, strong

[288] Implementing End-use Efficiency Improvements in India: Drawing from Experience in the US and Other Countries, Lawrence Berkeley National Laboratory, 2006
[289] http://www.bee-dsm.in/PoliciesRegulations_1_4.aspx#TOP
[290] Green buildings, climate change, energy security and the current economic crisis

demographic impetus, expansion of organized retail, increased demand for commercial office spaces by multinationals and IT sector and setting up of SEZs[291].

The building sector in India represents about 33% electricity consumption, with commercial and residential sector accounting for 8% and 25% respectively[292]. The commercial and residential sectors continue to be a major market for the construction industry. The sectors consume a lot of energy throughout the life cycle of buildings and thus becoming a major contributor to greenhouse gas emissions. The demand for air conditioning and other appliances in the residential and commercial sectors is likely to push electricity demand to high levels, straining the sector as a whole[293].

India's building and construction sector has seen unprecedented growth post liberalization. Commercial and residential building types constructed in western style with absolute disregard to context and climatic conditions led to a steady increase in building energy consumptions. The building trends ever since, have involved the use of high embodied energy materials such as aluminum and steel, extensive external glazing systems, leading to increased heat gains and consequently use of extensive refrigeration based space-conditioning systems, electrical appliances, etc. To cater to the increased demand for such equipment in the increasing urban settlements, more industries were set up to manufacture and provide such appliances, etc. Increasing travel times due to increased fringe development and satellite towns led to a sudden explosion in the transport sector as well, with unparalleled growth in the automobile sector and increased demand for petroleum and diesel. The current state of an overburdened energy infrastructure may be traced using the same route.

The first government initiative towards energy efficiency was when the Indian parliament passed the Energy Conservation Act, 2001 that led to the establishment of the Bureau of Energy Efficiency and kick started the formulation of the ECBC as India's first effort towards energy efficiency in buildings. ECBC aims to reduce India's baseline energy consumption by supporting adoption and implementation of building energy codes. It takes into account location and occupancy of the buildings and provides minimum standards for reducing energy demand of the buildings through design and construction practices while enhancing occupants' comfort.

ECBC has both prescriptive and performance-based compliance paths. The prescriptive path calls for adoption of minimum requirements for the building envelope and energy systems (lighting, HVAC, service water heating and electrical). The performance-based compliance path requires the application of Whole Building Simulation Approach to prove efficiency over base building as defined by the code.

[291] http://high-performancebuildings.org/pdf/HighPerformanceCommercial%20Buildings.pdf-High performance Buildings in India
[292] ECBC User Guide, pp1
[293] Prayas Energy Group, An Overview of Indian Energy Trends

For the purpose of ECBC, the definition of a building is as mentioned in the Energy Conservation Act, 2001*, i.e. any structure with a connected load of 500kW or contract demand of 600kVA and intended to be used for commercial purposes.* The code is also applicable to all buildings with a conditioned floor area of 1,000 m^2 (10,000 ft^2) or greater. The code is recommended for all other buildings.

Most commercial buildings have energy performance index (EPI) of 200 to 400 kWh/sq.m/year. Energy-conscious building design has been shown to reduce EPI to 100 to 150 kWh/sq.m/year in India.

Centre for Environmental Science and Engineering (CESE), IIT Kanpur reduced the EPI from 240kWh/m^2 to 98 kWh/m^2 through implementation of ECBC.

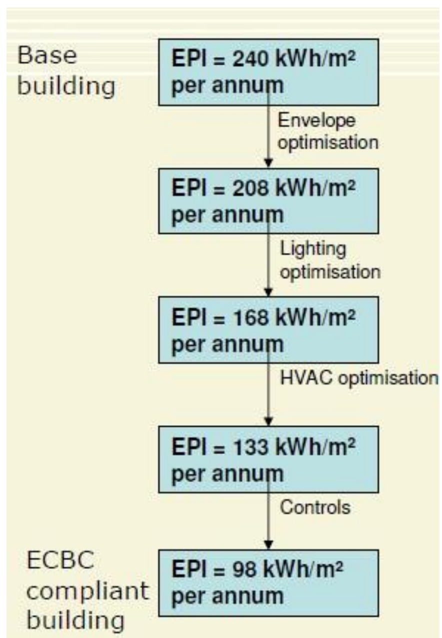

Figure 65-Reduction of WPI in building after applying ECBC[294]

Green buildings

Population in the cities will increase in the coming decades. A report by McKinsey cites that Maharashtra will be in the top five states that will be have more population living in the cities than in villages (figure 6). This will lead to an increase in housing requirements in cities, so buildings that will house large occupants will have to be constructed. Also buildings for commercial and industrial purposes will increase. This will evidently create pressure on the available resources required to construct and operate a building. Buildings have major

[294] http://www.indiaworldenergy.org/brochure/ECBC.pdf

environmental impacts over their entire life cycle. Resources such as ground cover, forests, water, and energy are depleted to construct and operate buildings.

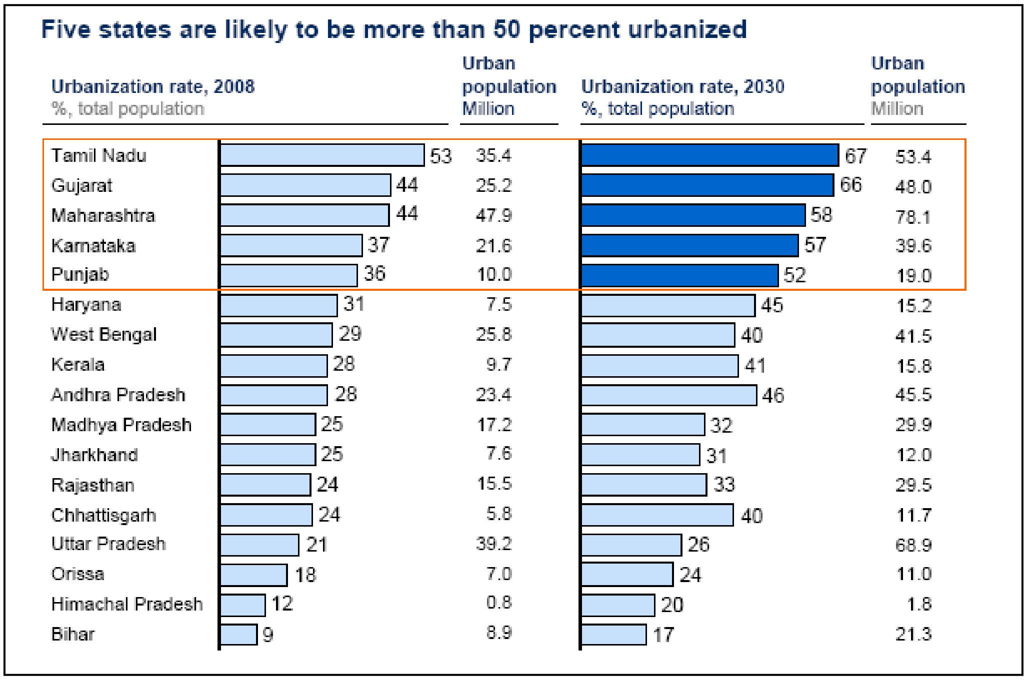

Figure 66 - Urbanization in India

In order to reduce the pressure on resources, green buildings need to be designed. Green buildings are not to be equated with energy savings. Reducing energy use is indeed one critically important aspect of sustainability. Green buildings, in comparison to traditional buildings reduce environmental footprints while still enhancing the indoor environmental quality (IEQ) for the occupants. Green signifies "getting more with less" *i.e.* more quality of life for building occupants by using less resources. Any building may be built or remodeled with improved green characteristics.

> A green building is one which uses less water, optimizes energy efficiency, conserves natural resources, generates less waste and provides healthier spaces for occupants, as compared to a conventional building
>
> Indian Green Building Council

A great deal of effort is placed in achieving sustainable development in the construction industry with the aim of reducing energy consumption in both construction and management of buildings, thereby limiting its consequences on local and global environment. Building green can involve many facets, but the main objectives include efficient use of land and energy, water conservation, improved indoor air quality, and resource conservation, primarily by using recycled & regional materials.

In India there are two major rating systems the LEED and GRIHA.

LEED (Leadership in Energy and Environment Development) Rating system

The LEED-INDIA Green Building Rating System is a nationally and internationally accepted benchmark for the design, construction and operation of high performance green buildings. It is run by the Indian Green Building Council (IGBC). Its certification scheme addresses all types of new commercial buildings. At present IGBC offers following exclusively dedicated programs for environmental ratings of the buildings:

(i) IGBC Green Homes Rating System (for residential sector)
(ii) IGBC Green Factory Building rating system (for industrial buildings)
(iii) LEED India for New Construction (To help in guide and design High Performance Green Building)
(iv) LEED India for Core & Shell (IT Parks)

Green Rating for Integrated Habitat Assessment (GRIHA) Rating System

Keeping in view Indian agro-climatic conditions and in particular the preponderance of non AC buildings, a National Rating System *viz.* Green Rating for Integrated Habitat Assessment (GRIHA) was developed by TERI and the Ministry of New and Renewable Energy. GRIHA has derived inputs from the codes and guidelines developed by the Bureau of Energy Efficiency, MoEF (Ministry of Environment and Forests), Government of India, and the Bureau of Indian Standards. It is now adopted as National Green Building rating system. It is also developed on a point based scoring system to evaluate buildings on "Green Scale"[295].

Energy savings potential in buildings

Energy savings potential is in the range of 20% - 50%.

If energy efficiency measures are implemented at the design stage, the potential for energy savings is 40-50%.

For existing buildings, the potential can be as high as 20-25% which can be achieved by implementing housekeeping and retrofitting measures.

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[295] http://www.nistads.res.in/indiasnt201011/T3_Industry/Status%20of%20Green%20building%20Sector%20in%20India.pdf

Conclusion

Energy conserving household appliances can save 2000 MW

Energy conservation initiatives in industrial sector can save 970 MW

Savings in agriculture 1175 MW

Energy efficiency in commercial buildings (green buildings) can save 25% of commercial energy consumption

Domestic and agriculture sectors alone can save 11250 MU of electricity (5% of the total consumption)

Integrated Energy Resource Management

Energy savings in the four thrust areas is analyzed quantitatively. Two scenarios are highlighted *viz.* Scenario 1- Business as Usual (BAU) and Scenario 2 - 'Integrated Energy Resource Management (IERM). In BAU scenario works in continuing with present trends of inefficient power plant performance, losses in transmission and distribution, slow pace of renewable energy generation and aversion to energy conservation.

The IERM scenario takes the BAU as the starting point but explores the four thrust areas to the fullest extent.

a. Operating power plants with maximum efficiency,
b. Introducing computerization and 100% metering, introducing innovative technologies like Smart Grid in T&D sector,
c. Promoting R&D and fast track implementation in renewable energy sector, and
d. Taking extraordinary efforts in inducing energy conservation across economic sectors.

IERM scenario

It will be of great importance to analyze the four thrust areas together quantitatively**.** We have seen the qualitative and quantitative analysis separately for each of the sectors. It is necessary to achieve a constructive confluence of improvement in these four key areas with inclusive growth.

Achieving maximum power plant efficiency and reducing losses in T&D are factors that are in consonance with the existing infrastructure. Even though efforts have been made constantly to improve performance in these sectors for the past several years, the result has not been satisfactory.

In the renewable sector, hydro power has been exploited for a long period of time. First hydropower plant was set up in Maharashtra in 1915 by Tata group. Wind energy has been in generation in the past, but solar power generation has just been introduced in the energy generation market. Solar power generation sector is yet to pick up pace due to high cost and operating efficiencies. The government has opened lucrative gateways for private enterprises in the renewable sector which will help renewable energy economy gain momentum.

The concept of conserving energy is yet to seep into the market and the minds of people. Theoretically it is easy to analyze the benefits of energy conservation, but it is equally hard to realize profits. Introducing energy conservation measures across economic sectors poses a major challenge as compared to the other three thrust areas.

A ten year time period has been considered for the transition from BAU to IERM scenario. It is assumed that till 2025, power plants will operate with excellent PLF, T&D losses will be negligible, renewable energy will have a substantial percentage in the energy mix and energy efficient appliances will replace inefficient ones.

Considering the efficiency of power generation and availability of resources & infrastructure, power generation from coal is the easiest way of power generation. But, in comparison to hydropower and renewable power generation which are a perennial inexhaustible option, power from coal is exhaustible. We can still rely on coal for the coming years in the near future. We shall try to achieve maximum possible generation from sources other than coal, and fill the gap with power from coal as base load power.

The situation that will ensue if every other alternative except coal is exploited to the fullest of its potential is shown mathematically shown in the table below.

Table 75-Quantitative analysis of IERM Scenario 2025

	Business As Usual		Power Plant Performance		T&D		Renewables		Energy Conservation		Integrated Energy Resource Management	
	MW	MU	MW	MU	MW	MU	MW	MU	MW	MU	MW	MU
Renewables (R)	9744	28948	9744	28948	9744	28948	15000	44676	9744	28948	15000	44676
Conservation (E)	0	0	0	0	0	0	0	0	0	11250	0	11250
Gas (G)	3972	24356	3972	24356	3972	24356	3972	24356	3972	24356	3972	24356
Hydro (H)	3378	13020	3378	13020	3378	13020	3378	13020	3378	13020	3378	13020
Coal (C)	12226	64260	12226	80325	12226	64260	12226	64260	12226	64260	12226	80325
Total Generation (R+C+G+H+E)	29320	130584	29320	146649	29320	130584	34576	146312	29320	141834	34576	173627
Available for consumption (with T&D loss)		97938 25%		109987 25%		117526 10%		109734 25%		106376 25%		156265 10%
Total requirement (Projected Consumption in 2025)		232000		232000		232000		232000		232000		232000
Consumption Deficit in 2025 - To be catered from base load coal power		134062		122013		114474		122266		125624		75735
Generation from coal required (with T&D loss)		178749 25%		162684 25%		127193 10%		163021 25%		167499 25%		84150 10%
Installed Capacity of Coal required (with PLF)	34009 60%		24762 75%		24200 60%		31016 60%		31868 60%		12808 75%	

the generation of electricity from installed capacity has been formulated from the power load factors of the respective sources of generation. For example, wind energy can give a maximum of 30% power load factor, while solar panels can deliver at 10%. For hydropower it is 50% and for gas power generation it is 60%.

(orange)	Constant values – Current installed capacities from coal, gas, hydro and renewables + proposed capacity addition for gas & hydro power stations + MEDA renewable potential
(green)	IERM thrust areas
(dark blue)	Final outcome

Quantitative analysis of BAU and IERM scenarios in 2025

1. Current installed capacities of thermal (coal gas) & hydro power plants as well as planned installed capacities of gas and hydropower stations are constant values in both scenarios. In the BAU scenario, MEDA potential for renewables is considered. In the IERM scenario however, the renewable potential suggested by MEDA seems underutilized and so a higher potential is considered.
2. The total energy available for consumption would be less than that generated at point source due to losses during transmission and distribution of electricity to the end user, and so T&D loss of 10% is considered in the IERM scenario while 25% in the BAU scenario.
3. Projected consumption of 2025 is calculated on the basis of annual growth (CAGR 7.8%) in consumption of electricity. So there remains a deficit in power supply which needs to be catered.
4. The table above also shows potential energy saving individually calculated for each of the thrust areas. A realistic estimate is considered while improving in power plant efficiency and reduction in losses in the T&D sector, while in case of renewables and energy conservation the estimate is idealistic and ambitious which will take immense effort to materialize.
5. Finally, the outcome is presented in the form of capacity required from coal in 2025. In the IERM scenario, the additive effect of saving in all thrust areas significantly reduces the need of base load generation from coal power.

Constant values in 2025

Current installed capacity of gas power is 1452 MW and comprises 672 MW from Uran power station, 180 MW from Tata power station and 600 MW from RGPPL. With availability of gas, complete utilization of RGPPL will take its installed capacity to 1875 MW (1900 is considered for calculation). Further, the proposed 1220 MW extension to Uran gas power station is taken to be completely realized till 2025.

The estimate of maximum hydropower potential given by MEDA has been considered as final hydropower estimate of 2025, which is 3378 MW.

Capacity of hydropower generation in 2025 - 3378 MW

Capacity of gas power generation in 2025 - 3972 MW

Gas and hydropower are exploited to the same extent in the BAU as well as IERM scenario.

For estimating future base load capacity, current installed capacity of coal power plants is considered.

Capacity of coal power generation in 2012 – 12226 MW

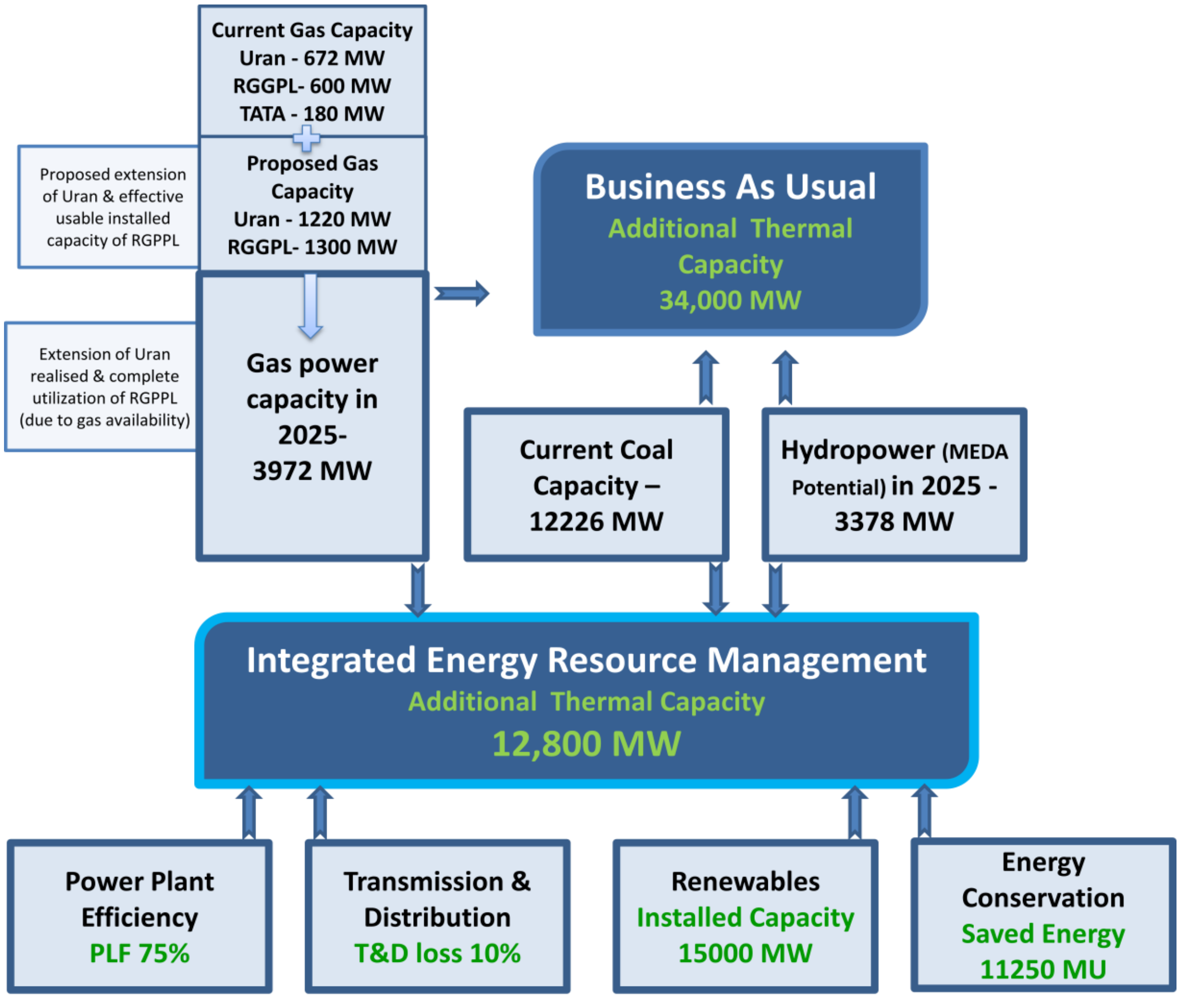


Figure 67-Schematic Representation of IERM Scenario 2025

Scenario 1: Business as Usual (BAU)

The BAU scenario assumes that situation of power and current energy policies will broadly continue in 2025 and major efforts to provide sustainable power to all will not materialize. Even though power would be available to all in the BAU scenario, it would be at the cost of available dwindling land and water resources, hence not sustainable.

In the BAU scenario, it is assumed that there will be no improvement in the efficiencies of the coal based power plants. Considering the apathy in the T&D sector and reluctance in investments in innovative technologies, minimal reduction in T&D losses is considered. However, the importance of renewables is not ruled out, but its share in the energy mix is low and the rate of expansion which plays a key role is also low too. Market infiltration of efforts in the energy conservation would be minuscule so it is not considered.

34,000 MW coal based capacity addition required

Consumption in the year 2025 is projected to be around 232,000 MUs (CAGR 7.8%). If the electricity sector follows the present trajectory, the demand supply deficit would be around 134,062 MUs in 2025. Electricity available for consumption from the constants would be less due to higher T&D losses of 25%.

This would require installation of additional base load capacity of ***34,009 MW***. Due to its abundance, availability in the foreseeable future and low cost, coal has been the primary fuel choice for base load power generation.

Scenario 2: Integrated Energy Resource Management (IERM)

The IERM scenario builds on the BAU scenario. In addition to applying the same constant values, it explores improved efficiency in each of the four thrust areas. The combined additive effect gives the final outcome.

IERM implies that the final capacity addition can be reduced by deploying smart grid technologies, using efficient electrical equipment and increasing share of renewables. It also focuses on policy measures that encourage energy efficiency through non-technical ways to make consumers' and producers' behavior less energy intensive.

12,808 MW additional coal capacity installation required in 2025

Upgrade Power Plant efficiency

Improvement in the PLF of coal fired power plants will bring in maximum saving in the energy required to be generated from coal itself.

24,762 MW of additional coal capacity will be required in 2025

27% of additional coal generating capacity will be saved if PLF of coal fired plants in Maharashtra improves to 75% as compared to 60% in BAU.

Strengthen T&D network

Reduction in transmission and distribution loss to 10% will drastically reduce requirement of electricity from coal fired power plants.

24,200 MW additional coal generating capacity will be required in 2025

28-30% of installed capacity in comparison to the BAU case would be saved. If T&D loss is further reduced to 7-8% as is the case in developed countries, savings in fossil fuel energy generation would further increase.

Increase in green energy

In BAU scenario it is assumed that full potential of renewable energy calculated by MEDA must be utilized. While in IERM scenario, it is recommended that renewable capacity addition be increased twofold than BAU scenario, considering the untapped solar and wind potential which is being identified in phases.

Renewable installed capacity should be elevated to 15000 MW in 2025

There is extensive potential for expansion of renewables to achieve the scale up. The difference between BAU and IERM is that the latter proposes a higher growth rate. Thus the two steps *viz.* identifying maximum potential and rapid installation are absolutely necessary.

Maharashtra has already picked up pace in the development of renewable energy. The state is at second position in India in terms of renewable installed capacity after Tamil Nadu[296], but as far as actual generation it is at the fourth position[297]. Utilization of full potential till 2025 will just reduce 1400 MW of coal capacity addition.

Here it is proposed that around 15000 MW be generated through renewable sources by 2025. To reach this proposed capacity, it is necessary to explore and deploy generation from renewables preferably DDG from sources biomass, waste to energy, solar, wind or hybrid renewables. If we extend models like "solar city" to other cities of Maharashtra, renewable power generation could reach 15000 MW, thus proving the claim.

31,000 MW additional coal generating capacity will be required in 2025

Energy conservation

Energy conservation is the most difficult part that the energy sector of Maharashtra faces. Use of energy efficient appliances reduces the domestic consumption of electricity. The most striking example is the use of CFLs in place of incandescent lamps. A 60-W bulb can be replaced by a 15W CFL lamp. This saves a lot of electricity (75%), as can be directly ascertained.

Here, it is not only necessary to manufacture appliances that are highly energy efficient, but there is an equally dire need to educate people the importance of using efficient appliances. Further, the cost of energy efficient appliances is very high compared to normal appliances. These factors have impeded the development of the philosophy of energy conservation.

31,868 MW additional coal generating capacity will be required in 2025

The net benefit of IERM scenario would be avoided cost of electricity generation such as capital cost, fuel cost, operation and maintenance, etc., savings in electricity bills, avoided environmental damage cost due to conservation and energy efficiency measures.

Net benefit =	**avoided generation cost + savings in electricity bills + avoided environmental damage cost - T&D reduction cost**

[296] http://www.cea.nic.in/reports/monthly/inst_capacity/aug12.pdf
[297] http://www.cea.nic.in/reports/articles/god/renewable_energy.pdf

Although IERM scenario shows a general pathway, the key lies in rapid implementation. Though macro-level analysis presented in IERM gives a crude estimate, case studies for each of the thrust areas strongly supports the recommendations.

If implemented, these recommendations would incur high initial costs, the benefits of which would be reaped in the long run. Heavy investments would be needed to revamp transmission and distribution network, which will pose a major challenge.

In the areas of green energy and energy conservation, the saving in additional coal capacity is less (3000 MW and 2000 MW respectively). The benefit lies in production of electricity from permanent source of energy and using less electricity per appliance. The ambitious returns and benefits of energy conservation can only be sought with patience.

The four thrust areas would play a significant role in alleviating the state's electricity deficit. It would reduce government outlay for 60% power capacity expansion. It would also lead to climate change mitigation by reducing carbon emissions.

> In IERM, 60% of coal capacity addition will be saved with a combined effort of improvement in power plant efficiency, transmission and distribution, use of energy efficient appliances and scaling up renewable energy potential in Maharashtra.

Conclusion

To provide uninterrupted electricity in all pockets of Maharashtra, blindly making capacity additions is not environmentally and technologically suitable solution. Proactive measures are necessary to deal with the challenges faced by this sector. Current energy habits must change in order to reduce significant public health risks, avoid placing intolerable stress on critical natural systems, and to manage the substantial risks posed by global climate change.

We will shift focus from the conventional approach to an integrated one encompassing renewable energy sources, energy efficient technologies, demand side management measure and decentralized systems. We will not rely on a specific technology but will evaluate the circumstances and provide solutions to suit the needs of local population and also create employment opportunities.

Annexures

Annexure I - List of Power plants and PPAs in Maharashtra

Existing Power Plants in Maharashtra

Power generating station	Installed capacity (MW)
Power available for use in Maharashtra except Mumbai	
MahaGenCo	9943.83
Interstate hydroelectric projects	444.5
RGPPL	740
Tarapur (Nuclear)	393
Central share	5169
Captive Power	908
Renewable	2498
Sub - total	**20096.33**
Power available for use in Mumbai	
Tata & Reliance thermal Power stations	1900
Tata gas power stations	180
Tata hydroelectric power stations	447
Tata renewable energy	82
Sub - total	**2609**
Grand Total power in Maharashtra	**22,766.25**

MahaGenCo Power Plants

Thermal Power Stations

Thermal Power Station	Date of commissioning	Total No. of Units	No. of working units	Unit Capacity (MW)	Total power station capacity	Working capacity (MW)	Average efficiency (%)
Koradi	1974,1975,1976,1977	7	7	4 x 105	1040	1040	**57**
	1978			1 x 200			
	1982,1983			2 x 210			
Nasik	1970,1971	5	3	2 x 125[298]	880	630	**60**
	1979,1980,1981			3 x 210			
Bhusawal	1968	5	4	1 x 55[299]	1475	1420	**61**
	1971,1982			2 x 210			
	2012			2 x 500			**-**
Paras	1961	4	2	30[300]	585	500	**-**
	1967			1 x 55[301]			**60**
	2008[302], 2010			2 x 250			**-**
Parli	1971	7	5	2 x 20[303]	1180	1130	**64**
	1980,1985, 1989			3 x 210			
	2007,			2 x 250			**-**
Khaperkheda	1989,1991,2000,2001	5	5	4 x 210	1340	1340	**70**
	2011			1 x 500			
Chandrapur	1983,1984,1985,1986	7	7	4 x 210	2340	2340	**59**
	1991,1992,1997			3 x 500			
Total		**40**	**33**		**8840**	**8400**	

[298] NOTE - The installed capacity of these units was initially 140MW, but has de-rated to 125MW wef 20-04-2007 vide CEA letter no. CEA/PLG/DMLF/513/(CDHUVARAN)/2007 dated 20/04/2007. The efficiency has been calculated taking into consideration the original installed capacity of 140MW

[299] NOTE - The installed capacity of this unit was 62.5MW initially, which was derated to 58 MWand later to 55 MW. So the efficiency has been calculated taking into consideration the old installed capacity. The total installed capacity is therefore 478MW

[300] http://www.parastps.co.in/index.php?option=com_content&view=article&id=53&Itemid=58

[301] NOTE - The capacity of this unit was 58MW, based on which the efficiency has been calculated. The power generation figures for the new unit of 250MW commissioned in the year 2008 are not available and hence efficiency has not been calculated.

[302] http://www.mahagenco.in/investor/pprojects_completion.shtm#parastps

[303] NOTE: These two units had an installed capacity of 30MW when installed. The capacity of both the units derated to 20MW from 20/4/2007. The efficiency was calculated prior to the de-rating considering 30MW each- http://www.parlitps.com/about-us.asp

Gas Power Stations

Power generating station	Installed capacity*) MW (	Total units	Capacity of units (MW)	Region
Uran Gas Turbine Power Station	612	7	3 x60 (120) 4x108 (432)	At/Post Bokadvira, Taluka Uran, District Raigad
Waste heat recovery	240	2	2 x 120 (240)	
Total	**852**			

Hydro Power Stations

Power generating station	**Installed capacity* (MW)**	**Total units**	**Capacity of units (MW)**	**Region**
Koyna (Four stages)	1920	16		Pophali, Taluka Chiplun, District Ratnagiri
Koyna State I&II	600	8	4 x 70 (280) 4 x 80 (320)	W. Maharashtra
Koyna State III	320	4	4x80 (320)	Konkan
Koyna State IV	1000	4	4x250 (1000)	W. Maharashtra
Koyna dam foot	40	2	2x20 (40)	Konkan
Ghatghar PSS	250	2	2x125 (250)	Nasik (W. Maharashtra)
Bhira Tailrace	80	2	2x40 (80)	Konkan
Bhatsa	15	1	1x15	Konkan
Tillari	66	1	1x66	W. Maharashtra
Terwanmedhe	0.2	1	1x0.2	Konkan
Surya	6	1	1x6	Konkan
Surya canal drop	0.75	3	3x0.25	Konkan
Dolwahal	2	2	2x1	Konkan
Radhanagri	4.8	4	4x1.20	W. Maharashtra
Bhatghar	16	1	1x16	W. Maharashtra
Veer	9	2	2x4.50	W. Maharashtra
Pawna	10	1	1x10	W. Maharashtra
Khadakwasla	16	2	2x8	W. Maharashtra
Kanher	4	1	1x4	W. Maharashtra
Dhom	2	2	2x1	W. Maharashtra
Manikdoh	6	1	1x6	W. Maharashtra
Dimbhe	5	1	1x5	W. Maharashtra
Warna	16	2	2x8	W. Maharashtra
Dudhganga	24	2	2x12	W. Maharashtra
Yevteshwar	0.075	1	1x0.075	W. Maharashtra
Karanjwan	3	1	1x3	Nasik (W.

				Maharashtra)
Vaitarna	60	1	1x60	Nasik (W. Maharashtra)
Vaitarna Dam foot	1.5	1	1x1.5	Nasik (W. Maharashtra)
Yeldari	22.5	3	3x7.50	Marathwada
Paithan	12	1	1x12	Marathwada
Majalgaon	0.75	1	1x0.75	Marathwada
Ujani	12	1	1x12	W. Maharashtra
Shahanoor	0.75	1	1x0.75	Marathwada
Wani	1.5	1	1x1.5	Marathwada
Total	**2606.83**			

Private Power Projects in Maharashtra

Hydro Electric Projects (Power for Maharashtra)

Power generating station/ Name of company	Total installed capacity (MW)	Total units	Capacity of units (MW)	Region
Vajra Fall	3	1	1x3	Konkan
Konal	10	2	2x5	Konkan
Devgad	1.5	1	1x1.5	Konkan
Chaskaman	3	1	1x3	W.Maharashtra
Nira Deoghar	6	2	2x3	W.Maharashtra
Tembhu Barage	4.5	3	3x1.5	W.Maharashtra
Bhandardara	46	2		Nasik
Bhandardara Phase I	12	1	1x12	
Bhandardara Phase II	34	1	1x34	
Total	**120**			

Thermal Power Plants (Power available for Mumbai)

Power generating station/ Name of Company	Installed Capacity (MW)	Total Units	Capacity of units (MW)	Region
Tata Power	1400			Konkan
Trombay	1150	3	1X150 2X500	
Trombay	250	1		
Reliance				Konkan
Dahanu Thermal Power Station	500	2	2x250	
Total	**1900**			

Hydro Electric Projects – Tata (Power available for Mumbai)

Power generating station/ Name of company	Total installed capacity (MW)	Total units	Capacity of units (MW)	Region
Bhira	150	6	6x25	Konkan
Bhira Pumped Storage Scheme	150	1	1x150	Konkan
Khopoli	72	6	6x12	Pune
Bhivpuri	72	6	6x12	Pune
Bhivpuri	3	2	2x1.5	Pune
Total	**447**			

*Gas based power stations – Tata (*Power available for Mumbai)

Power generating station/ Name of company	**Total installed capacity (MW)**	**Total units**	**Capacity of units (MW)**	**Region**
Trombay	120	1	1x120	Konkan
Trombay WHR	60	1	1x60	Konkan
Total	**180**			

*Renewable energy – Tata (*Power available for Mumbai)

Renewable energy	**Total installed Capacity (MW)**	**Region**
Wind Power		W. Maharashtra
Khandke	50	Ahmednagar
Supa	17	
Bramanvel	11	
Visapur	4	
Total	**82**	

Site wise Wind Farm Installations in Maharashtra (31/03/12)

Name of site	District	No. of Wind Turbines	Sub Total	Wind Turbine Make	Capacity KW per Turbine	Total Capacity MW	Sub Total
Dahanu	Thane	1		Vestas	90	0.090	
Deogad	Sindhudurga	10		Vestas	55	0.550	
		10		Bonus	55	0.550	
Vijaydurga	Sindhudurga	6		BHEL	250	1.500	
Sub-total (1)			**27**				**2.690**
Chalkewadi	Satara	8		BHEL	250	2.000	
		3		Suzlon Energy	1250	3.750	
		2		NEPC	225	0.450	
		1		REPL	320	0.320	
		16		Suzlon Energy	350	5.600	
		8		Vestas RRB	225	1.800	
		10		Vestas RRB	500	5.000	
		20		Enercon India	230	4.600	
		8		Enercon India	600	4.800	
Sub-total (2)			**76**				**28.000**
Thoseghar	Satara	36		Vestas RRB	225	8.100	
		52		Enercon India	230	11.960	
		18		Enercon India	600	10.800	
		8		Enercon India	800	6.400	
Sub-total (3)			**114**				**37.260**

Vankusavade	Satara	540	Suzlon Energy	350	189.000	
		7	Suzlon Energy	1000	7.000	
		28	NEG-Micon	750	21.000	
		25	Enercon India	230	5.750	
		21	Enercon India	600	12.600	
		1	IWPL/ NEG-Micon	750	0.750	
		4	IWPL	250	1.000	
		1	Vestas RRB	225	0.225	
		11	Vestas RRB	500	5.500	
Sub-total (4)		**638**				**242.825**
Matrewadi	Satara	25	Enercon India	230	5.750	
		30	Suzlon Energy	1500	45.000	
		2	Vestas Wind Tech	1650	3.300	
		10	Pioneer Wincon	250	2.500	
Sub-total (5)		**67**				**56.550**
Varekarwadi	Satara	15	Enercon India	600	9.000	
		5	Enercon India	800	4.000	
		4	Vestas Wind Tech	1650	6.600	
Sub-total (6)		**24**				**19.600**
Ambheri	Satara	24	Vestas RRB	600	14.400	
		4	Elecon	600	2.400	
		5	Gamesa	800	4.000	
		71	Southern Windfarms	225	15.975	
		66	Shriram-EPC	250	16.5	
		25	Pioneer Wincon	250	6.25	
		18	Kenersys	2000	36	
Sub-total (7)		**213**				**95.525**
Sadawaghpur	Satara	75	Suzlon Energy	1250	93.750	
		25	Suzlon Energy	600	15.000	
Sub-total (8)		**100**				**108.750**
Agaswadi	Satara	64	Regen	1500	96.000	
		15	Gamesa	850	12.750	
Sub-total (9)		**79**				**108.750**
Vaspeth	Sangli	2	Global Wind	2500	5	
		5	Kenersys	2000	10	
Sub-total (11)		**7**				**15.000**
Chavneshwar	Satara	87	Enercon India	800	69.600	
Sub-total (10)		**87**				**69.600**
Kas	Satara	12	Shriram-Leitwind	1500	18.000	
		1	Suzlon Energy	600	0.600	
Sub-total (11)		**13**				**18.600**

Palsi	Satara	19		Vestas Wind Tech	1650	31.350	
Sub-total (12)			**19**				**31.350**
Maloshi	Satara	19		Suzlon Energy	1250	23.75	
Sub-total (13)			**19**				**23.750**
Gudepachgani	Sangli	8		Enercon India	230	1.840	
		14		Enercon India	230	3.220	
		12		Enercon India	600	7.200	
		63		Enercon India	800	50.400	
		30		Suzlon Energy	600	18.000	
		24		NEG-Micon	1650	39.600	
		2		Suzlon Energy	1500	3.000	
Sub-total (14)			**151**				**123.260**
Dhalgaon	Sangli	14		Enercon India	600	8.400	
		51		Suzlon Energy	600	30.600	
		132		Suzlon Energy	1250	165.000	
		49		Suzlon Energy	1500	73.500	
Sub-total (15)			246				277.500
Bhud	Sangli	26		Regen	1500	39.000	
		26		Vestas Wind Tech	1650	42.900	
		3		Ghodawat Industries	1650	4.950	
Sub-total (16)			55				86.850
Mendhegiri	Sangli	25		Gamesa	850	21.25	
Sub-total (17)			25				21.250
Kavadya Dongar	A'Nagar	57		Suzlon Energy	1000	57.000	
		6		Suzlon Energy	1250	7.500	
Sub-total (18)			**63**				**64.500**
Panchpatta	A'nagar	24		Suzlon Energy	1500	36.000	
		65		Enercon India	800	52.000	
Sub-total (19)			89				88.000
Khandke	A'nagar	135		Enercon India	800	108.000	
Sub-total (20)			135				108.000
Sautada	Beed	52		RRB Energy	600	31.200	
		14		Shriram-EPC	250	3.500	
Sub-total (21)			**66**				**34.700**
Brahmanwel	Dhule	5		Windia	600	3.000	
		4		Windia	750	3.000	
		20		NEG-Micon	750	15.000	
		23		NEG-Micon	1650	37.950	
		16		Suzlon Energy	600	9.600	
		377		Suzlon Energy	1250	471.250	

		4		Suzlon Energy	1500	6.000	
		1		Suzlon Energy	2100	2.100	
Sub-total (22)			**449**				**547.900**
Jaibhim	Dhule	16		Suzlon Energy	2100	33.6	
Sub-total (23)			16				33.600
Chakala	Nandurbar	154		Suzlon Energy	1250	192.500	
		66		Suzlon Energy	1500	99.000	
		10		Suzlon Energy	2100	21.000	
Sub-total (24)			**230**				**312.500**
Motha	Amarawati	2		Suzlon Energy	1000	2.000	
Sub-total (25)			2				2.000
Aundhewadi	Nashik	13		Enercon India	800	10.400	
		28		Suzlon Energy	1500	42.000	
Sub-total (26)			41				52.400
Andhralake	Pune	133		Enercon India	800	106.400	
Sub-total (27)			**133**				**106.400**
	TOTAL		**3184**			**2717.110**	**MW***
*As on 31 Mar 2012							

PPA/LOI of MSEDCL with power producers

Brief details of PPAs/LOIs and other concrete proposals entered since formation of MSEDCL

A. Ultra Mega Power Project

- Mundra: Costal Gujarat Power Ltd. (4000 MW)

  PPA between MSEDCL and Costal Gujarat Power Ltd on 22.4.2007

  Expected COD: September 2011 to March 2013

  MSEDCL share: 800 MW

- Krishnapattanum: Costal Andhra Power Ltd (4000 MW)

  PPA between MSEDCL and Costal Andhra Power Ltd on 23.03.2007

  Expected COD: September 2013 (First Unit)

  MSEDCL share: 800 MW

- Tilaiya : Jharkhand Integrated Power Ltd. (4000 MW)

  PPA expected to be signed on 10.09.2008

  Share of MSEDCL is 300 MW

- Tamilnadu UMPP (4000 MW)

  PPA is yet to be signed.

  MSEDCL share: 400 MW

B. Proposed Future UMPP Projects

- Munge : Maharashtra (4000MW)

  MSEDCL share: 2000 MW

- Costal Project Karnataka State (4000 MW)

  MSEDCL share: 1000 MW

C. *MSEDCL's Projects under CBG*

- Case I Stage I (2000 MW)

  MSEDCL has issued LOI for supply of power of 1320 MW to Adani Power Ltd (APL) at rate of Rs. 2.642 per unit and 680 MW to Lanco Kondapalli Power Private Ltd. (LKPPL) at rate of Rs. 2.70 per unit.

  PPA will be signed in the month of September 2008.

  MSEDCL share: 2000 MW

  Expected year of commissioning: 2012

- Case I Stage II (2000MW)

  MSEDCL has submitted RfP document to MERC for procurement of additional 2000 MW through Case I CBG.

  MERC public hearing will be on 17.09.08

  After approval of MERC all other relevant process such as calling of bid , evaluation of bid , finalization of bid , issue of LOI and signing of PPA will be carried out.

  It is expected after completion of above formalities project will be commissioned in year 2013.

- Case II : Dhopave (1600 MW)

  MERC has conducted public hearing on 2.09.2008 for approval of deviations in RfP document.

  It is expected that project will be commissioned in year 2013 subject to land acquisition and other related clearance.

D. *Central Sector Projects:*

- Sipat: Stage-I (3x660 MW)

  MSEDCL share 510 MW

- Sipat: Stage-II (2x500 MW)

  MSEDCL share 258 MW out of that from one unit of 500 MW is commissioned on 26.06.2008 and MSEDCL is getting its share of 152.46 MW.

- Kahalgaon STPS Stage II U5: (3x500MW)

  MSEDCL share is 148 MW and out of 3x500 MW , one unit of 500 MW is commissioned on 1.08.2008 and MSEDCL is getting 58 MW from this unit.

- Vindhyachal Stage-III U9 (500MW)

  MSEDCL is getting 152.46 MW from 1.12.2006

- Vindhyachal Stage-III U10 (500MW)

  MSEDCL is getting 152.46 MW from 15.07.2007

- Mauda Super Thermal Power Station (2x500MW)

  PPA signed between NTPC and MSEDCL on 7.12.2007

  Commissioning year: 2012-2013

  MSEDCL share: Share is not yet allocated by CEA, but it is expected to get around 700 MW being a project coming instate of Maharashtra.

- Barh: (3x660MW)

  PPA signed between NTPC and MSEDCL on 9.03.2006

  Commissioning year: 2010

  MSEDCL share: 164 MW

- North Karnapura: (3x660MW)

  PPA signed between NTPC and MSEDCL on 9.03.2006

  Commissioning year: 2010

  MSEDCL share: 67 MW

E: Independent Power Projects

- Ratnagiri Gas & Power Station (2150MW)

  PPA signed on 10.04.2007 between RGPPL and MSEDCL

  Block II Commercial Operations Started on 1.09.2007

  Block-III Commercial Operations Started on 21.11.2007

Block-I is synchronized on 8.07.2008 and generating infirm power, COD not declared yet.

- Lanco Tista Hydro (4x125 MW)

  PPA signed on 29.08.2006 and approved by MERC on 8.05.2008

  Rate of this power is Rs.2.32 per unit.

  MSEDCL share is 500 MW

  Commissioning year: 2012

- MIDC : Bhadrawati (1100 MW)

  MSEDCL in principle agreed to purchase power from this station, which is developed by MIDC under Case II CBG and from which MSEDCL will get around 900 MW.

- Year wise power purchase on short term basis through traders to meet the shortfall to some extent. Day by day rate of short term power purchase is increasing trend and presently rate of short term power purchase is reached to the extent of Rs. 10 per unit at ex-bus. The cost of this power to the distribution company is around Rs. 11.30 per unit.

MSEDCL's Power Purchase Plan till 2014-15[304]

MSEDCL's Power Purchase Plan with 'Firmed Project'																
APPROVED PROJECTS	YEAR OF AVAILB.	CAP. IN MW	AX.CS. IN %	P.L.F. IN %	05-06	06-07	07-08	08-09	09-10	10-11	11-12	12-13	13-14	14-15	Expected Commercial Opn.	Hours of the day
Existing Capacity					9158	9365	9365	9365	9365	9365	9365	9365	9365	9365		
a) MSEB Projects																
1) Utilisation of existing capacity of GTPS	07-08	792	3	27			208	208	208	208	208	208	208	208		24 hrs
2) Parli TPS Extn. St-I	06-07	250	9	80		182	182	182	182	182	182	182	182	182	Feb-07	24 hrs
3) Paras TPS Expn. Stage - I	06-07	250	9	80		182	182	182	182	182	182	182	182	182	March-07	24 hrs
4) New Parli TPS Expn.-II	09-10	250	9	80					182	182	182	182	182	182	April- 09	24 hrs
5) Paras TPS Expn. - II	09-10	250	9	80					182	182	182	182	182	182	June- 09	24 hrs
6) Khaperkheda Project	10-11	500	9	80						364	364	364	364	364	April-10	24 hrs
7) Bhusawal TPS Expn Unit 1	10-11	500	9	80						364	364	364	364	364	April-10	24 hrs
8) Bhusawal TPS Expn Unit 2	10-11	500	9	80						364	364	364	364	364	Aug-10	24 hrs
b) Central Sector Projects																
1) Tarapur Unit - 4	05-06	196		80	157	157	157	157	157	157	157	157	157	157		24 hrs
2) Tarapur Unit - 3	06-07	197		80		158	158	158	158	158	158	158	158	158	Feb.07	24 hrs
3) Vindhyachal Stage - 3 Unit-9	06-07	169		80		135	135	135	135	135	135	135	135	135	Dec.-06	24 hrs
4) Vindhyachal Stage - 3 Unit-10	07-08	169		80			135	135	135	135	135	135	135	135	Aug.-07	24 hrs
5) Kahalgaon Stage-II Unit 5	06-07	70		80		56	56	56	56	56	56	56	56	56	March-07	24 hrs
6) Kahalgaon Stage-II Unit 6	07-08	30		80			24	24	24	24	24	24	24	24	May-07	24 hrs
7) Sipat Stage - II Units 4&5	07-08	319		80			255	255	255	255	255	255	255	255	Jun & Dec 07	24 hrs
8) Sipat Stage-I Unit-1&2	08-09	230		80				184	184	184	184	184	184	184	Apr-08 & May-09	24 hrs
9) Sipat Stage-I Unit-3	09-10	115		80					92	92	92	92	92	92	Dec-09	24 hrs
10)Barh Unit 1	08-09	33		80				26	26	26	26	26	26	26	Mar-09	24 hrs
11)Barh Unit 2	09-10	33		80					26	26	26	26	26	26	Jan-10	24 hrs
12)Barh Unit 3	10-11	34		80						27	27	27	27	27	Nov-10	24 hrs
13) Kawas Expansion Project	09-10	375		80			150	300	300	300	300	300	300	300	Dec-07&Mey-08	24 hrs
14) Gandhar Expansion Project	09-10	375		80			150	300	300	300	300	300	300	300	Dec-07&Mey-08	24 hrs
15)North Karanpura Unit 1	09-10	33		80					26	26	26	26	26	26	Feb-10	24 hrs
16)North Karanpura Unit 2	10-11	33		80						26	26	26	26	26	Dec-10	24 hrs
17)North Karanpura Unit 3	11-12	34		80							26	26	26	26	Oct-11	24 hrs
18) Subansiri Hydro	10-11	600		80						480	480	480	480	480	Sept-10	Mor/ Eve Peak hrs
c) Inter State Projects																
l)Sardar Sarovar Project	04-05	392		23	50	50	50	50	50	50	50	50	50	50		Mor/ Eve Peak hrs
Irrigation Project Ghatghar PSS	06-07	250		80		200	200	200	200	200	200	200	200	200		Mor/ Eve Peak hrs
d) IPP Projects																
(1) RGPPL (DPC)	06-07	2210		80		650	1118	1768	1768	1768	1768	1768	1768	1768		24 hrs
(2) LEPL	11-12	500									267.5	267.5	267.5	267.5	As per PPA	Mor/ Eve Peak hrs
e) Ultra Mega Power Project																
(1) Mundra UMPP	13-14	800									128	384	640	640	11-12 to 13-14	24 hrs
(2) Krishnapatnam	13-14	800									128	384	640	640	11-12 to 13-14	24 hrs
Capacity Addition during the year					207	1563	1390	1160	509	1625	550	512	512	0		
Peak Demand Availability with firmed projects					9365	10928	12318	13479	13988	15613	16162	16674	17186	17186		
Evening Peak requirement (6.65% CAGR)					14061	14996	15993	17057	18191	19401	20691	22067	23534	25099		
Evening Peak Shortfall					-4696	-4068	-3675	-3578	-4204	-3788	-4529	-5393	-6348	-7913		
Without Ghatghar PSS					-4896	-4268	-3875	-3778	-4404	-3988	-4729	-5593	-6548	-8113		

304 http://mahadiscom.in/2.Anne%20D%20hrs%20of%20supply%20from%20add%20gen%20capacity.pdf

MSEDCL Power Purchase Agreements with Bagasse Cogeneration projects

Sr. No.	Name of the Project (Location, District)	EPA		Installed Capacity (MW)	Date of Commissioning	Exportable Capacity (MW)		Energy Purchase Rate (Rs. per unit)	
		Date of Execution	Valid till date			Season	Off-season	Last Year	Current Year
1	M/s. Shri Datta SSKL,Shirol,Kolhapur	6.3.97	31.8.2007	8.00	4.3.1993	3.0	0.0	2.55	2.68
2	M/s. Jawahar SSKL,Hupari,Kolhapur	4.3.97	30.9.2007	1.50	23.10.1994	1.5	0.0	2.55	2.68
(\\)3	M/s. Devgiri SSK Ltd.,Aurangabad	23.7.97	28.2.2001	5.00	16.3.1995	1.5	0.0		
4	M/s. Majalgaon SSK Ltd.,Beed	8.9.97	31.5.2009	5.00	3.11.1995	1.5	0.0	2.32	2.43
(\\)5	M/s. Adinath SSK Ltd.,Solapur	27.5.97	21.2.2009	5.00	26.1.1996	1.5	0.0		
6	M/s Chopada SSK,Jalgaon	5.3.97	27.5.2009	5.00	28.5.1996	1.5	0.0	2.32	2.43
(*)7	M/s. Warna SSK Ltd.,Warnanagar	15.4.98	25.5.2005	6.36	26.5.1995	1.86	0.0	3.01	3.16
	SUB-TOTAL [A]			35.86		12.4	0.0		
	Plant Commissioned								
1	M/s. Jawahar SSKL,Kolhapur	5.10.02	22.11.2014	24.00	23.11.2001	8.0	12.0	3.23	3.29
(**)2	M/s.Kay Pulp & Pap. Mills Ltd.,Satara	7.6.00	10.1.2015	6.00	11.1.2002	4.5	0.0	3.23	3.29
3	M/s Terna SSK Ltd.Dhoki,Osmanabad	30.9.02	12.12.2015	14.00	13.12.2002	7.0	0.0	3.17	3.23
4	M/s. Adinath SSK Ltd.,Solapur	2.11.02	31.1.2016	6.00	01.02.2003	5.5	0.0	3.17	3.23
	SUB-TOTAL [B]			50.00		25.0	12.0		
	TOTAL COMMISSIONED CAPACITY			85.86		37.4	12.0		
	Plants Yet To Be Commissioned				Scheduled Commissioning				
1	M/s Pravara Power Pvt.Ltd.,A'nagar	2.2.99	****	35.00	Feb-06	22.5	28.0	--	--
2	M/s.Purti Sakhar Karkh. Ltd.,Nagpur	2.9.02	****	22.00	Aug-03	11.325	18.1	--	--
3	M/s. Baliraja S.K.Ltd.,Parbhani	3.10.02	****	15.00	Oct-03	10.0	0.0	--	--
4	M/s Vasantdada SSK Ltd.,Sangli	13.9.00	****	12.50	Jul-04	7.47	6.5	--	--

5	M/s Mula SSK,Ahemadnagar	8.8.03	****	16.00	Apr-05	9.35	13.45	--	--
6	M/s SMS Mohite Patil,Solapur	10.12.03	****	26.00	Nov-05	14.37	1.37	--	--
7	M/s Vighnahar SSK,Pune	10.12.03	****	18.00	Oct-04	10.2	10.2	--	--
8	M/s Pandurang SSK,Solapur	10.12.03	****	9.00	Feb-06	8.54	7.75	--	--
9	M/s Vitthalrao Shinde SSK,Solapur	7.1.04	****	10.50	Nov-05	6.30	0.00	--	--
10	M/s Standard Fibrochem, Nasik	31.1.04	****	24.00	Dec-05	16.93	20.90	--	--
11	M/s NV Energy Pvt. Ltd Mumbai	17.2.04	****	4.00	Sep-04	3.90	3.50	--	--
12	M/sRajarambapu Patil SSKL Sangli	6.4.04	****	12.00	Dec-05	6.90	0.00	--	--
13	Dr B. Ambedkar SSKL Osmanabad	7.6.04	****	16.00	Jun-06	9.70	0.00	--	--
14	M/s Bhimashankar SSK ,Pune	21.6.04	****	6.00	Mar-06	4.57	5.00	--	--
15	M/s Dnyaneshwar SSK A'Nagar	29.7.04	****	12.00	Jul-06	6.3	6.9	--	--
16	M/s Makai SSKL Solapur	6.8.04	****	7.50	Jul-06	4.8	6.2	--	--
17	M/s Jawahar SSSK Kolhapur	27.8.04	****	3.00	Nov-06	2.5	0	--	--
***18	M/s yash Agro Energy Pvt. Ltd. NGP.	25.10.04	****	8.00	Oct-06	5.62	7.18	--	--
19	M/s Malegaon SSK Ltd.,Malegaon BK	07.11.05	****	24.00	Oct-06	14.09	9.813	--	--
***20	M/s Chintamani SSKL, Yevatmal	03.12.06	****	30.00	Feb-06	15.86	25.60	--	--
21	M/s Loknete Baburao P. SSK Solapur	27.12.06	****	8.00	Dec-06	4.25	0.00	--	--
22	M/s Kranti SSKL Kundal, Sangli	27.12.06	****	13.00	Dec-06	6.65	0.00	--	--
	TOTAL[C]			331.50		202.1	170.5		
	TOTAL[B+C]			381.50		227.1	182.5		
	TOTAL[A+B+C]			417.36		239.5	182.5		

	(\\) Firm not responding for renewal of								
	**** Validity of EPA is 13 years from d		(*) Bio-gas		N/A - Not Applicable				
	-- Rate for the first year of commissioning		(**) Paper		(***) Bio-mass				
20	M/s Wardha SSKL Wardha			30.00	Dec-06	15.86	25.60		
23	M/sGayatri Energy (YCP&IPL)A'bad			7.00	Dec-06	4.29	6.42		
(***)4	M/s Gayatri Agro (Bio-mass),Gondia	5.10.02	****	6.60	Jun-04	5.9	0.0	--	--

Annexure II - Godbole Committee Report

Maharashtra started facing power shortage from the year 1999 – 2000 and since then load shedding was around 1820 MW. To deal with this crisis situation Maharashtra Govt. formed a committee namely Godbole committee under the chairmanship of Dr. Madhav Godbole (former Union home secretary) an expert from the power sector. The committee had to present its findings on the future demands for the next 10 years from 2002-03 and the solutions to meet the demands. In the report, the projected demands were incorrectly calculated, so the utility had to resort to load shedding to bridge the demand supply gap as sufficient investments were now made by the government for generating power. The committee had also stated in the report that the power deficit could be balanced with share from the central sector. One of the major reasons for power shortage was the miscalculation in future demand, which needs to be calculated more scientifically.

The demand projections and actual demand is tabulated below.

Table 76: Demand Projections and actual Demand

Year	Godbole committee	MSEB	TERI	Actual Demand	Load shedding
02-03	10109	11424	-	13418	**2496**
03-04	10657	11933	-	13692	**2042**
04-05	11169	12701	12260	14822	**3045**
05-06	11711	13518	12883	16049	**4205**
06-07	12272	14388	13526	16500	**4600**
07-08	12866	15314	14180	-	**-**
08-09	13438	16299	14854	-	**-**
09-10	**14038**	**17348**	**15545**	**-**	**-**

Pune Model of zero load shedding Jul 23, 2007-Indian Express; 22 Aug 08-ToI; Jan 03, 2008

Pune started the no-load shedding era in June 06, by roping in industries to generate captive power on a public-private partnership (PPP) model initiated by CII. In February this year, Maharashtra Electricity Regulatory Commission mooted extending the model to cities like Nasik, Kolhapur, Thane, Mulund, Bhandup, Navi Mumbai, etc.

In the original model (year 2006) around 30 CII member industries were brought together to draw around 80-100MW power from their Captive Power Plants (CPPs) so the power shortfall in Pune can be met. For a city that witnessed peak load shedding of 180-200 MW, such a measure gave instant relief, completely eliminating the need for load-shedding. Generating power was a relatively expensive affair as diesel was required to run the gen-sets. The cost of generation by CPPs was over Rs. 10/kWh.

The MSEDCL worked out a formula to reimburse the industrial units the differential cost i.e difference in cost of running CPPs and the electricity bill. Reliability charge of 42 paise per unit fixed for customers consuming more than 300 units per month for zero load-shedding convenience. This raised enough funds to successfully compensate participating industries.

With the demand for power going up in Pune, MERC in March this year directed the MSEDCL not to give grid support to keep the Pune model running and look for a franchisee that will secure additional power exclusively. The revised Pune model was worked out in association with Tata Power Trading Company Ltd and 100 MW power on round the clock basis was contracted for Pune. The reliability charge was fixed at 49 paise per unit.

However MSEDCL had told MERC that Tata Power be asked to contract power till June 2008 and later from October 2008 till June 2009. So from July – September, Tata Power did not contract power. But since there were no rains in July power shortfall increased and MSEDCL started demanding 225 MW additional power for Pune to prevent load shedding, whereas its earlier requirement projection was 150 MW for 12 hour basis. Load shedding was introduced in Pune and the model scrapped on July 15.

Tata Power Trading Company Ltd started securing additional electricity on 'day ahead' basis for Pune, Thane and Navi Mumbai through the Indian Energy Exchange from August 13. MSEDCL refused to accept power on 'day ahead' basis and insisted on 'firm' power, i.e. power contracted in advance. So load shedding was resumed in Pune from August 20.

Instead of generating power from CPPs, other alternatives could have been looked for reducing load shedding viz. 400MW idle generation capacity of Uran plant (by converting it to liquid fuel facility); incentivizing load withdrawals by big consumers; reducing technical and commercial losses; etc. These alternatives were not seriously analyzed.

Major landmarks in the energy sector

1970

Lowering agricultural tariffs

1980

De-metering of pumps to encourage growth of the agricultural sector

1991

Opening generation for private sector by making amendments in the Indian Electricity Act, 1910 and the Electricity (Supply) Act, 1948 with The Electricity Laws (Amendment) Act, 1991—Notification wherein

- Private Sector allowed to establish generation projects of all types (except nuclear)
- 100% foreign investment & ownership allowed

- New pricing structure for sales to SEBs
- 5 Year Tax holiday; import duties slashed on power projects

October 1991 Union Power Ministry began to publish a series of notifications seeking to encourage the entry of privately owned generating companies into the electricity sector

1992-97

- 8 projects given "fast-track" status
- Sovereign guarantees from Central Government
- Seven reached financial closure
- Dabhol (Enron), Bhadravati (Ispat), Jegurupadu (GVK), Vishakapatnam (Hinduja), Ib Valley (AES), Neyveli (CMS), Mangalore (Cogentrix)

1999-2000

State started facing power shortage – Godbole committee formed to calculate demand projections and provide solutions

2006

- GoM unbundled the MSEB into four companies' w.e.f June viz. MSEB Holding Company Ltd, Maharashtra State Power Generation Company Ltd (MSPGCL), Maharashtra State Electricity Transmission Company Ltd (MSETCL) and Maharashtra State Electricity Distribution Company Ltd (MSEDCL)
- Pune model of zero load shedding established w.e.f. September

2008

Pune model of zero load shedding revised in March, worked in association with Tata Power and suspended on July 15.

Tata Power secured additional power from Indian Energy Exchange on a day ahead basis on August 13, however MSEDCL insisted on firm power. Load shedding resumed in Pune from August 20.

Annexure III- Power plants in Pipeline

Land and water requirements of proposed and existing power plants in Konkan

No	Company	Location /Name of Project	Capacity (MW)	Land requirement (ha.)	Water requirement for cooling (m^3/day)	Fresh / Raw water requirement (m^3/day)	Total water req. (m^3/day)
	Coal and Gas based – Centre and State Government Projects						
1	NTPC	Dhopave, Guhagar, Ratnagiri	1600	485	4864000.0	7789.3	4871789.3
2	Central Govt. (NTPC)	Munge, Devgad (UMPP), Sindhudurg	4000	1236.3	12160000	19473.3	
	Gas based – Centre and State Government Projects						
3	RGPPL	Dabhol, Guhagar, Ratnagiri	1200 (Total land acquired by RGPPL)	688			
4	Uran upgradation	Uran, Raigad	1220	800.8	27000		27000
	Coal based-Private Power Projects						
5	GMR Energy	Bhopan, Dapoli, Ratnagiri	1980	612	6019200	9639	
6	JSW Energy	Jaigad, Ratnagiri	3200	989	9728000	15587.7	
			Existing 1200 MW	370.9	3648000	5842	
7	Finolex	Ranpar, Ratnagiri	Phase1-43	13.29	130720	209.3	
			Phase2-1000	200			198000
8	Reliance Energy	Shahpur, Thane	4000	919			200000
9	Reliance Industries Ltd	Saphale, Thane	495	263.1	1540480	2409.8	152889.8
10	TATA	Dehrand, Raigad	1600	444			130000
11	Ind Bharat Power (Konkan) Ltd	Dhakore, Anjagaon, Sawantwadi	1050	424.7	3192000	5111.8	

12	M/s IBPKL	Sindhudurg	450	182.1	1368000	2190.8	
13	M/s Ispat Energy Ltd	Dolvi, Raigad	1000	1011.7			100000
14	Tiana Power Projects Pvt. Ltd	Konkan- Anjarle	1500	344.7			75000
15	Larsen & Toubro	Nervi (Pawas & Purnagad)	2000	459.5			100000
	Nuclear power						
16	NPCIL, Central Govt.	Jaitapur, Ratnagiri	Units 1&2- 3350 Total- ~10,000	938.026	10368000		
	Gas based						
17	M/s Urban Energy Generation Pvt. Ltd	Vangni Tarfe Taloja, Raigad	2100	182.1			100440
18	Urban Energy Generation	Navi Mumbai Special Economic Zone at Dronagiri , Uran Taluka, Raigad	2000	40			3388920
19	Urban Energy Generation	Kondgaon, Roha, Raigad	2100	101.2			100400
20	Reliance Industries Ltd.	Nagothane, Raigad	800	69.4			38262.9
21	Poena Power Ltd.	Khalapur, Raigad	1300	242.8		72000	72000
	Captive Power Plant – Private Power Generation						
22	M/s Hi-Tech Carbon	Raigad	25	4.5			7200
		Total	**42263.0**	**9732.9**	**53045400.0**	**4403475.9**	**57448875.9**

The figures marked in red are calculated and those in blue were available in various database. The water and land requirements are bound to change depending on the type of technology used.

Vidarbha

It is learnt that 47 power plants will be set up in Vidarbha region. Vidarbha produces 67% of the total power in the state. According to the statutory board's report, the 47 projects would need 1,353 million cubic metres of water annually. This water, most of which is to be sourced from irrigation projects in the region, would deprive about 200,000 ha of agricultural land from irrigation, the statutory board and Vidarbha Industries Association estimated[305]. Of late in the summer months of April – May, 2010 certain units of the state power plants in Vidarbha were shut down due to scarcity of water.

No	Company	Location /Name of Project	Capacity (MW)
	Coal based thermal power projects		
1	Maharashtra State Power Generating Company Ltd (MahaGenCo)	Chandrapur Super Thermal Power Project Expansion	1000 (2x500)
2	Maharashtra Industrial Development Corporation ltd[306]	Bhadravati, Chandrapur	1320 (2x660)
3	Maharashtra State Mining Corporation (MSMC)	Nagbhid, Chandrapur	540
4	Gupta Energy Pvt. Ltd	Ghugus, Chandrapur	120 (2x60)
5	Gupta Energy Pvt. Ltd	Usgaon, Chandrapur	540 (2x270)
6	Wardha Power Company Pvt. Ltd. Unit I & II	Warora, Chandrapur	Phase I -270 (2x135)
7	EMCO Energy Ltd	Warora, Chandrapur	270
8	GMR Energy	Warora, Chandrapur	600
9	M/s Nagpur Energy infrastructure Ltd	Bhadravati , Chandrapur	1000
10	M/s Nagpur Energy Infrastructure Ltd[307]	Deulwada, Bhadravati Taluka Chandrapur / Nagpur	1200 (4x300)
11	Central Indian Power Company Ltd	Bhadravati , Chandrapur	1072 (2x536)
12	Dhariwal Infrastructure Pvt ltd	Tadali, Chandrapur	600 (2x300)
13	Nandlal Enterprises Ltd.	Kineboli, Chandrapur	750 (3x250)
14	Aryan Coal Benefications Pvt. Ltd	Pandarpauni, Chandrapur	60 (2x30)
15	Gopani Iron & Power	Chandrapur	15 (Captive use)
16	National Thermal Power	Mauda in Nagpur	1000 (2x500)

[305] Down to Earth, "47 power plants in Vidarbha", Aparna Pallavi, February 28, 2010
47 power plants in Vidarbha - Why set up thermal plants when the region is power surplus?
[306] http://thermalpower.industry-focus.net/index.php/industry-overview/342-list-of-upcoming-thermal-plants-in-india.html
[307] http://thermalpower.industry-focus.net/index.php/industry-overview/342-list-of-upcoming-thermal-plants-in-india.html

	Corporation (NTPC)		
17	Maharashtra State Power Generation Co. Ltd. (Mahagenco)	Koradi TPP expansion/replacement	1980
18	Maharashtra Airport Development Company	Khairi, Hingna taluka, Nagpur	100 (2x50)
19	Lenexis Energy	Khursapur, Umred taluka, Nagpur	1320 (2x660)
20	M/s Astarc Power Pvt. Ltd.	Pandhartal & Khursapar, Lohra taluka, Nagpur	1320 (2x660)
21	Vidarbha Industries Power ltd[308]	Butibori, Nagpur	300
22	Mantri Power Ltd	Bela in Nagpur	540 (4x135)
23	Ideal Energy Projects	Bela in Nagpur	270
24	Lanco Mahanadi Power Pvt.Ltd	Dahigaon, Wardha	1320
25	Abhijeet MADC Nagpur Energy Pvt. Ltd	Gumgaon, Nagpur	200
26	Suryalakshmi Cotton Mills	Ramtek, Nagpur	25 (Captive use)
27	Adani power	Tiroda, Gondia	1980 (3x660)
28	Sophia Power Company Ltd & Indiabulls Power Ltd.	Nandgaonpeth, Amravati	2640 (Stage I - 2x660) (Stage II- 2x660)
29	Maharashtra State Power Generation Co. Ltd. (Mahagenco)	Lohara village, Yavatmal	660
30	JV of Abhijeet group & Darda group	Yavatmal	1215
31	Jinbhuvish Power Generation Pvt.Ltd[309]	Dhanmukh, Mahagaon taluka, Yavatamal	540 (2x270) + 660
32	M/s Indo Rama Synthetics (I) Ltd.	Maregaon & Wani taluka, Yavatmal	1320 (2x660)
33	M/s Prithvi Khanij Sampada Pvt. Ltd	Tumsar taluka, Bhandara	1320 (2x660)
	Biomass based Thermal Power		
34	M/s A.A. Energy Ltd	Desaiganj taluka, Gadchiroli	10
	Cogeneration Plant		
35	RPL Urja	Kalmana in Yavatmal	100

[308] http://thermalpower.industry-focus.net/index.php/industry-overview/342-list-of-upcoming-thermal-plants-in-india.html

[309] http://thermalpower.industry-focus.net/index.php/industry-overview/342-list-of-upcoming-thermal-plants-in-india.html

Annexure IV- Regional Imbalance in Maharashtra

प्रादेशिक असमतोल आणि अनुशेष

१९६० मध्ये महाराष्ट्र राज्य स्थापन झाले, व त्यापूर्वी मध्य प्रदेशात असलेले विदर्भ आणि हैदेराबादेत असलेला मराठवाडा महाराष्ट्र समाविष्ट झाला. १९६० च्या अगोदर बॉम्बे प्रांतात मुंबई, पुणे, गुजरातेतला काही भाग असे सधन प्रदेश होते. भौगोलिक परिस्थिती, पश्चिम घाटाचे अस्तित्व, नैसर्गिक समृद्धी, पाण्याची बारमाही उपलब्धता यांमुळे कायमच सधन राहिलेला हा प्रदेश सर्वांगाने समृद्ध झाला. बरीच दशके मराठवाडा निझामाच्या राजवटीत असल्यामुळे तिथले मराठीपण कमकुवत झालेच होते. विदर्भ कायम ह्या राजवटीतून त्या राजवटीत प्रवास करत होताच. पश्चिम महाराष्ट्र च्या तुलनेत कमी समृद्ध असे हे दोन मोठे भौगोलिक आणि सांस्कृतिक प्रदेश महाराष्ट्रात एकवटले. विदर्भातली शेती पूर्णतः मोसमी पावसावर अवलंबून, तर मराठवाड्यात निजामाच्या अखत्यारीत मजुरी हाच उदरनिर्वाह असल्यामुळे यांचे विलीनीकरण 'महा'राष्ट्रात केल्यानंतर असमतोल चुकणार नव्हताच. पश्चिम महाराष्ट्रात पावसावर बहुसंख्यांची रोजी रोटी अवलंबून असली तरीही इथला पाउस काही भाग सोडता जवळपास सारखाच पडतो आणि पुरेसा होतो. विदर्भातला पाऊस पश्चिम महाराष्ट्रातील पावसाहून जास्त अव्यवस्थित आणि अनियमित आहे. पश्चिम महाराष्ट्रात उद्योजकता देखील पूर्वीपासून रूढ आहे, जी मराठवाड्यात तितकीशी नव्हती. सुखाने नांदणाऱ्या पश्चिम महाराष्ट्राला जेव्हा तुलनेने अल्प सुखात राहणारा विदर्भ आणि मराठवाडा येऊन चिकटला, तेव्हा असमतोल निर्माण झाला.

पश्चिम महाराष्ट्र आणि कोकण या विभागांना पश्चिम घाट छेद करतो. या दोनही विभागात पश्चिम घाटातील समृद्धीने मोलाची भर पाडली आहे. कोकण विभागात पश्चिम घाटाबरोबर समुद्र किनाराही आहे ज्यामुळे या विभागाचा विकास वेगळ्याच पद्धतीने झाला आहे.

महाराष्ट्र राज्याला ५२ वर्षे पूर्ण झाली. प्रादेशिक असमतोल जितका नैसर्गिक आहे तितकाच राहून इतर क्षेत्रांमध्ये एकत्रित विकास होणे ५२ वर्षात तरी अपेक्षित होते. पण तसे झाले नाही, असमतोल राहिलाच आणि वाढत्या लोकसंख्येमुळे राज्याचे आर्थिक संतुलन अधिकच बिघडले. विदर्भात व मराठवाड्यात पावसावर अधीनता, नोकऱ्यांची आणि उद्योगांची वणवण, यांमुळे राज्यातील विकास मुख्यत्वे पश्चिम महाराष्ट्र केंद्रितच राहिला.

नोव्हेंबर १९५६ मध्ये भारतीय संसदेत ७ वी घटना दुरुस्ती मंजूर झाली. त्यात काही राज्यांचे पुनर्गठन करण्यात आले ज्यामध्ये महाराष्ट्र राज्याला विभागवार विकास करण्याचे, विकास महामंडळे स्थापण्याचे आदेश मिळाले. संविधानिक तरतूद कायद्यात उतरवण्यासाठी महाराष्ट्र सरकार ने २८ वर्षे लावली, आणि जुलै १९८४ मध्ये महाराष्ट्र विधान सभेत आणि विधान परिषदेत विदर्भ विकास महामंडळ, मराठवाडा विकास महामंडळ, आणि उर्वरित महाराष्ट्र विकास महामंडळ स्थापित करण्याचे मंजूर झाले. त्या नंतर १० वर्षांनी मार्च १९९४ मध्ये राष्ट्रपतींनी महाराष्ट्र राज्याच्या राज्यपालांना घटनेच्या आर्टीकल ३७१ अन्वये

'विशेष जबाबदारी' चे आदेश दिले, ज्यानंतर महिन्याभरात एप्रिल १९८४ मध्ये तीन प्रदेशांसाठी तीन वेगवेगळी विकास महामंडळे स्थापन झाली.

केंद्रीय समित्या

असमतोल कमी करत करत सार्वत्रिक विकास घडून मानवी विकास निर्देशांक (Human Development Index) वाढवण्याचा राज्य सरकारचा उद्देश आहे. असमतोल कुठवर पोहोचला आहे, त्याची तीव्रता किती हे जाणण्यासाठी महाराष्ट्र सरकारने १९८३ साली अर्थतज्ञ व्ही. एम. दांडेकर यांच्या अध्यक्षतेखाली उच्चस्तरीय समिती गठीत केली (Fact Finding Committee). एप्रिल १९८४ मध्ये दांडेकर समितीचा अहवाल प्रसिध्द झाला. संतुलित विकास राखण्यासाठी विविध विभागांना साधनसंपत्ती ची गरज ३१८७ कोटी आहे असे अहवालाने सांगितले. त्यात विदर्भाचा वाटा ३९%, उर्वरित महाराष्ट्राचा ३७% आणि मराठवाड्याचा २४% इतका होता.

१९९५ साली राज्यपालांनी 'Indicators and Backlog Committee' गठीत केली. जुलै १९९७ मध्ये या समितीच्या अहवालात असे सांगण्यात आले की प्रादेशिक असमतोल भरून काढण्यासाठी १ एप्रिल १९९४ या तारखेला १५३५५ कोटींची गरज आहे[310]. त्यात विदर्भाचा वाटा ४७%, मराठवाड्याचा २८% आणि उर्वरित महाराष्ट्राचा २३% इतका होता.

रस्ते, सिंचन, ग्राम विद्युतीकरण, शिक्षण, तंत्रशिक्षण, आरोग्य, पाणी पुरवठा, जमिनीचा विकास आणि संवर्धन या मुद्द्यांना केंद्रस्थानी ठेवून या दोन्ही समित्यांनी आपला अहवाल प्रसिध्द केला.

पुन:चाचपणी साठी राज्यपालांनी १९९७ मध्ये पुन्हा एकदा 'Reconstituted Indicators and Backlog Committee' गठीत केली. या अहवालाने १ एप्रिल १९९४ ला १४००६ कोटींची गरज सिद्ध केली आणि विदर्भ आणि मराठवाड्याची टक्केवारी पुन: परीक्षणानंतर वाढवली.

तालिका 1 – प्रादेशिक अनुशेष भरून काढण्यासाठी निधीची प्रदेशनिहाय वाटणी

प्रदेश / समिती	दांडेकर समिती (१९८४)	Reconstituted Indicators and Backlog Committee (१९९४)
विदर्भ	३९.१२	४७.६०
मराठवाडा	२३.५६	२८.७७
उर्वरित महाराष्ट्र	३७.३२	२३.६३

[310] Business Standard, "Kelkar to head Maharashtra panel on regional balance", Sanjay Jog, Febryary 23, 2011 - http://www.business-standard.com/india/news/kelkar-to-head-maharashtra-panelregional-balance/426206/

तिन्ही समित्यांचे अहवाल आल्यानंतर देखील उर्वरित महाराष्ट्राला राखीव तरतुदीपेक्षा जास्त निधी वळवण्यात आळा, आणि विदर्भ आणि मराठवाड्यात कमी. मराठवाडा आणि विदर्भाचा वाढत चाललेला वाटा असमतोल वाढतो आहे हेच दर्शवतो.

सिंचन

सिंचन क्षेत्रात प्रादेशिक असमतोल अशा प्रकारे घडलेला आहे.

तालिका 2: एकूण अनुषेशातील सिंचनाची टक्केवारी[311]

प्रदेश / साल	१९८४	१९९४	२०००
विदर्भ	४२.३०	६१.६४	६८.४७
मराठवाडा	४२.१८	५९.९६	६१.२९
उर्वरित महाराष्ट्र	४५.५६	२७.६५	१८.४२

महाराष्ट्राची उर्जेची गरज देशात सर्वात जास्त आहे. मुंबई, ठाणे, पुणे, नाशिक येथील विकसित केंद्रांमध्ये ती सर्वात जास्त भागली जाते. पश्चिम महाराष्ट्रातील (उर्वरित महाराष्ट्र) ग्रामीण भागात देखील वीज पुरवठा जवळपास सर्व ठिकाणी झालेला दिसतो. विदर्भात नागपूर आणि मराठवाड्यात औरंगाबाद सोडले तर तेवढे मोठे शहरी केंद्र कोणतेही नाही. मुंबई जवळील विकसित विभागात १२ महानगरपालिका आहेत. याच भागात सुमारे राज्यातील ४ कोटी जनता वास्तव्यास आहे.

महाराष्ट्र राज्य विकास अहवाल[312] ही सांगतो की विकसित ११ जिल्हयांपैकी ७ जिल्हे पश्चिम महाराष्ट्रात आहेत. परकीय थेट गुंतवणुकीमुळे शहरी आणि ग्रामीण भागातील अंतर वाढले आहे असेही अहवाल सांगतो. यांमुळे या विकसित भागात उर्जेचा वापर प्रचंड प्रमणात आहे. शेती क्षेत्रात कोल्हापूर, नाशिक व अहमदनगर अग्रमानांकित आहेत. शेती पंप सर्वात जास्त प्रमाणात इथेच आढळतात. महाराष्ट्रात शेती साठी वीज विना-मीटर देण्याची सवलत आहे. या सर्व बाबींमधून विजवापराच्या प्रमाणाचा अंदाज येतो.

[311] http://rajbhavan.maharashtra.gov.in/responsibility/responsibilities_devboard.htm
[312] Government of India, Planning Commission, Maharashtra State Development Report, 2006

उर्जा निर्मिती

सिंचन आणि उर्जा निर्मिती यांच्यातील संबंध घनिष्ठ आहे. महाराष्ट्रात ६०% उर्जा कोळशातून निर्माण केली जाते. कोळशातून वीज निर्मिती साठी मुबलक पाण्याचा वापर करावा लागतो. पाणी पिण्यासाठी, शेतीसाठी, की ऊर्जानिर्मितीसाठी सोडायचे हा वाद कायमच उठतो. शहरी भागात जास्तीत जास्त लोकांचे स्थलांतर होत असते. शहराची लोकसंख्या आणि बाजारपेठ वाढत जाते, ज्यामुळे शहरांतील पिण्याच्या पाण्याला प्राधान्य दिले जाते. पण शेती व्यवसायावर अवलंबून असलेला वर्ग खूप मोठा आहे. उद्योगांच्या मार्फत तर राज्य सरकारला सर्वात जास्त महसूल मिळतो, आणि आर्थिक विकासही त्यांतूनच घडतो. त्यामुळे राज्य सरकारची दरसाल पाणी कोणत्या विभागाला, नेमकी कुठली गरज भागवण्याकरता द्यायचे याची चढाओढ सुरु असते. किंबहुना पाणी देण्याची सुरुवात कोणापासून करायची यावरून वाद उसळतात. आणि ह्याच्यामध्ये उर्जा निर्मिती फसते.

राज्याच्या सर्व भागात लोकसंख्येप्रमाणे पाण्याची समान वाटणी झाली पाहिजे आणि त्यानंतर व्यवसायाप्रमाणे वर्गवारी करून त्याप्रमाणे वाटणी झाली पाहिजे. शेती, उर्जा निर्मिती, फर्टीलायजर, सिमेंट, पेपर उत्पादन या उद्योगांना भरपूर प्रमाणात वीज आणि पाणी लागते. जसजसे शहरी केंद्रा वाढत जातील, तसतशी त्यांची पाण्याची गरज देखील वाढणार आहे. त्यातून पश्चिम महाराष्ट्रात आणि मराठवाड्यातील काही भागात ऊसाची बेमतलब लागवड आहे. ऊसाची पाण्याची गरज पाहता महाराष्ट्र राज्य किती उसाचे पीक सहन करू शकेल याला एक सीमा आहे. दुसऱ्या महाराष्ट्र राज्य सिंचन आयोगाचे अध्यक्ष डी. एन. मोरे यांनी देखील ऊसाच्या पिकाचा महाराष्ट्रातील पाणी टंचाई मध्ये मोठ वाटा आहे. इतकेच नाही तर धुळे ते सांगली हा पट्टा पर्जन्य छायेत येतो, आणि तरीही तिथे ऊसाचीच लागवड जास्त आहे.

जास्तीत जास्त ऊस पश्चिम महाराष्ट्रात (कोकण वगळून) निघतो. नगदी पीक असल्याने शेतकरी उसाच्या मागेच धावतो. राज्याच्या उत्तर भागातील नर्मदा आणि तापी सोडता सगळ्या नद्या पूर्व वाहिन्या आहेत - पश्चिम घाटात उगम पावून बंगाल च्या उपसागराला जाऊन मिळतात. कृष्णा आणि गोदावरी या दोन नद्यांच्या खोऱ्यांनी व उपखोऱ्यांनी महाराष्ट्र बहरला आहे. कधी टंचाई येउच नये इतके पाणी उपलब्ध आहे. पण अयोग्य पाणी वाटपामुळे मराठवाडा आणि विदर्भ या विभागांना झळ बसते आहे.

तालिका 3 – विभागवार धरणे, पाणी साठवण क्षमता आणि उर्जा निर्मिती क्षमता

विभाग	धरणे	पाणी साठवण क्षमता (द.ल.घ.मि.)	जलविद्युत क्षमता (MW)	महानिर्मिती औष्णिक विद्युत निर्मिती केंद्रे	खाजगी व केंद्रीय औष्णिक विद्युत निर्मिती केंद्रे	औष्णिक विद्युत क्षमता (MW)	वीज वापराची टक्केवारी	जिल्ह्यांची संख्या
पश्चिम महाराष्ट्र	918	16798	2975	1	5	5500	71.42	14
मराठवाडा	803	7583	0	1	0	1130	8.86	9
विदर्भ	731	6927	53	5	2	7185	19.72	12

मराठवाडा आणि विदर्भ मिळून जितका पाणीसाठा आहे त्याहूनही जास्त पाणी साठवण्याची क्षमता फक्त पश्चिम महाराष्ट्रात आहे. साहजिकपणे जलविद्युत प्रकल्प पश्चिम महाराष्ट्रात जास्त आहेत, किंबहुना फक्त पश्चिम महाराष्ट्रातच आहेत.

विदर्भात ७ औष्णिक प्रकल्पातून ७१८५ MW वीजनिर्मिती होते, मराठवाड्यात एका प्रकल्पातून ११३० MW तर पश्चिम महाराष्ट्रात ६ प्रकल्पातून ५५०० MW इतकी वीज निर्मिती होते.

महाराष्ट्रातील कोळसा खाई मुख्यत्वे विदर्भात आहेत. महाराष्ट्र, मध्य प्रदेश, छत्तीसगड आणि आंध्र प्रदेश सीमा भागात नैसर्गिकरित्या उपलब्ध कोळशाचे जाळे आहे. म्हणूनच महाराष्ट्रातील सर्वात जास्त औष्णिक उर्जा निर्मिती क्षमता विदर्भात आहे. पाण्याच्या उपलब्धतेमुळे पश्चिम महाराष्ट्रात खाजगी औष्णिक प्रकल्प आहेत. मराठवाड्यात पाणी आणि कोळसा दोन्हीची वानवा असल्यामुळे वीज निर्मिती प्रकल्पांना थारा मिळाला नसावा.

पश्चिम महाराष्ट्रात ऊसाला प्रचंड प्रमाणात पाणी दिले गेल्यामुळे, तर विदर्भात उर्जा निर्मिती साठी पाणी वळवल्यामुळे दोन्ही भागात पिण्याच्या पाण्याचे प्रश्न उभे राहिले आहेत. नवीन प्रकल्पांना पाणी मंजूर केले असता आंदोलने केली जात आहेत. पाण्याचे वाटप अव्यवस्थित झाले आहे, व त्यामुळे उर्जा क्षेत्रावर ताण पडतो आहे.

ऊर्जा वापर

वरील तक्त्यातून आपण हेही पाहू शकतो की पश्चिम महाराष्ट्रात राज्याजाडे असलेल्या विजेपैकी ७१% वीज वापरली जाते. राज्यात जवळपास ५०% वीज पुणे, ठाणे व मुंबई विभागात वापरली जाते. राज्यातील एकाच भागात इतका भरमसाठ वीजवापर आणि उरलेल्या भागात अत्यल्प वापर प्रादेशिक असमतोल गंभीरपणे दर्शवतो. मराठवाडा आणि विदर्भात २१ जिल्ह्यांमध्ये मिळून राज्यातील २८% वीजवापर होतो. याचे कारण अपुरी वीज निर्मिती देखील असू शकते. फक्त महत्त्वाच्या ठिकाणी उत्कृष्ट वीज पुरवठा केला जातो. पुणे, ठाणे मुंबई नक्कीच मोठी शहरे म्हणून प्रस्थापित झाली असतील, परंतु राज्यातील ५० वीज जर एकाच विभागातून मागणी असेल, तर इतर विभागांच्या सार्वत्रिक विकासाकडे लक्ष दिले गेले पाहिजे.

तालिका 4 – महावितरण च्या 'झोन' प्रमाणे वीज वापर

Zone	Consumers	Demand (Rs)	Collection (Rs)	Efficiency	% of total demand
Vidarbha					
Amravati	1966931	12007073868	11529724317	96.02	3.96
Nagpur Urban	932536	19488405605	19852276192	101.87	6.43
Nagpur	1276851	16501571159	16650616191	100.9	5.45
Jalgaon	1214033	11763769068	11043574227	93.88	3.88
Marathwada					
Aurangabad	834064	17137067844	16536710865	96.5	5.66
Latur	1058332	5230357640	4496328157	85.97	1.73
Nanded	828629	4465126597	3757700584	84.16	1.47
Western Maharashtra					
Baramati	1859715	21387447548	21316397374	99.67	7.06
Bhandup Urban	1550316	46431472069	46706818671	100.59	15.32
Pune	1848704	48873867996	50120524929	102.55	16.13
Kalyan	1905178	53243327924	51978151136	97.62	17.57
Kokan (Ratnagiri)	674725	5002047534	5082283693	101.6	1.65
Kolhapur	1480101	17040004548	17215933867	100.44	5.62
Nasik	1938580	24424756495	22497419456	92.11	8.06

विभागातील उद्योग, शेती, लोकसंख्या यांप्रमाणे ऊर्जा वापर कमी जास्त नक्कीच होऊ शकतो. सर्व विभागांमध्ये समान ऊर्जा वापरण्याचे धोरण आखता येणे अवघड आहे. विभागवार गरजा वेगळ्या, व्यवसाय वेगळे व त्यामुळे ऊर्जा वापर देखील वेगळा. पण वीज उपलब्धता ही एक मूलभूत गरज झालेली आहे. तटस्थपणे विजेची गरज पाहता एक किमान पातळी असावी की जितकी वीज राज्यातील प्रत्येकास त्याच्या स्वखर्चातून वापरायला मिळेल. कमीत कमी दिवे, पंखे, टी.व्ही., संगणक यांसाठी लागणारी वीज मिळणे आवश्यक आहे. एका व्यक्ती पेक्षा एका कुटुंबाला विजेची गरज नेमकी किती आहे, याची किंमत काढली तर अजून महाराष्ट्रात वीज पुरवठ्याचा अनुशेष प्रचंड प्रमाणात आहे.

तक्त्यात हे दिसून येते की पुणे, कल्याण व भांडूप या तीन वीज वितरण विभागात (zones) राज्याच्या ४९% वीज पुरवठा होतो. इतर विभागात विजेचा पुरवठा नाही की विजेची मागणी नाही हा मोठा प्रश्न आहे. पश्चिम महाराष्ट्र सोडल्यास इतर विभागात उद्योग, नोकऱ्या यांचे प्रमाण कमी आहे, व त्यामुळे तेथील बराच मोठा युवक वर्ग पश्चिम महाराष्ट्रात शिक्षण अथवा रोजगारासाठी येतो. राज्यातील सर्व विभागात शिक्षण, नोकरी, उद्योगांसाठी दारे उघडी झाली पाहिजेत जेणे करून सर्व विभागांत विकासाचे हात पोचतील. सर्वांगीण विकास होत असतानाच वीजवापर वाढतो; या दृष्टीने विजेची मागणी वाढली पाहिजे. मराठवाडा व विदर्भाच्या वीज निर्मिती, वापर व पुरवठ्याच्या उद्देशाने विशेष प्रयत्न केले पाहिजेत असेच यातून दिसून येते.

ग्रामीण (शेतीपंप) विद्युतीकरण

राज्यपालांच्या निर्देशांनुसार शेती पंप विद्युतीकरणासाठी महाराष्ट्राच्या शेती पंप अनुशेष निधीतून विदर्भाला ६०% निधी देण्याची गरज आहे313. मराठवाड्याला १३% व उर्वरित महाराष्ट्राला २७% इतका (२००८-०९).

एम.जी.किंमतकर, तज्ञ, विदर्भ वैधानिक विकास महामंडळ यांनी अहवालात दिलेल्या माहिती नुसार:

- १००० हेक्टरी विदर्भात १००.३२ पंप आहेत. पश्चिम महाराष्ट्रात तोच आकडा १९१.२५ तर मराठवाड्यात १२६.१३ आहे. (२००५)
- शेती पंपासाठीचा प्रति-हेक्टरी वीजवापर पश्चिम महाराष्ट्रात ८२८ युनिट, मराठवाड्यात ४८७ युनिट, तर विदर्भात प्रति-हेक्टरी वीजवापर १९३ युनिट इतकाच आहे. (२००६-०७)
- शेती पंपांच्या एकूण वीज वापरात पश्चिम महाराष्ट्र ६६%, मराठवाडा २२% आणि विदर्भ १२% अशी टक्केवारी आहे. (२००५)
- राज्यात सरासरी पेक्षा पश्चिम महाराष्ट्रात ३.८५ लाख जादा शेती पंप बसवले आहेत. मराठवाड्यात आणि विदर्भात सरासरीहून कमी शेतीपंप बसवले गेले आहेत. (२००८)
- फक्त पुणे जिल्ह्याचा शेती पंपांसाठीचा वीज वापर विदर्भातील ११ जिल्ह्यांच्या एकूण वीज वापराहूनही जास्त आहे.
- २०१२-१३ साठी चे राज्यपालांचे निर्देश असे सांगतात की ६ जिल्हे सोडल्यास सर्व ठिकाणी शेती पंपांचा अनुशेष भरून निघालेला आहे. कोकणातील ठाणे, रायगड, आणि रत्नागिरी तर विदर्भातील यवतमाळ, चंद्रपूर आणि गडचिरोली यांमध्ये अजूनही एकूण ५८०६८ शेती पंपांची कमतरता आहे. (२०१२)

[313] Government of Maharashtra, Governor's directives for Regional Backlog, 2008-09

केंद्रीय विद्युत प्राधिकरणाच्या (Central Electricity Authority) अहवालाप्रमाणे महाराष्ट्रात ३८,३६,१७३ शेती पंपाना वीज पुरवठा आहे314. महाराष्ट्रातील भूजलाच्या पातळीप्रमाणे २४,४९,८०० इतकेच किंवा याहून कमी शेतीपंप असावेत असे CEA चा अहवाल सांगतो (२०१२).

वितरण हानी

महावितरणने दिलेल्या माहिती नुसार मराठवाड्यातील बीड, परभणी, लातूर, उस्मानाबाद; विदर्भातील अकोला व वाशीम; आणि उत्तर महाराष्ट्रातील नंदुरबार इथे वितरण हानी सर्वात जास्त आहे. मराठवाड्यातील जिल्ह्यांत उच्चांकी वितरण हानी दिसून येते. वितरण हानीचा फटका वितरण कंपनीला बसतो, आणि वितरण कंपनी ही वीज निर्मिती कंपनीला देयक असल्यामुये अंतिमतः हा फटका वीज निर्मिती करणाऱ्या कंपनीला बसतो. फक्त काही जिल्ह्यातील दुय्यम दर्ज्याच्या वीज पुरवठ्यामुळे संपूर्ण ग्राहकवर्गाला वाढीव वीज आकार पडतो.

वितरण हानीची प्रमुख कारणे आहेत बिगर-मीटर वीज जोड, अव्यवस्थित मीटर व बेकायदेशीर मीटर जोड व यांमुळे होणारी वीज चोरी. खराब झालेले फीडर, खराब झालेल्या विद्युत पारेषण तारा यांमुळे देखील वितरण व पारेषण हानी वाढते. जिल्हा स्तरावर यांचे मोजमाप होते. याशिवाय वीजबिल संचायानाची कार्यप्रवणता (collection efficiency) देखील मराठवाड्यातील जिल्ह्यांना समाविष्ट करणारे महावितरणचे विभाग - लातूर व नांदेड - यांमध्ये उच्चांकी आहे. जवळपास १५% बिल किंमत ग्राहकांकडून वसूल करण्यात महावितरणला अपयश येते. मराठवाड्यात वीजवितरण व वीजबिल संचायानात अडचणी दिसून येत आहेत, व त्यांना संपुष्टात आणण्यासाठी प्रादेशिक दृष्ट्या पावले उचलली पाहिजेत.

वितरण हानीची आकडेवारी स्वतः महावितरणने संपादित केलेली आहे. एका त्रयस्थ समितीने ती मोजण्याचे काम केले पाहिजे. ज्या विभागांमध्ये महावितरणला सर्वात जास्त तोट्याला सामोरे जावे लागत आहे त्या विभागांमध्ये फक्त लोड शेडींग करून प्रश्न सुटणार नाही असेच इतिहासाने सांगितले आहे. एखाद्या विभागात कर्ज माफी, थकबाकी माफी केल्याने निर्मिती व वितरण कंपनी यांचाच तोटा होतो, व तो ग्राहकाकडून वसूल केला जातो.

१. ज्या विभागांत वितरण व संचायानात अडचणी येत आहेत, त्या त्या विभागांतील अधिकाऱ्यांना या बाबतीत जबाबदार धरले पाहिजे, व त्यांच्याकडून जबाब मागितला पाहिजे.
२. तांत्रिक व अतांत्रिक दोन्ही कारणांमुळे या तोट्याला तोंड द्यावे लागत आहे. सर्व प्रथम खराब झालेले मीटर, फीडर, पारेषण तारा यांना बदलून तांत्रिक अडचणींना पहिले नेस्तनाबूत केले पाहिजे.
३. त्यानंतर फसवे मीटर, बेकायदेशीर मीटर यांचा शोध घेऊन त्यांवर कायदेशीर कारवाई केलीच पाहिजे.

[314] Government of India, Ministry of Power, Central electricity Authority, “Progress Report of Pumpset energisation”, October 2012

४. त्याचबरोबर जिथे वीजबिल संचयन अव्यवस्थित आहे, तिथे खास समिती/पोलीस/SIT गठीत करून तपास केला पाहिजे. थकबाकी असलेले फीडर जोपर्यंत बिल भरणा होत नाही तोपर्यंत बंद केले पाहिजेत.
५. बिगर मीटर वीज जोड (कनेक्शन) कायमचे बंद केले पाहिजेत. शेती साठी देऊ केलेल्या या योजनेत जिथे वापरलेल्या विजेचे मोजमाप होत नाही, तिथेच वीज चोरी ला सर्रास वाव असतो, ज्याला प्रथम आळा घातला पाहिजे.
६. शेतीचे फीडर वेगळे करून प्रश्न अर्धवट सुटेल; पण १००% ग्राहकांकडे मीटर बसवले गेले तर संपूर्णतः सुटेल.

समित्यांनी केलेल्या शिफारशींची अंमलबजावणी

राज्य सरकारने औपचारिक रित्या संगठीत समितीच्या अहवालातील शिफारशी मान्य केल्या नाहीत, परंतु १९८५ नंतर अल्प प्रमाणात प्रदेशक अनुशेष कमी करण्यासाठी देऊ केला गेला. १९८५ साली २०० कोटी पासून ते १९९३ साली ५०० कोटी पर्यंत निधी देण्यात आला. सन १९९४ मध्ये प्रादेशिक विकास महामंडळांची स्थापना झाल्यानंतर अनुशेष निधी ५०० कोटी वरून ९०० कोटी पर्यंत नेण्यात आला. १९९७-९८ ते २०००-०१ दरम्यान ११०० कोटी अनुशेष निधी राज्य सरकारने देऊ केला, जो २००१-०२ साली १७२० कोटी पर्यंत नेण्यात आला315.

वर्ष	१९८५	१९९३–९४	१९९४	१९९७–९८	२००१–०२
अनुशेष निधी	२०० कोटी	५०० कोटी	९०० कोटी	११०० कोटी	१७२० कोटी

प्रस्तावित वीज निर्मिती केंद्रे

भारतात प्रस्तावित कोळशावर आधारित औष्णिक वीज निर्मिती केंद्रांमध्ये सर्वात जास्त वीज निर्मिती केंद्रे महाराष्ट्रात प्रस्तावित आहेत. ८९२६९ MW वीज निर्मिती महाराष्ट्रातील औष्णिक केंद्रांत होणार आहे. त्यातील ४११९५ MW इतकी वीज निर्मिती फक्त विदर्भात प्रस्तावित आहे, व कोकणात ३०९७८ MW इतकी प्रस्तावित आहे.

या घडीला देखील विदर्भात अर्ध्याहून जास्त वीजनिर्मिती क्षमता आहे, आणि वीजवापर २०% आहे. तेथील लोकांमध्ये असमतोल घडवून आणल्याचा राग आहे. वेगळ्या विदर्भ राज्याची मागणी संयुक्त महाराष्ट्राच्या वेळीसुद्धा केली गेली होती, आणि ती आत्ताही केली जात आहे त्यात या कारणांची देखील भर आहे.

315 http://rajbhavan.maharashtra.gov.in/responsibility/responsibilities_devboard.htm

डॉ. विजय केळकर उच्च स्तरीय समिती (२०११)

अनुशेष आणि विकास खर्चाचे समान वाटपाचा नव्याने विचार करून साधन संपत्ती चे सामान्यायातेने वाटप करण्यासाठी व त्यांची तत्वे सूचित करण्यासाठी ज्येष्ठ अर्थतज्ञ डॉ. विजय केळकर यांच्या अध्यक्षतेखाली ३१ मे २०११ रोजी उच्चस्तरीय समिती स्थापन करण्यात आली. ३१ मे २०१२ पर्यंत[316] अहवाल प्रसिध्द करण्याचे आदेश समितीला होते, परंतु २० जुलै २०१२ च्या GR (General Resolution) द्वारे महाराष्ट्र सरकारने मार्च २०१३ पर्यंत मुदतवाढ करून दिली[317].

या अहवालावर सर्वांगीण चर्चा होणे व त्याप्रमाणे आराखडा आखून तंतोतंत अंमलबजावणी होणे महाराष्ट्रासाठी प्रचंड महत्त्वाचे आहे. वेगवेगळ्या प्रदेशांमध्ये नैसर्गिक संपत्ती, प्रादेशिक इतिहास, लोकसंख्या यांमुळे फरक असणारच, पण राज्यातील लोकांसाठी पाणी, वीज व इतर इन्फ्रास्ट्रक्चर, रोजगार अर्थातच एकूण समृद्धीसाठी सारखेच मार्ग मोकळे झाले पाहिजेत, प्रदेश निहाय असू नयेत.

निष्कर्ष

पाण्याची उपलब्धता, सिंचन, कोळशाची उपलब्धता, उर्जा निर्मिती, उर्जा वापर, वितरण हानी आणि वीज बिल वसुली यांच्या बाबतीत महाराष्ट्राच्या विविध विभागात प्रचंड असमतोल आहे. विदर्भात कोळसा व वीज निर्मिती, मराठवाड्यात वितरण हानी, आणि पश्चिम महाराष्ट्रात विजेचा वापर असा महाराष्ट्रातील उर्जेच्या संबंधित असमतोल विखुरलेला आहे. राज्यात सर्वत्र वीज जोड मीटर बसवणे, संपूर्ण वीजेचे जाळे संगणक प्रणालीत अंगीकृत करणे प्रचंड महत्त्वाचे आहे. वीज निर्मिती, वीज वितरण आणि वीज वापर या तिन्ही क्षेत्रात असमतोल कमी व्हावा यासाठी राज्य सरकारने प्रादेशिक अनुशेष निधी संबंधित विकास महामंडळाकडे त्वरित वळवणे गरजेचे आहे.

[316] http://samatolvikas.org/attachments/article/45/gr_20110609124500001.pdf
[317] http://samatolvikas.org/attachments/article/45/extension_gr_20_july_2012.pdf

Annexure V - Installed Capacity, Generation and Efficiency of MahaGenCo Thermal Power Stations

Table 77- Installed capacity, generation and efficiency of Koradi Thermal Power Station

Year	Installed capacity (MW)	Generation (MW)	Efficiency (%)
74-75	120	40	33
75-76	360	125	35
76-77	480	206	43
77-78	480	299	62
78-79	480	321	67
79-80	680	411	60
80-81	680	401	59
81-82	680	407	60
82-83	890	458	51
83-84	1100	393	36
84-85	1100	388	35
85-86	1100	460	42
86-87	1100	446	41
87-88	1100	532	48
88-89	1100	506	46
89-90	1100	625	57
90-91	1080	652	60
91-92	1080	689	64
92-93	1080	695	64
93-94	1080	715	66
94-95	1080	648	60
95-96	1080	716	66
96-97	1080	724	67
97-98	1080	653	60
98-99	1080	670	62
99-00	1080	647	60
00-01	1080	681	63
01-02	1080	697	65
02-03	1080	704	65
03-04	1080	716	66
04-05	1080	735	68
05-06	1080	737	68
06-07	1080	776	72

Average Efficiency of Koradi thermal power station (units 1 to 7) is 57%

Table 78 - Installed capacity, generation and efficiency of Nasik Thermal Power Station

Year	Installed Capacity (MW)	Generation (MW)	Efficiency (%)
70-71	140	18	13
71-72	280	123	44
72-73	280	171	61
73-74	280	171	61
74-75	280	156	56
75-76	280	135	48
76-77	280	173	62
77-78	280	176	63
78-79	280	163	58
79-80	490	227	46
80-81	700	323	46
81-82	910	430	47
82-83	910	419	46
83-84	910	466	51
84-85	910	473	52
85-86	910	581	64
86-87	910	571	63
87-88	910	615	68
88-89	910	523	58
89-90	910	565	62
90-91	910	533	59
91-92	910	554	61
92-93	910	570	63
93-94	910	576	63
94-95	910	589	65
95-96	910	576	63
96-97	910	578	63
97-98	910	590	65
98-99	910	618	68
99-00	910	670	74
00-01	910	667	73
01-02	910	646	71
02-03	910	609	67
03-04	910	644	71
04-05	910	650	71
05-06	910	657	72
06-07	910	745	82

Average Efficiency of Nasik thermal power station (units 1 to 5) is 60%

Table 79-Installed capacity, generation and efficiency of Bhusawal Thermal Power Station

Year	Installed capacity (MW)	Generation (MW)	Efficiency (%)
68-69	62.5	25	41
69-70	62.5	36	57
70-71	62.5	34	54
71-72	62.5	42	66
72-73	62.5	45	73
73-74	62.5	47	75
74-75	62.5	45	72
75-76	62.5	31	49
76-77	62.5	53	85
77-78	62.5	41	65
78-79	272.5	46	17
79-80	272.5	44	16
80-81	272.5	135	50
81-82	272.5	125	46
82-83	482.5	114	24
83-84	482.5	227	47
84-85	482.5	221	46
85-86	482.5	288	60
86-87	482.5	241	50
87-88	482.5	278	58
88-89	482.5	305	63
89-90	482.5	311	65
90-91	482.5	355	73
91-92	482.5	310	64
92-93	482.5	340	71
93-94	482.5	289	60
94-95	482.5	329	68
95-96	482.5	296	61
96-97	482.5	286	59
97-98	482.5	355	74
98-99	482.5	328	68
99-00	482.5	384	80
00-01	482.5	335	69
01-02	482.5	384	80
02-03	482.5	296	61
03-04	482.5	379	78
04-05	482.5	376	78
05-06	482.5	386	80
06-07	482.5	365	76

Average Efficiency of Bhusawal thermal power station (unit 1 to 3) is 61%

Table 80 - Installed capacity, generation and efficiency of Paras Thermal Power Station

Year	Installed capacity (MW)	Generation (MW)	Efficiency (%)
67-68	62.5	13	21
68-69	62.5	25	40
69-70	62.5	21	34
70-71	62.5	35	56
71-72	62.5	36	58
72-73	62.5	36	58
73-74	62.5	47	75
74-75	62.5	45	72
75-76	62.5	33	53
76-77	62.5	42	67
77-78	62.5	46	74
78-79	62.5	43	69
79-80	62.5	45	72
80-81	58	45	78
81-82	58	33	57
82-83	58	37	64
83-84	58	32	55
84-85	58	24	41
85-86	58	39	67
86-87	58	25	43
87-88	58	39	67
88-89	58	31	53
89-90	58	36	62
90-91	58	32	55
91-92	58	41	71
92-93	58	31	53
93-94	58	32	55
94-95	58	23	40
95-96	58	23	40
96-97	58	24	41
97-98	58	23	40
98-99	58	34	59
99-00	58	40	69
00-01	58	44	76
01-02	58	42	72
02-03	58	34	59
03-04	58	48	83
04-05	58	45	78
05-06	58	55	95
06-07	58	49	84

Average Efficiency of Paras thermal power station (unit 1) is 60%

Table 81 - Installed capacity, generation and efficiency of Parli Thermal Power Station

Year	Installed capacity (MW)	Generation (MW)	Efficiency (%)
71-72	60	4	7
72-73	60	39	66
73-74	60	49	82
74-75	60	45	76
75-76	60	47	79
76-77	60	49	82
77-78	60	50	83
78-79	60	53	88
79-80	60	51	86
80-81	270	71	26
81-82	270	100	37
82-83	270	203	75
83-84	270	189	70
84-85	270	200	74
85-86	480	231	48
86-87	480	220	46
87-88	480	290	60
88-89	690	390	57
89-90	690	358	52
90-91	690	312	45
91-92	690	296	43
92-93	690	251	36
93-94	690	363	53
94-95	690	400	58
95-96	690	375	54
96-97	690	434	63
97-98	690	447	65
98-99	690	512	74
99-00	690	471	68
00-01	690	519	75
2001-02	690	505	73
2002-03	690	523	76
2003-04	690	492	71
2004-05	690	559	81
2005-06	690	589	85
2006-07	690	522	76

Average Efficiency of Parli thermal power station (Stage 1 & 2 – units 1 to 5) is 64%

Table 82- Installed capacity, generation and efficiency of Khaparkheda Thermal Power Station

Year	Installed Capacity (MW)	Generation (MW)	Efficiency (%)
89-90	210	0.5	0
90-91	420	103	25
91-92	420	287	68
92-93	420	265	63
93-94	420	325	77
94-95	420	353	84
95-96	420	291	69
96-97	420	377	90
97-98	420	350	83
98-99	420	337	80
99-00	420	283	67
00-01	630	400	63
2001-02	840	629	75
2002-03	840	702	84
2003-04	840	684	81
2004-05	840	718	85
2005-06	840	651	78
2006-07	840	751	89

Average Efficiency of Khaparkheda thermal power station (units 1 to 4) is 70%

Table 83 - Installed capacity, generation and efficiency of Chandrapur Thermal Power Station

Year	Installed Capacity (MW)	Generation (MW)	Efficiency (%)
84-85	420	84	20
85-86	630	199	32
86-87	840	395	47
87-88	840	470	56
88-89	840	428	51
89-90	840	505	60
90-91	840	484	58
91-92	1340	581	43
92-93	1840	643	35
93-94	1840	893	49
94-95	1840	1013	55
95-96	1840	1286	70
96-97	1840	1347	73
97-98	2340	1346	58
98-99	2340	1533	66
99-00	2340	1805	77
00-01	2340	1776	76
2001-02	2340	1852	79
2002-03	2340	1733	74
2003-04	2340	1853	79
2004-05	2340	1818	78
2005-06	2340	1597	68
2006-07	2340	1502	64

Average Efficiency of Chandrapur thermal power station (units 1 to 4) is 59%

Annexure VI - Works undertaken under APDRP

Table 84 - List of works undertaken under APDRP Phase-I (as on 30 September 2008)

Works undertaken	Program
No of 33 KV Substations (Nos.)	64
33 KV Line (Km)	706.1
11 KV Line (Km)	4757.1
LT Line (Km)	1205.5
No of New Distribution Transformers (Nos.)	7172
S/S Revamping (Nos.)	243
S/S Augmentation (Nos.)	33
Single Phase meters (Nos.)	1686882
Three phase meters (Nos.)	77486
CT operated Meters at DTC (Nos.)	30514
Agriculture Meters (Nos.)	374511
Enhanced Supervisory Control and Data Acquisition (SCADA) at 10 towns (Amravati, Aurangabad, Kolhapur, Sangli, Nasik, Nanded, Nagpur, Malegaon, Pune & Pimpri-Chinchwad)	

Table 85 - List of works undertaken under APDRP Phase-II (as on 30 September 2008)

Type of Work undertaken	Program
New 33/11 kV Substation (Nos.)	9 Nos.
33 kV Line (km)	45.2
22 kV Line (km)	47.7
22 kV U/G Cable (km)	211.2
11 kV Line (km)	157
11 kV U/G Cable (km)	137
DTC (Nos.)	595
0.6 MVAR Capacitors	74
DTC R &M (Nos.)	339
Aug of DTC (Nos.)	234
DTC Meters (Nos.)	893
Enhanced SCADA is proposed in following 14 towns- Akola, Khamgaon, Shegaon, Mulund-Bhandup, Dombivali, Solapur, Bhandara, Buldhana, Malkapur, Yavatmal, Thane, Ulhasnagar, Osmanabad & Jalgaon	

Gaothan Feeder Separation Scheme

Table 86 - Gaothan Feeder Separation- Phase I (Commissioned on June 2009)

Type of Work undertaken	Program
No. of feeders (Nos.)	1504
11KV Line (km)	23011
Total DTC's (Nos.)	9785
No. of villages covered (Nos.)	7437
Load Management (MW)	1976

Table 87-Gaothan Feeder Separation- Phase II

Type of Work undertaken	Program
No. of feeders (Nos.)	1067
11KV Line (km)	27063
Total DTC's (Nos.)	13722
No. of villages covered (Nos.)	8491
No. of wadis covered (Nos.)	2020
Load Management (MW)	1646

Bhiwandi Franchisee Model – Case Study

Bhiwandi is a major textile hub of western India having one third of the country's power looms. The estimated demand in the circle is 750 MVA with an annual power input of around 2600 million units. About 55% of the total sales are to the power loom sector. Government of Maharashtra provides significant subsidy to these consumers. The town has a reputation as a chronic defaulter of power bills for more than 10 years and has a record of very high level of Aggregate technical and commercial (ATC) losses (around 60% in the year 2006-07). GoM grant to MSEB holding company and subsidy to MSEDCL/MSETCL for reduction in agriculture and power loom tariff in 2009-10 was `4238 crores[318]. **Torrent Power Ltd took over operation of Bhiwandi circle from Januray 2007 for a period of 10 years, after signing a Distribution Franchisee Agreement (DFA) with MSEDCL.** DFA gives complete autonomy to the franchisee in planning and execution of capital expenditure without requiring any regulatory approval. The tariffs to the franchisee consumers are the same as applicable to consumers of the rest of the license areas.

In the first two years of franchisee period he following observations have been made:

- Aggregate technical and commercial losses have reduced considerably from 63% to 19%;
- The service and supply quality has also improved substantially;
- Due to reduction in distribution losses, consumer payments have doubled and so has the gross revenue of the franchisee from `160 crores in the first year to `340 crores in the second year;
- Compared to the increase in revenue of franchisee, the licensee (MSEDCL) revenue is quite moderate. Compared to pre-franchisee year (FY 06-07) the MSEDCL revenue in first full year of franchisee (FY 07-08) decreased by 3% and in the second year of franchisee operation (FY 08-09) it increased by 7%. This is because MSEDCL revenue is based on fixed annual input rate (determined through bidding process) and is indexed to average billing rate (ABR). The ABR for FY 06-07, which was about `4.3/unit has dropped to around `3.6/unit for FY 07-08 and then increased to `3.75/unit for FY 08-09. This drop of about `0.60/unit in ABR in FY-08 compared to ABR for FY 07 has led to MSEDCL earning less revenue than the previous year. Another fact is that, in the first year of franchisee operation, sales to power loom increased by about 30% but the subsidy claim increased by only 2%, leading to about `0.60/unit decrease in power loom subsidy.

The franchisee model adopted in Bhiwandi has proved to be useful in reducing the distribution losses considerably. However the following aspects need to be considered prior to implement such a model in other areas.

[318] Government of Maharashtra, Ministry of finance, Financial Statement – Budget, 2010-11

- Realizing the importance of ABR and subsidy, the franchisee agreement stipulates certain process and timeline (quarterly and annual) for undertaking audits of ABR, subsidy claims, metering and billing systems/database, etc. The audit in case of Bhiwandi was not complete even after two years and the audits for metering and billing were yet to begin. A third party monitoring of metering and billing would prove beneficial.
- The audits need to be completed as stipulated and the bidding process should be brought under the purview of state regulatory commission.
- Before embarking on franchisee model, efforts should be made to build quality base line data which should include existing level of losses, network status, consumer mix and sales, metering and billing. This would provide confidence for prospective bidder and realistic bids be expected. It would also increase accountability of licensee and of successful bidder for post franchisee performance.
- Capital expenditure should be regulated and not be under the complete autonomy of the franchisee as is the case of Bhiwandi.

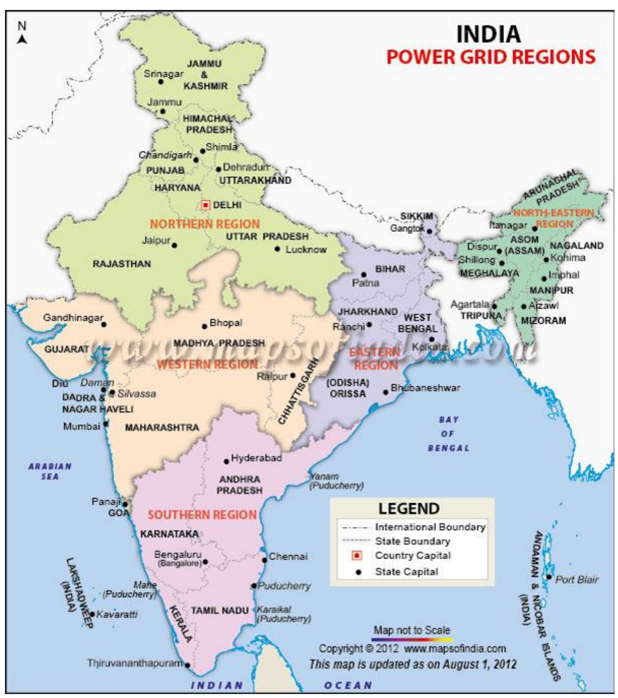
Annexure VII – Case Study on Power Grid Failure: 30-31 July 2012[319]

Exactly 10 years after the Western grid collapse on July 30, 2002 the northern grid of the Power Grid Corporation of India collapsed on Monday July 30, 2012. The magnitude and number of people affected was so huge that *The Economic Times* the next day bloated with the caption, "Superpower India, Rest in Peace".

Grid system in India

The entire electricity matrix of the country consisting of transmission lines and sub-stations with generating stations on the one side and load dispatch centres on the other is called the power grid. The power grid in our country is owned by *Power Grid Corporation of India Ltd*. a Govt. of India enterprise. It is divided into five regional grids –

- **Northern** (UP, Uttarakhand, Rajasthan, Himachal Pradesh, Punjab and Haryana)
- **North-eastern** (Assam, Arunachal Pradesh, Meghalaya, Nagaland, Manipur, Mizoram, Tripura)
- **Eastern** (West Bengal, Bihar, Jharkhand, Odisha, Sikkim)
- **Western** (Gujarat, Maharashtra, Madhya Pradesh, Chhattisgarh) and
- **Southern** (Karnataka, Kerala, AP, Tamil Nadu)



[319] Government of India, Ministry of Power, "Report of the Enquiry Committee on Grid Disturbance in Northern Region on 30th July 2012 and in Northern, Eastern and North-Eastern Region on 31st July 2012", August 16, 2012 http://www.powermin.nic.in/pdf/GRID_ENQ_REP_16_8_12.pdf

The four grids except the southern are connected to each other via HVAC (alternating current) lines. This makes the direct transfer of load *in between these grids* easier (synchronous interconnection). The scenario is very close to having different switches in the house for a tube light and television; although both the appliances are a part of the same AC circuit of the house. The southern grid is connected with the rest of the grid in HVDC (direct current). As a result, the southern grid is insulated from the rest, and it is secure from damage caused in the upper four grids (asynchronous interconnection). The transfer of load with southern grid is not as easier since it requires AC to DC conversion and more loss is incurred.

A group of states comprise a grid in which internal power load transfers (in MW)[320] are already planned within the states and the schedule is registered at regional load dispatch centre (for Maharashtra, it is the State Load Dispatch Centre, Kalwa, Thane). The limit for power load transfer is limited by the existing network of infrastructure (transmission lines). The **inter-state load transfer** is fixed and it always goes as per schedule. In many instances load scheduling is done as promptly as every 15 minutes. Likewise, **inter-grid load transfer** also goes as per the schedule. The national grid controls the transfer of power between adjacent grids.

Responsibilities of the National Grid

- Supervision over the Regional Load despatch centres.
- Scheduling and dispatch of electricity over the inter-regional links in accordance with grid standards specified by the authority and grid code specified by Central Commission in coordination with Regional Load Despatch Centres.
- *Coordination with Regional Load Despatch Centres for achieving maximum economy and efficiency in the operation of National Grid.*
- Monitoring of operations and grid security of the National Grid.
- Supervision and control over the inter-regional links as may be required for ensuring stability of the power system under its control.
- Coordination with Regional Power Committees for regional outage schedule in the national perspective to ensure optimal utilization of power resources.

Power Grid and Load transfer

The whole concept of a centralized power grid has arisen from the experiences from calamitous situations, where electricity supply of a part of the region had failed due to foggy conditions, excessive moisture, rains, etc. If it would take 2 to 3 days to restore the supply, the residents would have to bear the burden for that time period. Instead, when you have a centralized grid, power transfer can be scheduled as per the surplus or deficiency in a region and power failure in a division can be restored easily as it is inter-connected totally in the region.

The amount of load that can be transferred is limited according to the capacity of inter-grid transmission lines. The amount of load to be sold and purchased is scheduled, and the grids

[320] SEE TOP RIGHT CORNER - http://mahasldc.in/wp-content/themes/mahasldc/report2.html

have to abide by the schedule. Transmission gateways are accordingly kept open or closed. The Power System Operation Corporation (POSOCO) controls the regional despatch centres and their inter-transmission. **If the regional corporation allows the region to draw more power than scheduled, *more power* tries to come *through a gateway* temporarily designed for *less amount of power*.** If a certain region draws *less power* than scheduled, even then it calls for imbalance; as less power is drawn from a gateway temporarily designed for more power transfer.

Drawing more power than scheduled, and **drawing less power** than scheduled – **both** are potentially dangerous for the grids, and are not at all advisable. Drawing more power reduces the frequency of the alternating current during transfer, and drawing less power increases the frequency, both of which can lead to massive electrical hazards.

The standard alternating current frequency of power in India is 50 Hz. In operation, frequency oscillates between 49.8 Hz to 50.2 Hz. If frequency goes beyond these values, there is strain on the grid – the more frequency drops or increases, more the strain. In this strenuous condition if some state tries to extract more power – disobeying the scheduled interchange – it is very likely that the grid will trip and it will trip each and every power generating station that is connected with it.

In our house when some appliance tries to extract more power (current) from the AC mains, the fuse breaks the circuit, or the circuit breaker (MCB) trips the electrical line in the house. This saves the excess current from flowing at the cost of temporary loss of power.

If the same thing happens between two adjacent grids, the grid collapses.

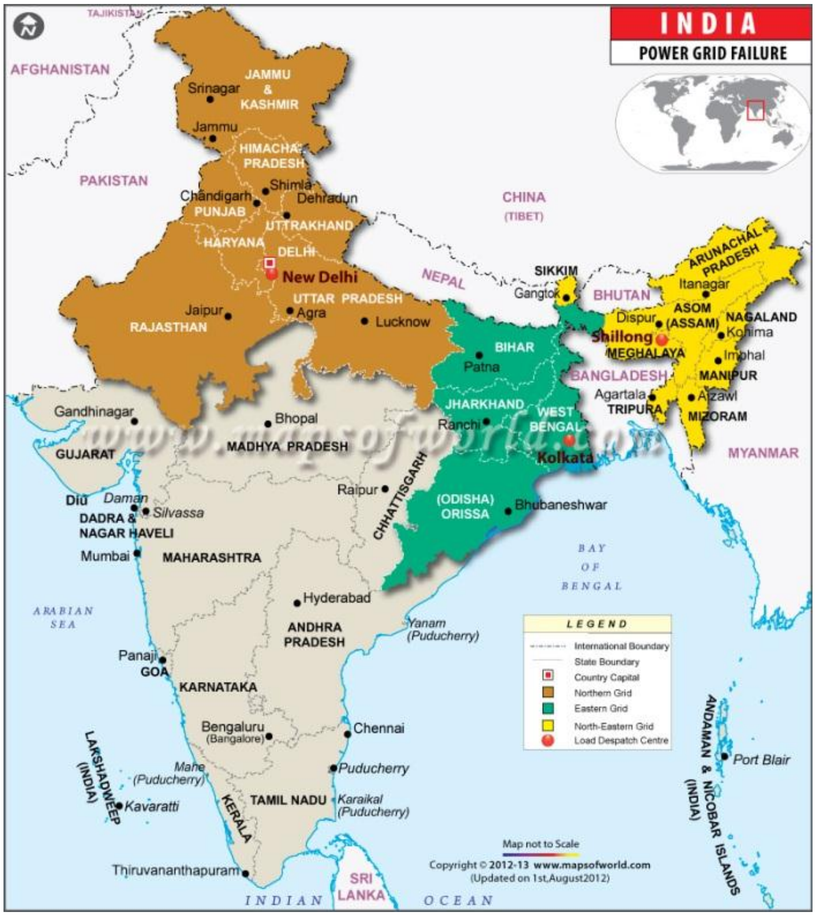
The state which tries to draw more power than scheduled is nothing but fined. There is an UI (unscheduled interchange) charge per unit of electricity, which the state pays off. It is clear that just a monetary penalty for a grave mistake – keeping half of the nation in dark – is not enough. More limitations must be imposed on states which cross over the schedules. They must be made to perform better, reduce their T&D loss in order to make up for their mistake.

In United Kingdom, both excess and less than schedule withdrawal has a penalty associated to it. But in India, only excess withdrawal is penalized, which is unfair and risky.

What happened on July 30, 2012

In July 2002, it was Madhya Pradesh load dispatch centre that tried to extract more power than scheduled. In July 2012, the northern grid collapsed on Monday, July 30. As it was recuperating from the collapse, the eastern grid failed on the subsequent day. But this time the damage was worse. The northern and north eastern grids collapsed after the eastern grid collapse, thus **bereaving 600 million Indians of power**. The actual intensity of the effect of this failure on the lives of Indians is *half* than what it seems since over **300 million people are not even connected**

with the grid[321]. The western grid saved itself from tripping by taking adequate measures, otherwise it was equally susceptible. Who did it this time is a matter of propriety and responsibility on the doer's side.



At 0230 hours in the peak of the night, the Agra-Bareilly transmission section (400kV Bina-Gwalior transmission line) tripped and it started the collapse. Majority of the other transmission lines interconnecting NEW grid were out due to planned and forced outages. Thus the inter-regional corridor itself was weak.

The current power deficit supplemented by deficient rains all over the country has proved to be a nightmare for agriculture. Rainwater scarcity has forced millions of cultivators to draw ever lowering groundwater, or depend on pumped water supply of the respective state. In the monsoon, the problems of poor coal quality and wet coal loom large and it reduces the Operating Availability as well as the Plant Load Factor (PLF) of the generating station. As more than 50% power is generated from coal fired thermal power plants, the actual power generated

[321] Government of India, Ministry of Home Affairs, Census of India, 2011 and http://blogs.wsj.com/indiarealtime/2012/08/01/how-many-people-actually-lost-power-in-india/

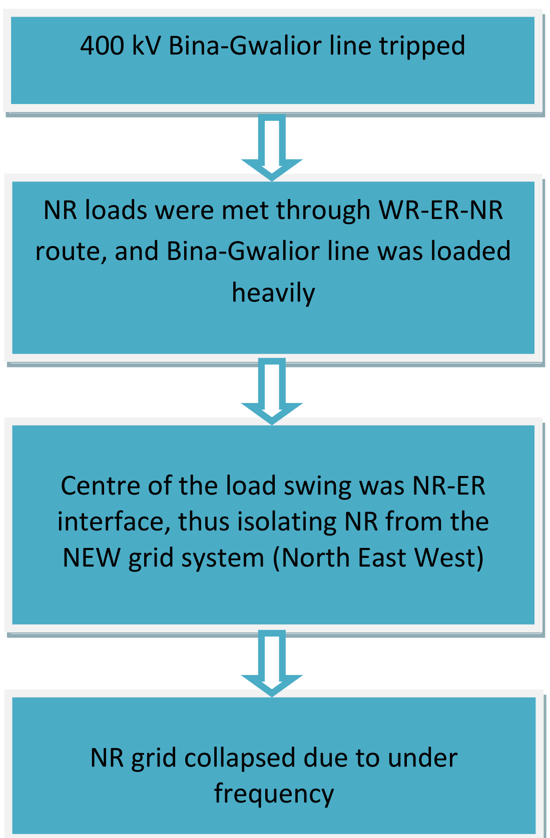
in these unfavorable conditions is less and the demand-supply gap increases. Deficient rainfall has affected power demand restriction, aggravating the power crisis.

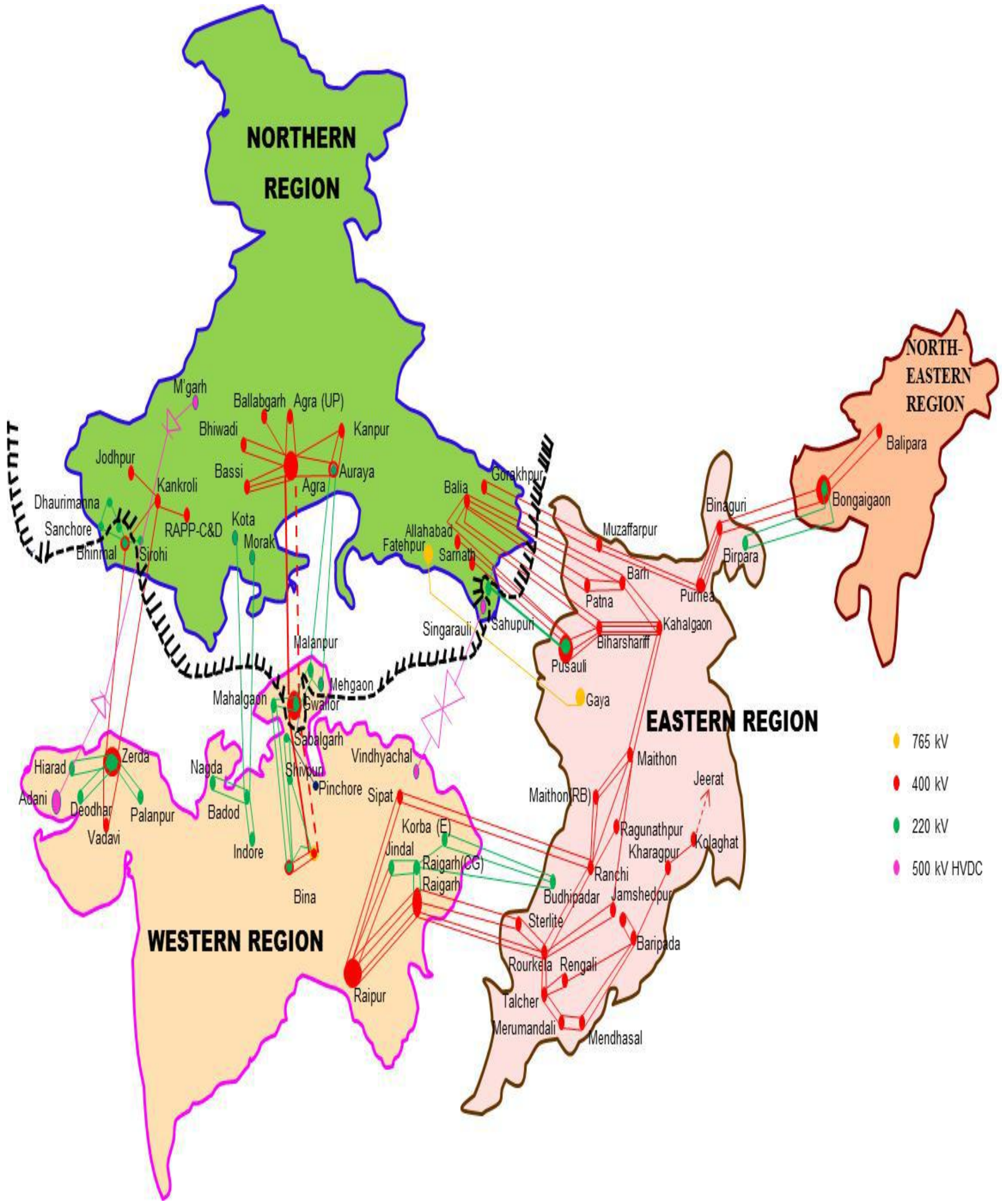
In this situation, a member state of the Northern Grid drew more power than scheduled to meet its demands; the frequency was lowered below the critical value and the grid tripped.

(The grids are equipped with *'Under Frequency Relay'* technique where if the frequency of generated alternating power goes to alarmingly low levels, it trips the grid)

After the grid tripped, important parts of south and central Delhi and the IGI airport were supplied electricity from NTPC's Badarpur Thermal Power Station in NCT, Delhi. When the Badarpur station tripped at 7 am, power was acquired from Bhutan to deliver power for Metro transport, PM's residence and AIIMS (All India Institute of Medical Sciences). PGCIL (Power Grid Corporation of India Ltd.) claims that 60% of power was restored in 4-5 hours, while it took more than 12 hours to restore full supply.

Sequence of events





NEW – North East West Grid System

The Agra – Bina – Gwalior transmission line can be clearly identified

Impact on Public Life

Trains were running indefinitely late in Northern India after the grids collapsed on July 30 - 31[322]

- 30 crore people were directly affected by the giant power cut
- Railways and some airports were shut down till 0800 hours. About a third of the rail network is electrified, so the effect on rail network was less – due to the use of old technology (diesel). Close to 300 trains came to a halt.
- Even local transport was affected, traffic signaling loss led to traffic jamming.
- Hospitals and water treatment plants were shut for half of the day [323]
- Over 200 coal miners were trapped in the states of Jharkhand and West Bengal as their mining shafts went off operation due to grid failure.

What happened on July 31, 2012

The Northern Grid collapse on Monday was restored in record time, as per the spokesperson of PGCIL. To make matters worse, the Northern Grid again collapsed at 1300 hours, which triggered the collapse of Eastern and North-eastern grids along with itself.

This affected 60 crore Indians – half of the country was powerless. It was the worst blackout till date. About 500 trains in the northern and eastern part of the country were said to be stranded.

The north eastern grid was restored quickly. The evening of Tuesday saw eastern grid restore to 60% and northern grid to 80%. After the midnight on August 1, 2012 all the grids were restored to 100%[324].

[322] Deccan Chronicle
[323] Wikipedia – July 2012 power blackout

Despite being a part – with the highest power generation and consumption – of the NEW grid (Northern, North eastern, Eastern, Western), the Western grid was successful in insulating itself from the grid failure. Koyna hydroelectric project poured in 400MW when the NTPC power plant at Vindhyachal stopped supplying 600MW which had induced high variability in the frequency of the electricity. The Maharashtra state power ministry, from 2009, had continuously informed the union power ministry of the excess withdrawal by some northern states – UP, Punjab, Haryana. After the Monday's grid failure, Maharashtra, Gujarat, MP and Chhattisgarh coordinated to utilize the daily 3000 MW transfer internally, by reducing their generation by same amount. Even load shedding hit areas were supplied with power in order to avert possible disaster in western grid[325].

This coordinated effort from the four states in Western Grid did partly help in saving it from a collapse and subsequent blackout.

What could have averted the Grid Failure?

- Better coordinated planning of outages of state and regional networks, specifically under depleted condition of the inter-regional power transfer corridors.
- Mandatory activation of primary frequency response of Governors i.e. the generator's automatic response to adjust its output with variation in the frequency.
- Under-frequency and *df/dt* based load shedding relief in the utilities' networks.
- Dynamic security assessment and faster state estimation of the system at load despatch centers for better visualization and planning of the corrective actions.
- Adequate reactive power compensation, specifically Dynamic Compensation.
- Better regulation to limit over drawal/under drawal under UI mechanism, specifically under insecure operation of the system.
- Measures to avoid mal-operation of protective relays, such as the operation of distance protection under the load encroachment on both the days. [326]

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[324] http://www.powergridindia.com/PGCIL_NEW/newscontent.aspx?newsid=N:345

[325] The Times of India, "Maharashtra shared grid's extra burden, insulated itself", Chittaranjan Tembhekar, August 1, 2012 - http://articles.timesofindia.indiatimes.com/2012-08-01/mumbai/32980390_1_western-grid-northern-states-grid-failures

[326] Government of India, Ministry of Power, "Report of the Enquiry Committee on Grid Disturbance in Northern Region on 30th July 2012 and in Northern, Eastern and North-Eastern Region on 31st July 2012", August 16, 2012

Cost

The worst power blackout in the world on July 30 and 31, 2012 hit power generation companies with a potential loss of **Rs. 550 crore**[327], considering 85% generation Plant Load Factor (PLF) and electricity unit price of Rs. 3/unit.

NTPC was the worst affected; it was deprived of a profit of Rs. 42 crore.

Enquiry

An enquiry committee was appointed by the then Union Minister for Power with members:

1.	A. S. Bakshi,	Chairperson CEA – Chairman
2.	A. Velayutham,	Member Retd., MERC, Member
3.	S. C. Shrivastava,	IIT Kanpur, Member
4.	K. K. Agarwal,	Member (Grid operation and Distribution) CEA, Member Secretary
5.	R. N. Nayak,	CMD, Power Grid Corporation of India Ltd.
6.	S. K. Soonnee,	CEO, Power System Corporation of India
7.	Balvinder Singh,	Retired IPS officer

Terms of Reference of the committee

- To analyze the causes and circumstances leading to the grid disturbance affecting power supply in the affected region.
- To suggest remedial measures to avoid recurrence of such disturbance in future.
- To review the restoration of system following the disturbances and suggest measures for improvement in this regard, if any
- Other relevant issues concerned with safe and secure operation of the Grid.

The panel submitted the report[328] on August 16, 2012.

Impact on economy

The grid collapse on 30th July also persuaded the *Income Tax Department* to extend the deadline for e-filing of Income Tax returns. The deadline was extended till August 31, 2012 which seems illogical. The last two days of the July 31 deadline were marred by loss of power; an extension of a month in this situation raises eyebrows.

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[327] http://www.business-standard.com/india/news/power-companies-lose-rs-550-cr-in-2-days/482225/

[328] Government of India, Ministry of Power, "Report of the Enquiry Committee on Grid Disturbance in Northern Region on 30th July 2012 and in Northern, Eastern and North-Eastern Region on 31st July 2012", August 16, 2012

Confederation of Indian Industry (CII) - which plays an advisory and consultative role in between the industry and the government - expressed grim views over the grid collapse. It said that such a huge failure of power system will have a negative impact on the growth of industry and thus the economy. It also said that it may have lowered the already low sentiment about the current economic situation in India.

"The widespread power blackouts that hit India's north, east and northeast regions on Monday and Tuesday have had a credit negative effect on the country's economic activity. Power disruptions will further depress business sentiment, already dampened by slowing growth and the government's inability to implement measures to revive investment. Unreliable power supply limits the private sector's international competitiveness. Existing and new facilities tend to invest in contingency generators and diesel stockpiles, thus diverting capital and undermining the scope for productivity improvements. India's prevalent subsidy system artificially depresses end-prices, leaving state-owned power companies to incur losses and making the sector unattractive for private investment."

Moody's Investors Service[329] (Renowned credit rating agency)

According to Moody's, the power failure underscores inadequacy of the country's infrastructure, which inhibits growth by discouraging investment and impeding productivity improvements.

Critical Analysis and Practical Solution

Critical Analysis of the following is necessary

- Depleted transmission network – a minimum sustainable capacity must always be present
- Load Despatch Centres tend to draw less power than scheduled to have minimum spending on UI (Unscheduled Interchange) charges. Some resort even to Load Shedding just to spend less on UI.
- Compliance of State Load Despatch Centres to Regional Load Despatch Centres.
- The status of technological safety mechanisms like UFR – Under Frequency Relays, *df/dt* relays, PSS- Power System Stabilizers, PMU – Phasor Measurement units, Time Synchronization, etc.

Following subjects should be considered to design and implement practical solutions

Recommendations have been underlined by the Enquiry Committee; time frames have been set and pertaining authorities who have been given corresponding responsibilities.

329 http://en.wikipedia.org/wiki/Moody's_Investors_Service

- Review of Penal Provisions under Electricity Act, 2003.
- Review and improve protection systems
- Review 'Islanding System'
- Autonomy to Load Despatch Centres
- Co-ordinated outage planning
- Network strengthening and visualization – fiber optic connectivity

Solutions pertaining to power generators

- *Ultimate Solution*: Stress on the availability and quality of coal (which produces 65% of country's power)
- Reduction in start-up times of generators
- Make way for gas power to boom with assurance of gas availability, which is reliable and less time consuming process

All this, will collectively increase power generation across the country, to meet the ever rising demand. There is no other option than to increase the generation, whether by making existing systems efficient, or replacing them with efficient systems. When this is supplemented with a robust makeover of the transmission and distribution power grid, we can surely avert such electrical disasters in the future.

Institutional reform

- To make profits from the investment made, PGCIL spent too less on the maintenance work, on the upkeep of the equipment in the grid. The relays that protect the grid were covered with tall grass in some instances, making it difficult to operate them. This neglect of grid maintenance also may have led to the failure of the entire grid on July 30 and 31.
- The ultimate source of revenue for power companies is tariff. But political interests make it difficult to increase the tariff, and it is kept low while heavy losses – extremely heavy losses - are incurred. The distribution company of Maharashtra MSEDCL has audited a revenue loss of about Rs. 5000 crore for the year 2010-11.
- For both urban and rural consumers, the tariff has risen at a rate lower than the rate of increase of incomes of households, and the rate of increase of expenditure.
- In India, overdrawing is penalized, while under drawing is rewarded. Under drawing is also a sign of grid indiscipline, and it is well accepted by UK where under drawing is penalized. We need to heavily penalize any deviation from the scheduled interchange; over or under.

Annexure VIII- Financial Assistance by MEDA and MEDA Budget Estimate

Pattern for providing the financial assistance to unit or facility by MEDA

Sr. No	Sector	Category	Annual Energy Bill	Financial Assistance if energy Audit is done by Class A Energy Auditing firm	Financial Assistance if energy Audit is done by Class B Energy Auditing firm
1)	Industrial Unit	I-1	Less than Rs.20 lakhs	Rs. **20,000/-** or **50%** of the cost of Energy Audit study, whichever is less	Rs. **15,000/-** or **50%** of the cost of Energy Audit study, whichever is less
		I-2	More than or equal to Rs.20 lakhs but less than or equal to 50 Lakhs	Rs. **30,000/-** or **50%** of the cost of Energy Audit study, whichever is less	Rs. **25,000/-** or **50%** of the cost of Energy Audit study, whichever is less
		I-3	More than Rs. 50 Lakhs	Rs. **40,000/-** or **50%** of the cost of Energy Audit study, whichever is less	Rs. **35,000/-** or **50%** of the cost of Energy Audit study, whichever is less
2)	Commercial Buildings	C-1	More than or equal to Rs.1 lakhs but less than or equal to 5 Lakhs	Rs. **25,000/-** or **50%** of the cost of Energy Audit study, whichever is less	Rs. **20,000/-** or **50%** of the cost of Energy Audit study, whichever is less
		C-2	More than Rs. 5 Lakhs	Rs. **30,000/-** or **50%** of the cost of Energy Audit study, whichever is less	Rs. **25,000/-** or **50%** of the cost of Energy Audit study, whichever is less
3)	Government / Semi-Government/ Government/ Local self Government Buildings	G-1	Less than or equal to Rs.5 Lakhs	Rs. **25,000/-** or **50%** of the cost of Energy Audit study, whichever is less.	Rs. **20,000/-** or **50%** of the cost of Energy Audit study, whichever is less.
		G-2	More than Rs. 5 Lakhs	Rs. **35,000/-** or **50%** of the cost of Energy Audit study which ever is less	Rs. **30,000/-** or **50%** of the cost of Energy Audit study whichever is less.
6)	Residential Complex	R-1	Minimum Transformer rating 200 kVA	Rs. **20,000/-** or **50%** of the cost of Energy Audit study which ever is less	Rs. **15,000/-** or **50%** of the cost of Energy Audit study whichever is less.
7)	Water Pumping stations of rural and urban local bodies	W-1	More than or equal to Rs.25.00 lakhs	Rs. **35,000/-** or **50%** of the cost of Energy Audit study which ever is less	Rs. **30,000/-** or **50%** of the cost of Energy Audit study whichever is less.
8)	Street Lighting systems of rural and urban local bodies	SL-1	More than or equal to Rs.3.00 lakhs	Rs. **20,000/-** or **50%** of the cost of Energy Audit study which ever is less	Rs. **15,000/-** or **50%** of the cost of Energy Audit study whichever is less.

Sr. No.	Sector	Category	Energy Bill	Financial Assistance if energy Audit done by Class A Energy Auditing firm	Financial Assistance if energy Audit done by Class B Energy Auditing firm
1)	Industrial Unit	I-1	Less than or equal to Rs. 75 Lakhs	Rs. **20,000/-** or **50%** of the cost of Energy Audit study whichever is less	Rs. **15, 000/-** or **50%** of the cost of Energy Audit study whichever is less
		I-2	More than Rs. 75 Lakhs	Rs. **25,000/-** or **50%** of the cost of Energy Audit study whichever is less	Rs. **20, 000/-** or **50%** of the cost of Energy Audit study whichever is less
2)	Commercial Buildings	C-1	Less than or equal to Rs. 5 Lakhs	Rs. **15,000/-** or **50%** of the cost of Energy Audit study whichever is less	Rs. **10, 000/-** or **50%** of the cost of Energy Audit study whichever is less
		C-2	More than Rs. 5 Lakhs	Rs. **20,000/-** or **50%** of the cost of Energy Audit study whichever is less	Rs. **15, 000/-** or **50%** of the cost of Energy Audit study whichever is less
3)	Govt. Buildings	G-1	Irrespective of Energy Bill	Rs. **25,000/-** or **50%** of the cost of Energy Audit study whichever is less.	Rs. **20, 000/-** or **50%** of the cost of Energy Audit study whichever is less.
4)	Buildings of Govt. Undertaking/Local self Government	G-2	Irrespective of Energy Bill	Rs. **25,000/-** or **50%** of the cost of Energy Audit study	Rs. **20, 000/-** or **50%** of the cost of Energy Audit study whichever is less.
5)	Buildings of ULBs / MIDCs	G-3	Irrespective of Energy Bill	Rs. **25,000/-** or **50%** of the cost of Energy Audit study	Rs. **20, 000/-** or **50%** of the cost of Energy Audit study whichever is less.

MEDA Budget Estimate

Table 88- MEDA budget estimate for financial year 2011-12 ('in lakhs)[330]

Name of Scheme / Programme/System	**Non-Conventional & Renewable Sources of Energy** (NRSE)			**Tribal Sub Plan** (TSP)			Total			
	Target	**State Share**	**Central Share**	**Target**	**State Share**	**Central Share**	**Target**	**State Share**	**Central Share**	**Total**
Public Awareness Campaign		20	0				0	20	0	20
Walk Through Energy Audit	400	12	0				400	12	0	12
Save Energy Program (Nos.)	35	14	0				35	14	0	12
Waste Heat Recovery (Nos.)	4	4	0				4	4	0	3
Bright Street Light Program (Nos)	8500	136	0	4375	70	0	12875	206	0	220
Demo Project in Govt. / Semi Govt. office buildings of Energy Consv (Nos)	6	150	0				6	150	0	150
Installation of EC Devices in Municipal Councils - Street Lights & Water Supply Schemes (Nos)	15	375	0				15	375	0	300
Total		**711**	**0**		**70**	**0**		**781**	**0**	**717**

330 http://www.mahaurja.com/MEDA%20budget.html

Annexure IX – Energy Savings in Households

Appliance	Power			For one consumer & one appliance					No. of Appliances per consumer	Urban Consumers of MSEDCL	TOTAL Units saved/year URBAN (MU)	Timing	Peak Demand Relief (MW)		
	Wattage (W)	Energy Eff. Wattage (W)	Saved Watts (W)	HOP (DAY) (hrs)	HOP (month) (hrs)	HOP (year) (hrs)	saved units/ month (units)	saved units/ year (units)							
													Morning	Afternoon	Evening
Tube light	36	28	8	6	180	2190	1.44	17.52	4	8000000	561	Evening			256
Incandescent Lamp	60	20	40	2	60	730	2.4	29.2	1.5	8000000	350	Morning & evening			960
Fan	70	55	15	9	270	3285	4.05	49.275	2	8000000	788	Afternoon & night	240		
Refrigerator	128	100	28	24	720	8760	20.16	250	0.5	8000000	1000	Round the clock	114		
Air Conditioner	2300	1900	400	2	60	730	24	292	0.05	8000000	117	Afternoon	160		
Geyser (boiler)	2500	0	2500	0.5	15	182.5	37.5	456.25	0.1	8000000	365	Early morning	2000		
Television	90	50	40	6	180	2190	7.2	87.6	0.75	8000000	526	Round the clock		240	
											3707				

HOP: Hours of operation

Annexure X – Other Policy measures

Utilities

- To review the installations on new set ups by expert committee. The newly installed units should have a warranty and guarantee period of 5 years within which if a defect generates, complete replacement should be demanded. e.g. as in the case of Dabhol.
- Improve quality of coal used.
- Establish a separate body for agriculture sector supply which would bill the agricultural consumer and in turn be billed by the MSEB. If this body failed to pay bills the service would be suspended.

Alternate sources of energy

- Landfill sites – Electricity to be generated from landfill sites. (Methane gas generated can be collected and used to produce electricity.) Benefits (carbon credits) to be shared by stakeholders viz MSGPCL, Municipal Corporation / Gram panchayats. MSGPCL to take landfill sites on lease for power generation for a fixed period of time.
- Use of industrial waste (biomass) for electricity generation. Incentives should be offered to such industries based on the generation capacity. These industries instead of providing electricity to the grid should be allowed to sell electricity to neighboring industries directly.
- Loans could be provided at a lower rate to the industries to set up alternative energy plants. These plants should be maintained by the industry itself.
- Every apartment / building should have alternate source of energy for heating water and for other uses such as lighting parking spaces, gardens, etc.
- Loans at a lesser interest rate should be made available for installing solar panels. The maintenance of these panels would be the responsibility of the apartment owners / builder.
- Every apartment of more than 10 flats to compulsorily use solar heaters for water heating. A time frame of six months should be given for implementation. The societies should be divided ward wise and the corporator of the area should be responsible for getting the measures implemented.
- The use of alternate energy to be increased ward wise.
- For the increase in use of solar water heating system the State govt. should provide subsidies, tax benefits and loans at a low interest rate.
- Power should not be provided for street lights and hoardings in the cities as well as highways. They should produce their own power by way of solar energy.
- To provide commercial giants in the market like the malls, plazas, multiplexes and hotels (5 star/ 3 star) 60% of their total electricity requirement. The balance 40% share should be generated from alternative sources such as solar, biomass, etc. This should be a mandatory measure.
- As the rural areas face power cut offs for longer durations, alternative sources of energy should be provided at a subsidized rate. This source could be a standalone local grid stations or connected grid whichever is feasible depending on the location of the village. But the power generated should be consumed by the villagers. These units should not be installed and forgotten about but proper monitoring should be carried out for effective functioning of the system and checking the need of

replacement. The power can be used by the villagers during the night and by the farmers for irrigation and industries during the day time. These would assure uninterrupted supply for domestic uses and also make the villages self-sufficient in terms of power. The Gram Panchayat and/ or NGOs should be given the monitoring responsibility. The village that becomes self-sufficient in energy should be rewarded appropriately. There are substantial economic and social advantages for standalone power systems in rural areas.

- Biomass-based power generation systems for rural applications could effectively make up for the absence of grid electricity supply in many remote areas.
- The sugar industries as it is get the benefit by way of incentives, so it should be made mandatory for these cooperatives to sell at least 30% electricity to the farmers.
- Providing alternate fuel for cooking to rural areas. In rural areas most people use wood / coal as fuel which causes health hazards by indoor pollution. The rural areas would be provided with alternate pollution free fuel for cooking, such as solar cookers / gobar gas plants.

Energy conservation and efficiency

- To improve efficiency of coal based power plants. This would increase consumer benefits through cost reduction and reduce local and global pollution through more efficient coal use.
- To promote replacement of inefficient lighting by CFLs, LEDs, Ceramic Metal Halide or any other efficient lighting system at industrial, commercial as well as household level. Energy efficient lighting should be made mandatory at all parking spaces, apartment gardens and club houses, etc.
- To replace incandescent bulbs in villages (households, schools, dispensaries, Gram Panchayats) with CFLs, LEDs, Ceramic Metal Halide or any other efficient lighting system, provided at subsidized rates.
- To make it mandatory for municipal corporations (administrative buildings/ street lights) to replace inefficient lighting with energy efficient lighting within a given time frame of 6 months. This would be the responsibility of the corporator for each ward.
- To promote use of energy efficient household appliances. Design energy labels for consumer's convenience for energy efficient refrigerators, air conditioners, washing machines, microwaves, geysers / boilers, television sets, water pumps/ electric motors, irons, heaters, mixers/ grinders/ juicers and fans.
- Enforce strict regulations on energy efficient improvement such as industrial equipment, use of cleaner and more efficient production technologies.
- The industries that implement energy conservation and efficiency measures should be provided with tax benefits (0.5%).
- To adopt energy efficient processes in industry viz. more efficient and end use electrical equipment, heat and power recovery. Provide with benchmark information, performance standards, subsidies and tax credits and a time frame of one year to fulfill these measures.
- To provide green label for industries manufacturing energy efficient products.
- To give tax benefits (0.25%) to industries purchasing energy efficient products.
- To make it mandatory for commercial consumers (malls, multiplexes, shops) to use energy efficient lighting.

- To construct commercial complexes should be constructed as per the Energy Conservation Codes for commercial buildings where a minimum efficiency standard has been set for external walls, roof, glass structure, lighting heating ventilation and air conditioning. A ban should be imposed on constructing glass structured buildings. Every construction should be monitored for the standards set as per the Energy Conservation Code.
- To make the energy conservation code mandatory for all new constructions, and to provide attractive tax benefits to the already existing constructions if they upgrade to the standard.
- To meter the agriculture sector's power supply for judicious use of power and water. This would also provide the exact power consumption by this sector. The installing of meters should be done gradually as there would be a strong resistance and opposition from the farmers.
- To make it compulsory for farmers to use energy efficient pump sets. A time frame should be given to farmers to implement the measures viz. 1 year for poor farmers and 6 months for rich farmers. Farmers should be provided subsidies to install energy efficient pumps; again the subsidy should be based on the economic condition of the farmer.
- Rewarding consumers for using energy efficient means and saving power by way of incentives and tax benefits and penalizing the excessive users.

Incentives & Subsidies

To design tariff rates, incentives and subsidies in a manner such that consumers benefit.

To provide subsidies and electricity tariff rate on the farmer's economic background. Develop a monitoring mechanism to ensure that benefits provided are reaped by the needful farmers. Most of the power subsidy to agricultural consumers is used by big and middle level farmers drawing large amounts of water for cash crops and often small farmers using small amounts of electricity and water for grain crops

To provide subsidies for harnessing indigenous energy sources.

To provide incentives to renewable sources of power generation based on generation capacity and not on installed capacity viz. wind power generating station, solar plants, bagasse co-generation, biomass, etc. The incentives should be based on the units generated and not on the installed capacity as this would only increase the number of installations with and not power generation.

Environmental and Social benefits

- To conduct environmental and social impact assessment not only for documentation purpose but for implementation as well.
- To introduce emission control measures in coal fired plants such as installation of high efficiency sulfur scrubbers and electrostatic precipitators.
- Prior to giving permission to set up new industrial units, the technology should be checked for energy consumption and equipment to be used. Corrective measures should be suggested for the use of energy efficient equipment.
- Industries large and small are divided as per their energy needs. They should be divided as large, medium and small scale consumers and suitable energy management practices to be designed for them.

- To formulate R & R policies for PAPs. Other than providing employment to PAPs their land should be taken on lease for setting up power plants and benefits in terms of dividends, etc. to be paid to the PAPs.
- To establish a monitoring mechanism.

Monitoring and enforcement

- To monitor the application of corrective measures suggested in the EIA.
- To enforce state level environmental regulations and standards for power plants. To monitor emission levels from power plants twice a year.
- To appoint a special taskforce for rural areas for generating power from alternate sources, monitor the functioning of these generating stations and for distribution of power as well as revenue collection.
- To set efficiency standards for industrial equipment and products. The industries that don't use efficient equipment shall pay energy tax.
- To monitor energy conservation and energy efficient mechanisms of medium and large scale industries twice a year and for small scale enterprises once a year.
- Energy conservation measures to be implemented within a given time frame. The industry not following the corrective measures to be penalized.
- The MSEDCL & MSETCL to monitor the electricity consumption of each society before and after implementation of solar water heaters, thus setting up a consumption trend.
- To develop a monitoring mechanism to ensure that subsidies provided are reaped by the needful farmers.
- An individual from each of the village or an officer from the MSEB should be appointed to monitor the implementation as well as to guide the farmers on a day to day basis.
- Power Users Association (PUA) should also be formed by the farmers so electricity would be every farmer's business. The members of this association should be monitored by an NGO and an MSEB official, as this should not become an association of the powerful farmers of the villages. The PUA would monitor the meters, check for and prevent thefts, collect bills and also create awareness on the judicious use of power.
- To monitor the electricity supply.

Research and development

- To strengthen financial support to R & D for energy efficient equipment, renewable energy sources, thermal power generation, clean coal technology and low or zero emission energy alternatives.
- To conduct pilot studies for feasibility of newer cheaper technologies developed.
- Provide incentives (to buyers) for a fixed period of time viz. 1 year in order to create a market for newer cheaper technologies
- Capacity-Building, Education, Training and Awareness-Raising
- To spread awareness among industrial consumers by rewarding the most energy efficient and energy conserving industry by the GoM.

- To restrict the sale of less energy efficient equipment or by putting heavy taxes on such appliances.
- To promote energy conservation and consumer education programs through creating public awareness through the media (television, radio & newspapers) and also through advertisements in malls. It should be made mandatory for malls selling electronic equipment to put up these advertisements and also provide information to customer about the energy efficient appliances. Media campaigning could involve radio programs every month; publication of energy conservation guides; leaflets/ brochures/ stickers/ posters for consumers; advertisements in the TV should be aired at prime time.
- To develop energy conservation curriculum in schools and colleges and also conduct workshops organized by the MSEB.
- To conduct local and state level training programs on energy conservation and use of energy efficient appliances for government officials; MIDC (business owners, industrial technicians, operators, service providers of household appliances like refrigerators, air conditioners, etc.); IT industry; primary and secondary school level (urban and rural schools); housing complexes and societies; and villages (farmers, farm laborers, women self-help groups, etc.). These programs/ workshops aim at strengthening the capability of the energy sector in the region as well as developing skills and knowledge of people.
- To design special workshops covering conservation measures for running electrical appliances, cooking, etc. for women
- To conduct training workshops in urban areas could be held ward wise. Every ward in case of urban areas and villages that has adopted maximum energy efficient measures would be rewarded appropriately. Every ward should also be encouraged to use energy efficient lighting.
- To create awareness among farmers about use of energy efficient pump sets and judicious use of power and efficient irrigation techniques. This is to be done by conducting regular stakeholders meetings and distributing brochures in local language.
- To increase communication between electricity distributors and agricultural consumers by conducting quarterly meetings and random survey on farms (pump set sites) to analyze and address the problems.
- To strengthen and professionally develop the MSGPCL, MSETCL and MSEDCL and make them politically independent and responsible. The decision makers (be it the minister / MSGPCL/MSETCL/MSEDCL) should be accountable directly to the public. Making the MSGPCL, MSETCL and MSEDCL politically independent will not allow any minister to break the legal guidelines and by pass the regulatory processes.

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