Captive Power Plants: Case Study of Gujarat, India

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About the PESD – IIM Study

Since 2002 the Program on Energy and Sustainable Development (PESD) has been engaged with the Indian Institute of Management in Ahmedabad (IIM-A) to study reforms in the electric power sectors of two key Indian states: Gujarat and Andhra Pradesh. These are critical states as India works to translate visions of power sector reform adopted at the Central (Federal) level into state and local practice. This work, funded by the US Agency for International Development, has involved surveying every unit of every thermal power plant in both states. In addition, we have surveyed a sample of the captive power plants in Gujarat state. We have been particularly interested in computing the "baseline" of fuel consumption and emissions of key pollutants, including carbon dioxide; our studies also explore how those baselines change over time and may change in the future as the reform efforts proceed. The baseline is a key measure of the efficiency of the sector; it is also the core concept needed to make operational such schemes as the clean development mechanism (CDM) of the Kyoto Protocol, which seeks to encourage investment in projects that result in emissions that are lower than the baseline level.

Abstract

In India, in the last few years, the installed capacity of the Captive Power Plants (CPPs) has grown at a faster rate compared to the utilities. This study examines the factors responsible for the growth of the CPPs. For this purpose the case study of the CPPs of Gujarat is undertaken. In 2002, Gujarat had 2.44 GW installed capacity of captive power plants, which represent almost 22% of the total installed capacity. The factors which caused the CPPs in Gujarat grow at a faster rate compared to the utilities are unreliable power supply by the utilities, poor quality of power, higher industrial tariffs, multiple benefits like cogeneration of steam and electricity and lower internal transaction costs for running the CPPs. Due to these varied reasons the CPPs are not a homogeneous group of plants, but are categorized into various segments. These are back-up type CPPs, CPPs for reducing production cost, CPPs for multiple benefits, and CPPs for quality power.
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Captive Power Plants: Case Study of Gujarat, India[1]

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1. Introduction

The power generation entities in India can be divided into two broad categories: Generation Utilities and Generation Non-Utilities or Captive Power Plants (CPPs). The central[2] (federal) government, state government, or private investors own the generation utilities.

On the other hand, industries principally commission the CPPs. Various state level and central level acts defines CPPs in a variety of ways. Captive Power Plant (CPP) means

> …the power plant set up / proposed to be set up by an industry / institution / a person for its / his own use… (Government of Andhra Pradesh, 1998)
>
> …generating unit(s) with aggregate capacity not exceeding 166 MW, which produces power for captive consumption of its owners… (Government of Rajasthan, 1999)
>
> …the power plant set up/proposed to be set up by a person or a group of persons for his or their own use… (Government of Madhya Pradesh, 2000)
>
> …a power plant set up by any person to generate electricity primarily for his own use and includes a power plant set up by any co-operative society or association of persons for generating electricity primarily for use of members of such co-operative society or association… (Electricity Act, 2003)

For the purpose of this paper, the term CPP means the power plants commissioned by the industries for their self-consumption.

The objective of the paper is threefold. Firstly, the paper traces the historical development of the CPPs at the state level. Secondly, the paper tries to compare the utilities and the CPPs at the state level on various parameters like unit size, fuel type etc. Thirdly, the paper tries to explain the various reasons for the development of the CPPs. The state of Gujarat is chosen as the case study.

The state of Gujarat came into existence in the year 1960. It is one the most industrialized state of India. It is also one of the richer states compared to the other states of India. Per

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[1] Working Paper, not for citation or quotation

[2] The central government in India is equivalent to the federal government of USA.

capita consumption of electricity of Gujarat is also much higher in comparison to that of India (Planning Commission, 2002). The capacity of the utilities in Gujarat for the year 2002 is around 8 GW. The capacity for the CPPs for 2002 on the other hand is 2.5 GW. The Gujarat Electricity Board (GEB) is one of the better performers as compared to other State Electricity Boards (CRISIL, 2003). Inspite of these achievements the state of Gujarat has been facing shortage of electricity and the financial condition of the SEB is poor (Ministry of Power, 2002). For these reasons, the state has started reforming the power sector. To facilitate the reforms the Gujarat state assembly has further passed "The Gujarat Electricity Industry (Reorganization and Regulation) Bill, 2003." Moreover, Gujarat government on 27th August, 2003 announced its decision to reorganize the GEB into separate generation (Genco), transmission (Transco) and distribution (Discom) companies by September, 2003.

This paper is arranged in six sections. In section 2, the design of the study is explained. In the next two sections (section 3 and 4), the development of the CPPs in Gujarat is described. In this section, the comparison of the CPPs and utilities is also provided. In section 5, reasons for the growth of CPPs are listed down. In the concluding section, the effects of the growth of CPPs are described and some broad conclusions from the case study of Gujarat are drawn.

2. Design of the Study

For analyzing the factors that prompted the growth of the CPPs, the case study of CPPs installed in Gujarat is undertaken. There are many reasons for choosing Gujarat as the case study. These reasons are broadly macro -economic reasons; the diverse nature of the CPPs in Gujarat; and the electricity regulations of Gujarat.

Gujarat is economically one of the most prosperous and industrialized states of India. The per capita income[3] of Gujarat (Rs. 12975 for 2001[4]) is higher that that of Indian per capita income (Rs. 10254 in 2001). In addition, the per capita consumption of electricity in Gujarat (835 KWh/person in year 2000) is more double than that of India (354 KWh/person in year 2000)[5]. At this high income level and industrial activity, CPPs are most likely to arise in Gujarat.

Gujarat has a large number of CPPs that vary according to commissioning industry, vintage, fuel type, and capacity. The smallest CPP is of 0.088 MW in size and the largest is as big as 240 MW[6]. The fuel types used for generation also varies greatly. The fuel types used by the CPPs are oil, bagasse, coal, lignite, gas, naptha etc.

In addition to the diverse nature of the CPPs, Gujarat is one of the progressive states in terms of the electricity regulations. Gujarat is one of the few states of India, which has captive power plant policy (Resolution No. CPP 1197/2253/PP Cell, 1998). In addition, the government of Gujarat has passed the Gujarat Electricity (Reorganization and Regulation) Bill, 2003 for reforming the state's electricity sector.

The study design:

The study design comprises of four key elements: collection and analysis of data from secondary sources; collection and analysis of primary data through questionnaire survey of a sample of CPPs; interviews with the captive plant owners and interviews with experts from industry and academics.

Gujarat in the year 2002 had 163 captive power plants. Data is collected from of all these 163 captive power plants. The data collected includes of plant sizes, fuel type used by the plant, the number of units present in a particular plant, the unit sizes, and the vintage of these units. These 163 power plants have in total 338 units. This data is collected from two different sources namely, from Gujarat Electricity Board, Baroda and from Commissioner of Electricity Duty, Gandhinagar. The data provided by the different sources were crosschecked for better reliability of the data. In addition, the data was also

[3] Per capita income is calculated by diving the Net State Domestic Product by Population
[4] http://www.indiastat.com, dated 25th Aug, 2003
[5] Planning Commission, 2002 p 85
[6] Data collected from Commissioner of Electricity Duty, Gandhinagar for the year 2002.

verified with the managers of the power plants of some industries through telephonic conversations.

In addition to collecting data from the centralized data sources, unit level data is also collected through a questionnaire survey. The questionnaire used is adapted from the study carried out by Chi Zhang, May and Heller on the Guangdong province of China (Zhang, May, Heller, 2001) and modified for use in the Indian context. Some more items were added to the original questionnaire. Experts then reviewed the content validity of the modified questionnaire. The first set of questionnaires was tested with a private utility and experts framed the final questionnaire after the initial reviews. The same questionnaire has been used (Paper WP 2/2003/ESR-IDE; IIM, Ahmedabad- Stanford joint study, 2003) for the Gujarat State level study on the technology, efficiencies and emissions of the thermal power plants. This questionnaire required the plant manager to furnish details about the technology, efficiency, cost, consumption, production, and other parameters related to the generating units. For various fuel types, separate questionnaires were designed to capture the use of different technologies.

This questionnaire was sent to plant managers of sixty-four CPPs. These CPPs are larger than five MW capacities. For analysis a sample of twenty-three questionnaires are used. The sample is selected to cover all the range of the CPPs both by type of industry and by fuel type. The industries covered include Cement, Chemicals, Fertilizers, Manufacturing, Paints, Paper, Petrochemicals, Steel, and Textiles. The fuel type covers Coal (1)[7], Natural Gas (5), Naptha (4), Residual Crude Oil (1), Furnace Oil [FO](5), High Speed Diesel [HSD](2), Light Diesel Oil [LDO](3), and Lignite (2).

The administration of the questionnaire was followed up with interviews with practicing managers, regulators and other stakeholders connected with the captive power plants in the state. More than 90 domain experts from industry (68), government (14), and academics (12) were interviewed to capture the various dynamics of the CPPs. The purpose of the interview was to understand the various factors that influence decisions about "*make or buy electricity*"[8] decision adopted by the industries; the technology selection procedure; the reasons for the existence of a wide range of plant sizes; and the impact of CPPs on the environment etc. The interviews also helped to bring forth the various institutional and other factors that influence changes in this sector.

In addition to these four key elements we draw on an extensive survey of literature. While the questionnaire and interviews explain why certain industries commission the CPPs the literature suggests some hypothesis to explain these dynamics.

[7] The figures in the brackets represent the number of plants belonging to the particular fuel type category.
[8] The decision of the industry can be "make electricity" on its own or "buy electricity" from the utilities.

3. Context: State of Gujarat

3.1 Economic Profile

Gujarat is a state in the western part of India with an area of 196 thousand square km. It was created on May 1, 1960 from the North and West portions of Bombay state facilitated under "The Bombay Reorganization Act, 1960. The total population of the state in 2000 was 50.6 million. The population growth rate in the state in the last decade (1991-2001) has increased to 22.48 percent (Ministry of Finance, 2002) as compared to 21.19 percent in the previous decade (1981-1991).

The state of Gujarat is highly industrialized and one of the most developed states in India. The Annual Survey of Industries conducted in 1994 showed that in terms of net value added, cement industry contributed 30 percent followed by others like rubber, plastic, petroleum, and coal products (15%), electricity generation (14%), and textiles (11%).

Table 1: Gujarat and India (2001)

	Gujarat	**India**
Population (million)	50.6	1027
Area (1000 sq. km)	196	3287
GDP ($ Billion)	936[9]	11987
GDP Growth Rate (%)	4.45	3.9

Source: Monthly review of the Gujarat Economy, CMIE, May 2003.

3.2 Electricity Sector

Prior to independence (1947), private companies and local authorities supplied more than 80% of the total capacity in India. The Electricity Act of 1910 governed the functioning of these organizations. With development of the western region, which includes today's Gujarat, many of the organizations had opted for their own electricity generation during that time. Gaekwad Mills Limited set up the first captive generating plant in Gujarat[10] in 1935. The plants set up by Tata Chemicals Ltd. and ACC Ltd. followed it. The initial plants used coal as the primary fuel source. These plants were all less than 5 MW in capacity.

[9] National State Domestic Product at factor cost at current prices is as a measure of state output.

[10] The state of Gujarat was created in 1960. The area falling within the present geographical boundaries is referred here.

After independence, electricity has been in the "Concurrent List"[11] in the Constitution of India. The introduction of the Electricity Supply Act of 1948 laid down the conditions of supply. The central government adopted a policy of development of electricity through the public sector after the Industrial Policy Resolution of 1956 leading to the creation of State Electricity Boards, which looked after the power sector at the state level. With the formation of Gujarat in 1960, the Gujarat Electricity Board (GEB) came into being as a vertically integrated entity in charge of generation, transmission, and distribution of electricity in the state. The existing licensees continued their operations. The different departments under the state government of Gujarat draw their own five-year plans along with the federal plans. Tax revenues, federal assistance and other resources managed by the state support the state plans. During the period from 1960 to 1990, GEB and Ahmedabad Electricity Company (AEC), which is a private licensee, was the main generators. Up to 1960, the existing captive capacity was merely 29 MW. Since the formation of the state to the period prior to the reforms in the early nineties, an additional captive capacity of over 500 MW was installed. This was around 10 percent of the addition of capacities of the utilities in the same period.

Post 1990, after the initiation of the reforms that allowed private sector participation in generation, a number of Independent Power Producers (IPP) set up generating stations in the state. Among the IPPs, there are three players, Essar Power Limited (EPL), Gujarat Paguthan Energy Corporation (GPEC), and Gujarat State Energy Generation (GSEG). Other players who have added to the capacity include Gujarat State Electricity Corporation Limited (GSECL), Gujarat Industries Power Company Limited (GIPCL), GEB, and AEC.

The captive power policy adopted by the state government in 1995 and 1998 has encouraged the growth of captive capacity largely. By 2002, the total captive capacity in the state exceeds a quarter of all the utilities combined. The captive plants have moved from coal to natural gas, liquid fuels, and bagasse due to the constraints on coal transport and opening up of the other fuel markets.

The per capita electricity consumption in Gujarat is almost double that of the national average. The projected demand far outstrips the available supply. The SEB is cash strapped and no major investments in the utilities are forthcoming at the present. The new Electricity Act, 2003 introduced by the central government, which is also binding on the states encourages captive generation largely. Hence, the growth of captive capacity may present one of the solutions to this dilemma.

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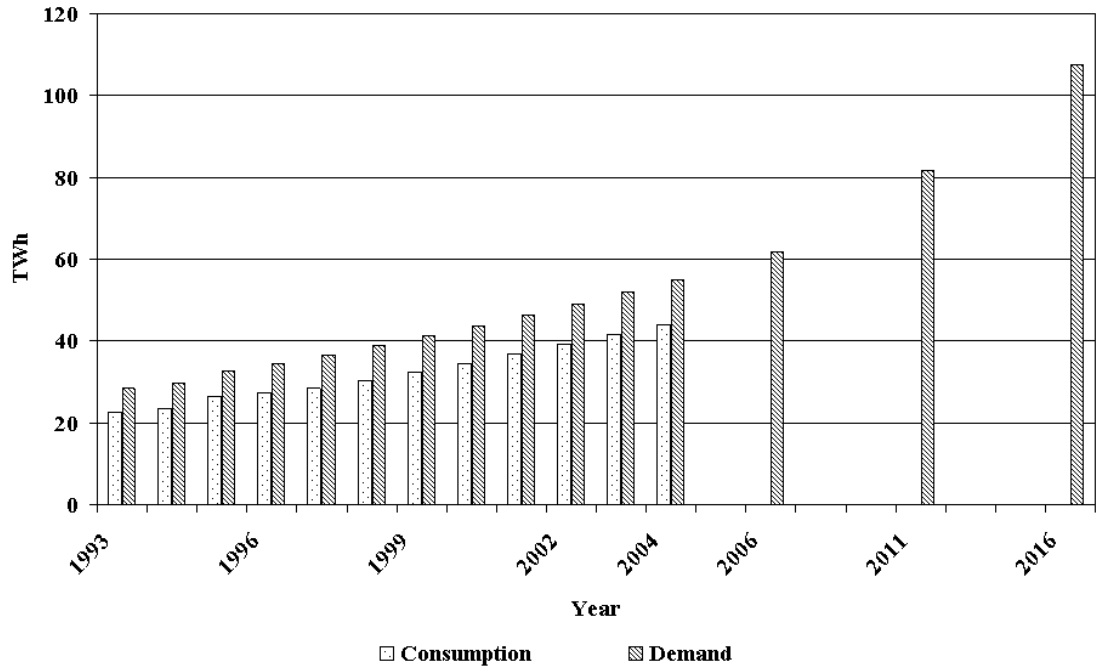
[11] The constitution of India enumerates the responsibilities of the state government and the central government in three lists, namely, state list; central list and the concurrent list. The elements listed in the concurrent list are the joint responsibilities of state and center.

Figure 1: Electricity Consumption and Demand



Source: 15th and 16th Electric Power Survey, CEA.

4. Overview from Survey: Captive Power Plants of Gujarat

Historically, Gujarat is one of the most industrialized states in India. Some of the industries that developed first in Gujarat (before independence of India) are cotton textiles and chemicals (salt). These industries were the first ones to commission the captive power plants. The Gaekwad Mills of Bilmora (Cotton Textile Industry) commissioned a 1.25 MW coal based plant in the year 1935[12]. Tata Chemicals in Mithapur commissioned three coal-based units of total capacity of 10 MW in the year 1940. Since then the installed capacity of captive power plants in Gujarat has increased every year. In 2002, the total installed capacity of CPPs in Gujarat is 2.44 GW (22% of the total installed capacity).

4.1 Capacity

The installed captive power capacity of Gujarat has grown continuously. It was 569 MW in 1991, which was around 12% of the total installed capacity[13] in the same year. The capacity became almost four times in 9 years and grew to 2192 MW in 2000, which was 21% of the total installed capacity of Gujarat.

Table 2: Installed Capacities (GW)

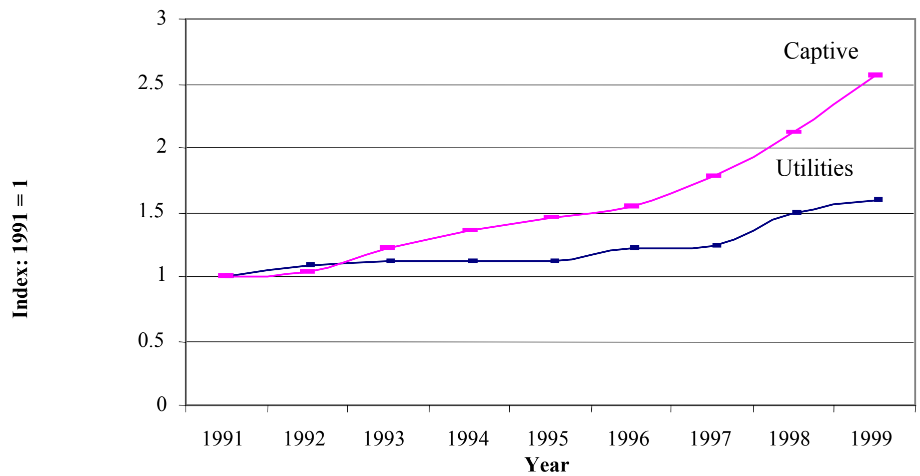
Year	India				Gujarat			
	Utilities*	Captive*	Total	% Captive	Utilities#	Captive#	Total	% Captive
1991	66.1	8.6	74.7	11.5	4.1	0.57	4.67	12.2
1996	83.3	11.8	95.1	12.4	6.7	1.01	7.71	13.1
2000	97.8	15.2	113.0	13.5	8.4	2.19	10.59	20.7

Source: * Planning Commission 2002
Gujarat Electricity Board; Commissioner of Electricity Duty, Gandhinagar, Gujarat

The total capacity of Gujarat, which was 6.3% of that of total Indian capacity in 1991, grew to 9.4% in 2000. However, the growth of the installed capacity of captive power plants was much greater compared to the utilities. The captive capacity of Gujarat was 6% of that of the total Indian capacity in 1991. This grew to 14.4% in the year 2000.

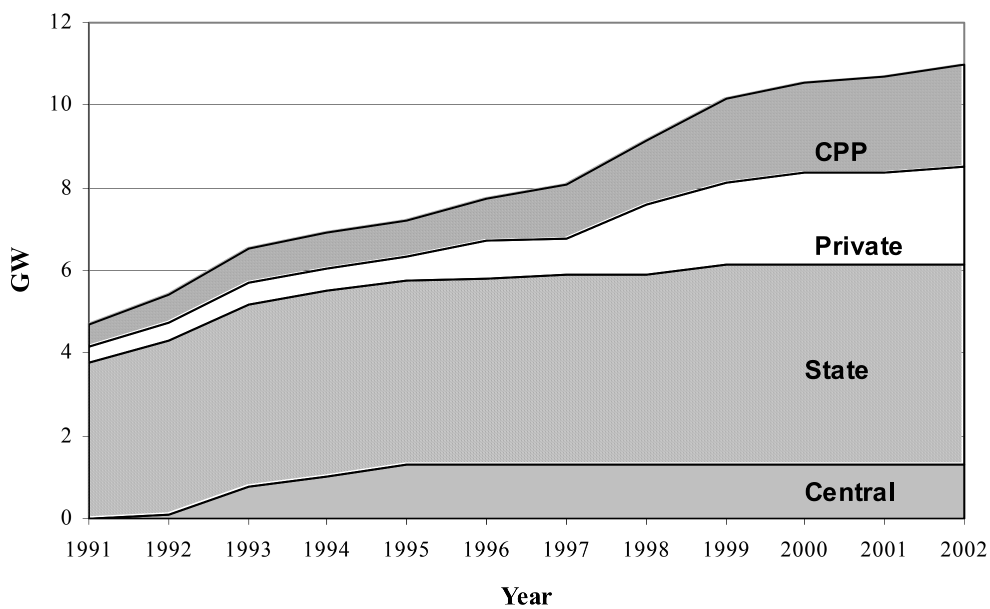
[12] Year 1935 represents the financial year 1935 i.e. year starting 1st April 1934 to 31st March 1935
[13] Total Installed Capacity = Installed Capacity of Utilities + Installed Capacity of Captives

Figure 2: Comparative growth of CPPs and Utilities in Gujarat



Source: Center of Monitoring India Economy, Energy 2002

Figure 3: Installed Capacity- Gujarat

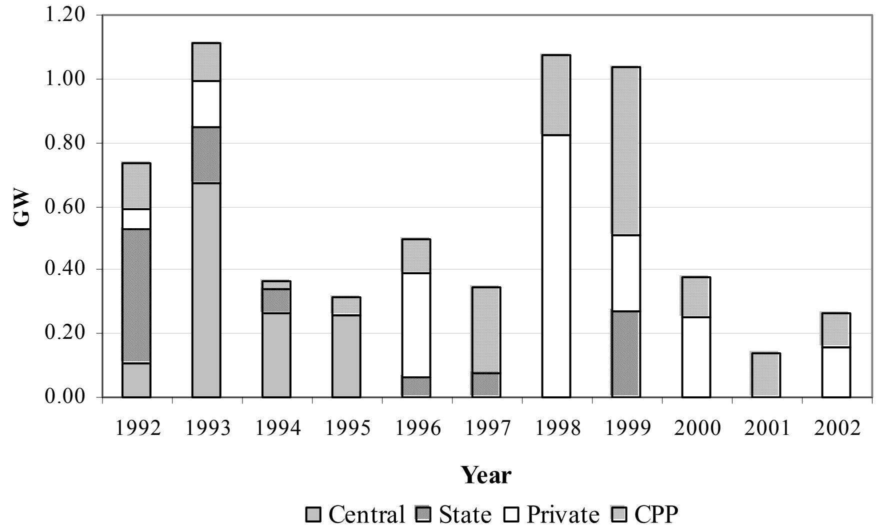


Source: Gujarat Electricity Board, 2002
Commissioner of Electricity, Gandhinagar, Gujarat, 2002

Almost 6.3 GW of installed capacity has been added in Gujarat in the last 11 years (1991 to 2002).The growth of the utilities from 4.1 GW in 1991 to 8.5 GW in 2002 is mainly due to the growth of the private utilities and the plants commissioned by the central utilities. The Gujarat Electricity Board (GEB, State Utility) hardly added any capacity in this period. The main reason for this was the poor financial status of GEB (IIM Ahmedabad – Stanford University, 2003).

The growth of the CPPs attribute to around 30% of the capacity addition in Gujarat. Various factors prompted the growth of the CPPs in Gujarat. These factors can be macro level factors such as policy changes or can be micro level factors such as reduction of cost etc. Section 5 elaborates on these factors.

Figure 4: Capacity Addition- Gujarat



Source: Gujarat Electricity Board, 2002 Commissioner of Electricity, Gandhinagar, Gujarat, 2002

4.2 PLANT AND UNIT SIZE

Gujarat had 163 CPPs in the year 2002. The plants vary greatly in size. The smallest CPP size being 0.088 MW and the largest plant size being 240 MW, which is larger than many of the plants commissioned by utilities.

Table3: CPPs Gujarat- Plant Sizes

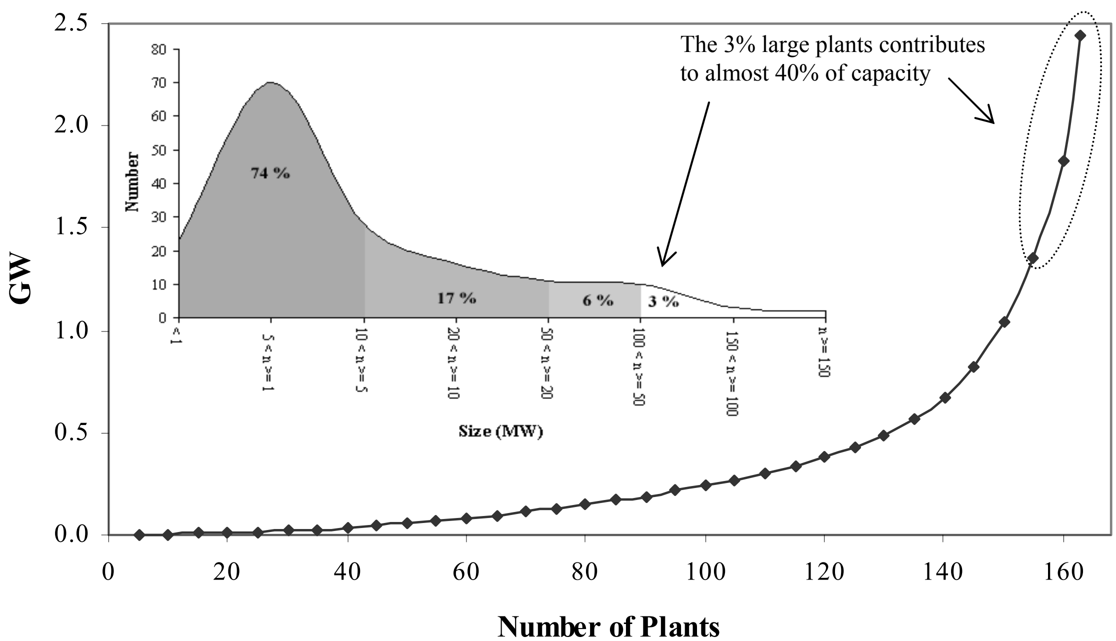
	Number		Plant Size (MW)			Unit Size (MW)		
Fuel	**Plants**	**Units**	**Min**	**Max**	**Average**	**Min**	**Max**	**Average**
Lignite	9	24	2.5	22	11.47	0.86	16.8	4.30
Coal	12	27	1.5	115	18.67	1.25	30	8.30
Fuel Oil (FO)	41	76	0.8	52.6	6.63	0.2	19.2	3.58
Light Diesel Oil	15	33	0.6	6.16	1.71	0.40	2	0.78
High Speed Diesel (HSD)	10	24	0.6	10.92	4.34	0.26	4	1.81
Naptha	14	39	4	240	65.97	2.10	41	23.68
Natural Gas	35	62	0.088	114.5	14.73	0.088	34	8.32
Bagasse	22	44	1.5	8.2	4.21	0.85	3	2.11
Others	5	9	0.85	84	48.18	0.85	50	26.77
Total	**163**	**338**			**14.98**			**7.22**

Source: Gujarat Electricity Board, 2002
Commissioner of Electricity, Gandhinagar, Gujarat, 2002

The main reasons of the variability of the sizes are the different factors that cause the industry to commission the CPPs. For example, the CPPs, which are commissioned as back up to the failure of regular electricity supplied by the utilities, are of smaller sizes. On the other hand, the CPPs, which are commissioned for reducing the cost of electricity, are of much larger sizes.

In Gujarat, the CPPs are predominantly of smaller sizes. More than 70% of the CPPs in Gujarat are below ten MW capacities and only about 9% are above 50 MW capacity.

Figure 5: CPP Gujarat- Plant Sizes



Source: Gujarat Electricity Board, 2002
Commissioner of Electricity, Gandhinagar, Gujarat, 2002

The utilities on the other hand are much bigger plants. In Gujarat, 20 utilities are present that have a cumulative capacity of 8.4 GW. The average size of the utilities is above 425 MW.

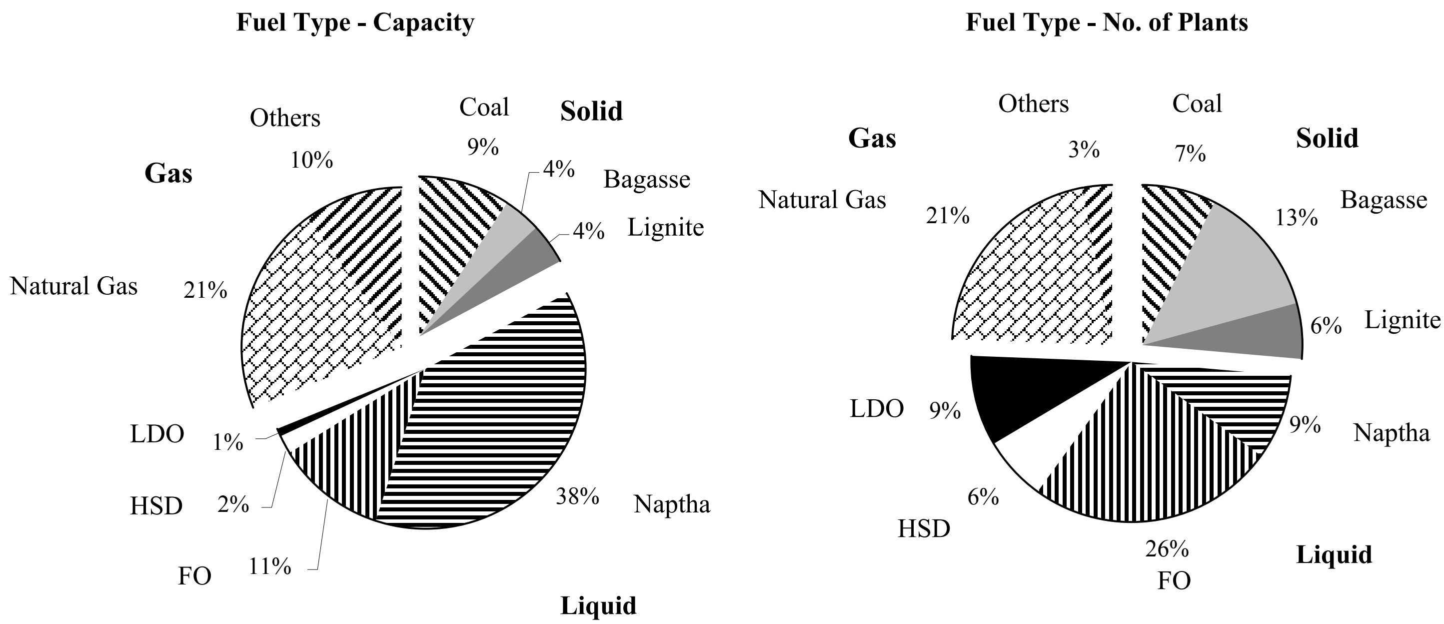
As observed in the case of the plant sizes, the unit sizes of the CPPs in Gujarat also vary considerably. The smallest unit is of the size is of 0.088 MW size and the largest is of 50 MW size. Most of the units of larger size have been installed after the starting of the electricity sector reform in 1991.

In contrast, in the case of the utilities in Gujarat, the smallest unit size is 1 MW for hydro plants and 30 MW for the thermal plants. The largest unit commissioned by a utility is as large as 255 MW.

4.3 Fuel Type

The industries in Gujarat use various fuel types in the respective CPPs. The CPPs use conventional fuels such as coal, lignite, natural gas, naptha etc, which are used by the utilities also. They also use furnace oil, residual crude oil, peat coke, LDO, bagasse etc which are rarely used by the utilities as fuel. In Gujarat, 14% of the installed capacity of CPPs is oil (FO, LDO and HSD) based. However these oil-based CPPs represent 41% of the total number of plants. Thus, most of the smaller CPPs chose oil as the fuel. On the other hand, 38% of the installed capacity of CPPs uses Naptha, but it represents only 9% of the total number of CPPs. Similarly, coal represents 9% of the fuel share (in MW) and 7% of the total number of CPPs in Gujarat. Thus, it is clear that the larger CPPs use naptha or coal (conventional fuel) as the fuel.

Figure 6: CPPs Gujarat- Fuel Type



Source: Gujarat Electricity Board, 2002 Commissioner of Electricity, Gandhinagar, Gujarat, 2002

The industries commission smaller CPPs as back up to the regular electricity supply. The industries do not use these plants regularly. This is reflected through the low (20-30%) Plant Load Factor (PLF) and high (90% to 100%) Plant Availability Factor (PAF) of these plants. Table 6 elaborates these figures for different fuel types. Since the industries to not use the power plant that frequently, they try to keep the fixed costs of these plants low, and the variable cost becomes secondary.

For this reason, the industries settle for second hand oil based plants that are of lower cost. For example, in Gujarat, many industries buy these generator sets from Alagh shipyards where used generators from the ships are sold at very cheap prices. The industries incur some cost of reworking, but overall, they are able to procure the generators at low cost. Moreover, in India, the oil market is well established. Thus, procuring the oil from the market place requires less transaction cost. These dynamics prompts the industries to use oil-based CPPs.

On the other hand, many industries commission CPPs for cost cutting purposes. These industries commission larger power plants. They chose the fuel such that the variable cost of producing electricity is less. Thus, these industries end up choosing technologies that use conventional fuel for producing electricity.

Table 5: Installation cost and cost of generation[14]

Fuel Type	Installation cost (million rupees per MW)	Generation cost (rupees per unit)
Lignite	50 - 52.5	1.59 - 1.90
Coal	42.5 – 45	1.78 - 1.92
FO	10 - 12	3.5 - 3.75
LDO	7.5 - 10	4.25 - 4.6
HFO	10 - 15	4.5
Naptha	35 - 41	3 - 3.25
Natural Gas	42.5 - 50	2.3 - 3.3

Source: Gujarat based CPPs

In contrast, the utilities in Gujarat chose conventional fuels like coal and gas for electricity generation. This is because the utilities try to produce electricity in lower costs. The average cost of production for the coal based plants was rupees 1.6 and for the gas based utilities was around rupees 1.95 in 1999 (IIMA-Stanford Joint Project, Working Paper WP 2/2003/ESR-IDE).

4.4 VINTAGE

As stated earlier, the CPPs in Gujarat was commissioned as early as 1935. Until the end of 1980s, coal and lignite were the preferred fuels used by the CPPs. Many of these plants came over because the utilities were not able to supply electricity and there were severe shortages. During this period, various sugar mills used bagasse as fuel to generate both electricity and steam. Very few industries used gas or naptha as fuel. These industries were mainly petrochemicals (Example Indian Petrochemical Company Limited) or gas companies (Example Gas Authority of India Limited) which had a secured supply of these fuels.

In the 1990s, naptha, oil (FO, LDO, and HSD etc) and gas became the preferred fuel of the CPPs. Coal, Lignite and Bagasse, which was the dominating fuels of 1980s, saw very marginal capacity addition during this period. Small sized back up type CPPs chose oil as the preferred fuel. Naptha and Gas as fuel were chosen by the larger and middle-sized CPPs. There are essentially three main reasons for this. Firstly, medium sized plants with some degree of economies of scale were available as technological choice (manufacturers like GE, Siemens came in) during this period. Second, gas fields were struck near Hazira, Gujarat. Thus, gas as a fuel became an option for the power plants situated in Gujarat. Also, the higher industrial tariffs made these medium sized Naptha or gas based plants a viable option.

[14] The figures are of the year 1999

Figure 7: Vintage of Gujarat CPP Units

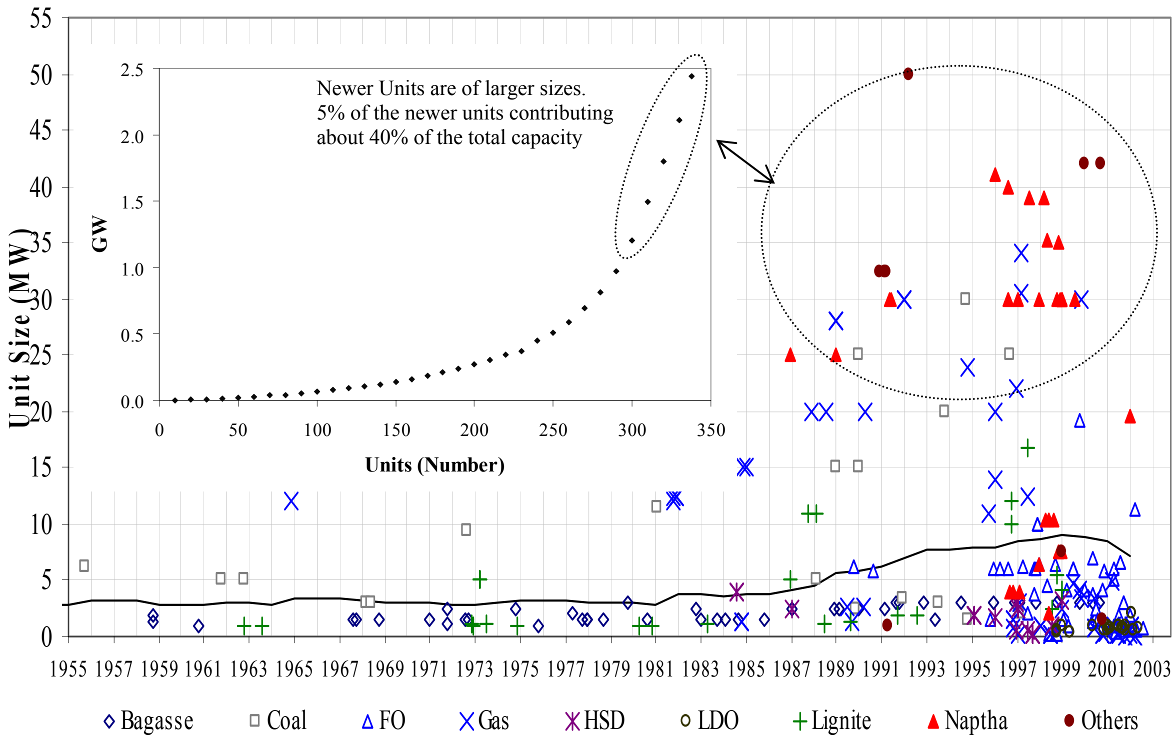
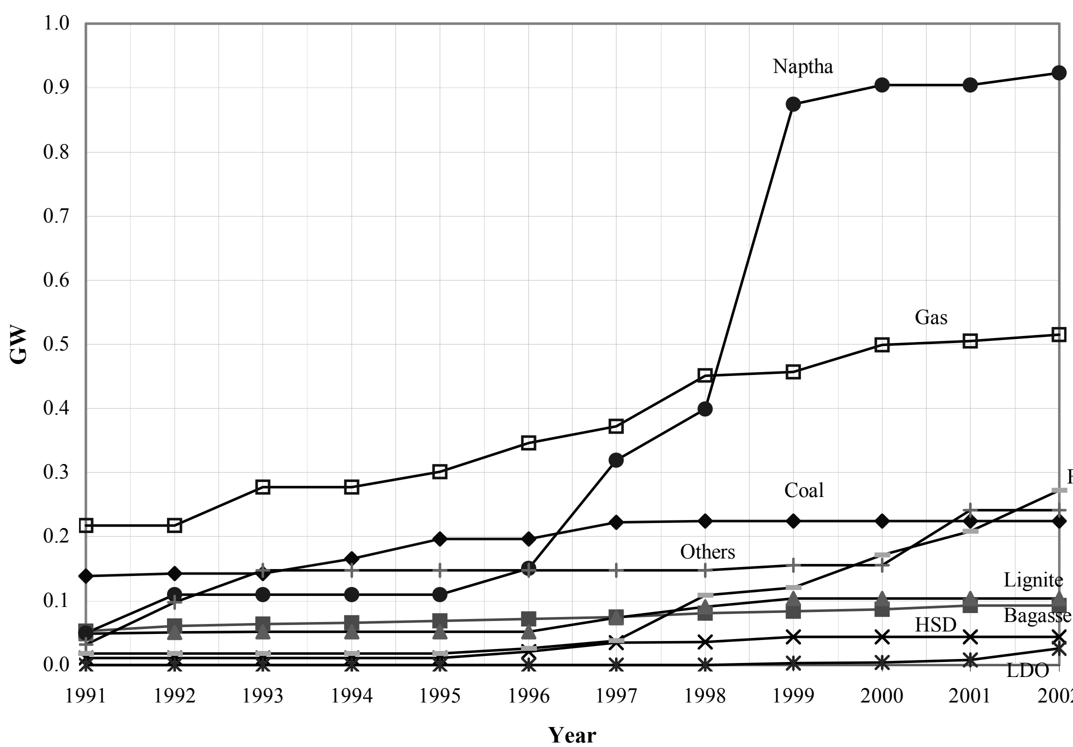


Figure 8: Growth of CPPs- Fuel type



Naptha based CPPs grew in the mid 1990s. The naptha price was very low (Rs 6 to 8/ kg) during this period. This prompted the CPPs to choose naptha as the preferred fuel. In addition, the industries which commissioned naptha based CPPs during this period were mainly petrochemical and chemical industries. However, in early 2000, the installed capacity of CPPs with naptha as fuel started being saturated. The main reason for this was with the opening up of the fuel markets, the naptha prices rose (Rs 15 to 20/ kg).

4.5 Performance

The performance of the CPPs varies with the fuel type. The oil based technologies show a lower plant load factor. The lower plant load factor (PLF) can be explained by the fact that the oil based CPPs are mainly used as the back up to the grid power. Therefore, it is mainly used when there is a black out for the critical operations of the industry.

Table 6: Performances of the CPPs

Fuel Type	PLF (%)	PAF (%)
Lignite	80- 88	75-80
Coal	70- 75	75-85
FO	20- 65	95-100
LDO	15-40	95-98
HFO	20-30	95-100
RCO	75-85	90-100
Naptha	70 – 75	85-88
Natural Gas	75- 85	80-85

Source: Various Gujarat based CPPs

In addition, the set up time for the oil-based plants are much lower than the coal and gas based plants. During black outs the machines need to be started at the earliest to start the production process. Thus for CPPs built as back ups, oil technology is a better choice.

On the other hand, the oil based CPPs has a higher (near to 100%) plant availability factor (PAF). This is another reason for choosing oil-based technology for back up type CPPs. The maintenance of coal, gas or naptha based plants require much higher time than that of the oil based plants.

5. Reasons for the growth of CPPs

In 1991, Gujarat had 0.57 GW installed capacity of the CPPs. This capacity grew about 4 times in 11 years time and became 2.5 GW in the year 2002. The growth of the CPPs in Gujarat can be attributed broadly to two factors: macro level changes policy environment and at the micro level economic and financial factors at the firm level.

In 1991, India opened up its economy. This gave an opportunity to the various industries to import modern and better equipments. This case was true for the industries, which wanted to set up captive power plants. They had a choice to get power technology from the Indian manufacturers like BHEL or from abroad from companies like General Electrics, Siemens; Wartsila NSD, Finland; ESSAN, Germany; AEG, Germany etc. These companies were capable of producing smaller capacity plants in a reasonable price. This gave the industries more choices and flexibility in the form of technology selection and fuel choices. Thus, the macro policy of liberalization and globalization had an indirect impact on the growth of CPPs.

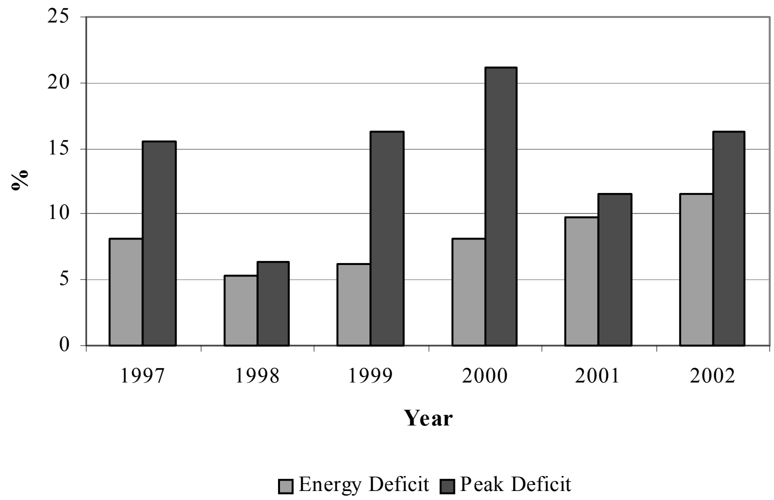
Post 1991 the policy regime for the power generation experienced lot of changes. In 1991, the Ministry of Power, Government of India at the center formulated “The Policy on Private Participation in Power Sector, 1991.” This gave boost to the private sector to invest in the business of power generation. Bur here the private players invested in power plant, which were utilities in nature. In 1998, Energy and Petroleum Department, Gujarat Government passed a resolution “Resolution No.CPP 1197/2253/PP Cell, 1998” which was a policy for the Captive Power Projects. This resolution addressed issues like wheeling of power; wheeling tariffs; supply of surplus power to the group companies (parent company); supply surplus power to the state utility (GEB); supply of surplus power to AEC (licensee) etc. This policy farther enhanced the growth of the CPPs in Gujarat.

Though the macro level changes enabled the CPPs to grow, this by itself cannot justify the 400% growth of the CPPs in just 11 years. Case studies of various industries owning CPPs and interviews of the CPP owners and industry experts show that major reason of the growth of the CPPs for the power sectoral level inefficiencies and other micro level factors. These factors are non-availability of grid power; poor quality and reliability of power; high industrial tariffs; multiple benefits; and lower production cost of the outputs of industry. The industries can commission a power plant because of any or a combination of these factors.

5.1 Non Availability of Power

Gujarat, like other Indian state faces a persistence problem of power shortage. However, with time, the utilities have increased the generation capacity and have been able to reduce demand -supply gap, but they have not been able to eliminate this problem.

Figure 9: Peak and Energy Deficit- Gujarat

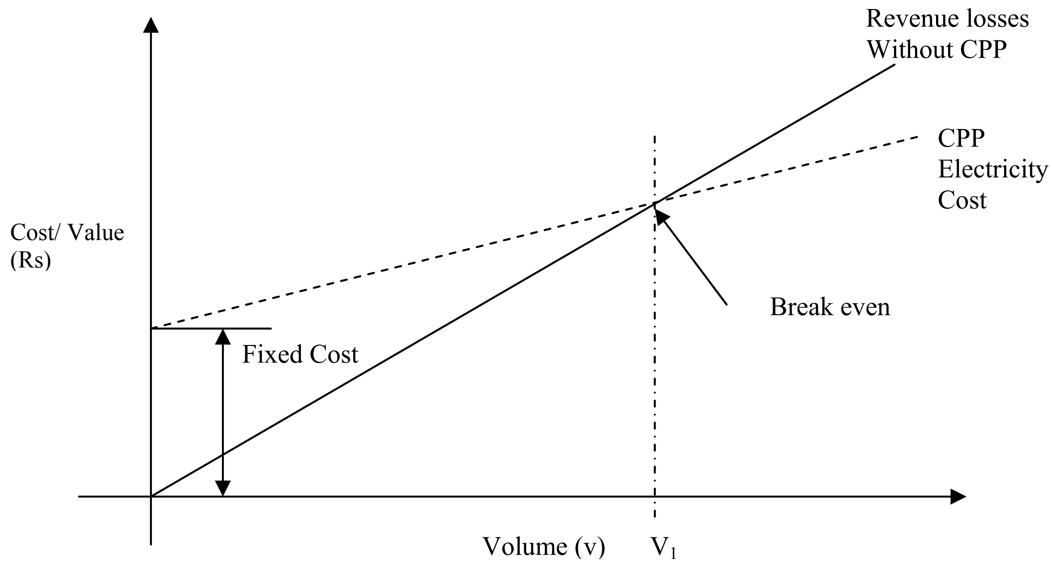


Source: CMIE, 2003

Power is an important input for any industry. Inadequate supply of power will reduce the production period and thus affect the production volume for the industries. Thus, many industries have commissioned captive power as an alternative source of energy so that they can hedge against the uncertainty of not receiving adequate electricity supply from the utilities. These power plants generally act as back up power supply options for the critical operations. In this case, the rupee value of production losses due to inadequate supply of power from the grid is compared with the installation cost and the operational cost of captive power plants. The industry goes for the captive power plant when the expected cumulative production loses in monetary terms (revenue) is greater than that of the installation cost and the operational cost of the captive power plants. In this case

$\sum$ *Revenue loss due to less production attributed to inadequate electricity supply* $\geq$
Cost of installation and other fixed costs of the CPP + $\sum$ *Units of electricity produced x cost of generation*.

Figure 10: CPP for avoiding loss of production



Note: Dotted line represents cost due to production of electricity
Plane line represents the loss due to loss in volume of industrial production

For example, in the case of Ashima Mills (one of the leading textile manufacturers in Ahmedabad), which got roughly 1 billion rupees in 2002 as revenue from the jeans sales, one min production loss will amount to an average revenue loss of around Rs. 1902 from there jeans sale alone. This per minute revenue is large amount compared to the installation and operation (Refer to table 5) of back up plants for critical operations. This figure is such higher for the service industries such as IT firms, hotels etc.

5.2 Poor Quality and Reliability of the Grid Power

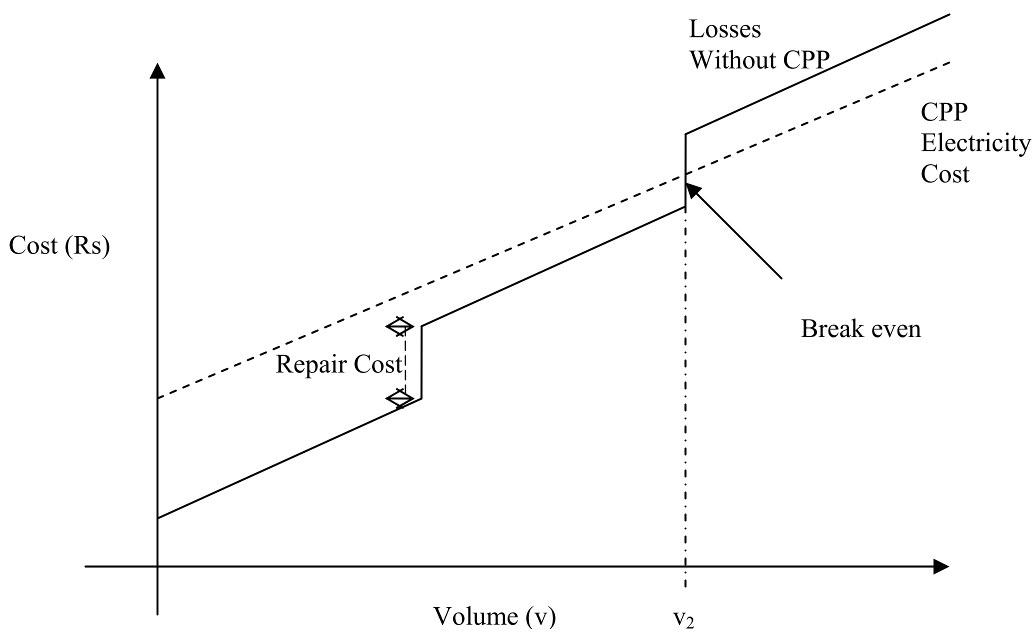
Poor quality and reliability of grid supply is the second reason that prompts industries to install captive power plants. Poor quality essentially creates two problems to the industries. First, it reduces the output by reducing the efficiency of the machines and secondly it damages the machine itself and reduces the production time. We explain these phenomenons with example in the next paragraphs.

One of the important parameters to measure quality of electricity is the frequency at which the electricity is supplied. In many industries, the production capabilities of the machines are directly dependant on the frequency of electricity. Thus, if the frequency of electricity is low the production volume is reduced. For example, some of the textile looms work best if the frequency of electricity is 50 Hertz. The normal grid frequency of Gujarat is about 48.5 Hertz. Thus, there is a production loss of 3% each day due to this factor.

The voltage fluctuation is an additional problem faced by the industries using the electricity supply from the grid. The voltage fluctuation does two things. Firstly, voltage fluctuations result in the damage of sensitive machines and thus the industry loses important production time and the volume of production gets affected; and secondly it affects the quality of the batch and increases the rejection rates of the products. Moreover, the industry has to incur unplanned repair and maintenance costs to bring back the production process back to normalcy. This prompts the industries to commission captive power plants. In this case

∑ Revenue losses due to less production + ∑ Repair and Maintenance cost ≥ Cost of Installation and other fixe

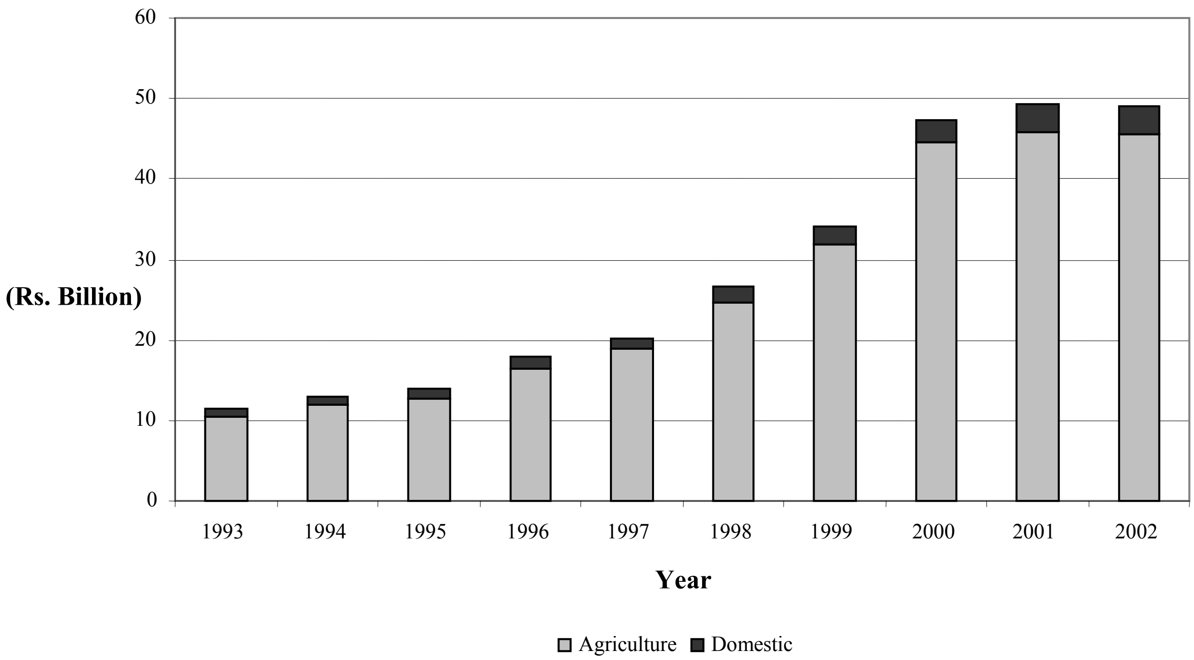
Figure 11: CPP for Quality Power



5.3 HIGH INDUSTRIAL TARIFF

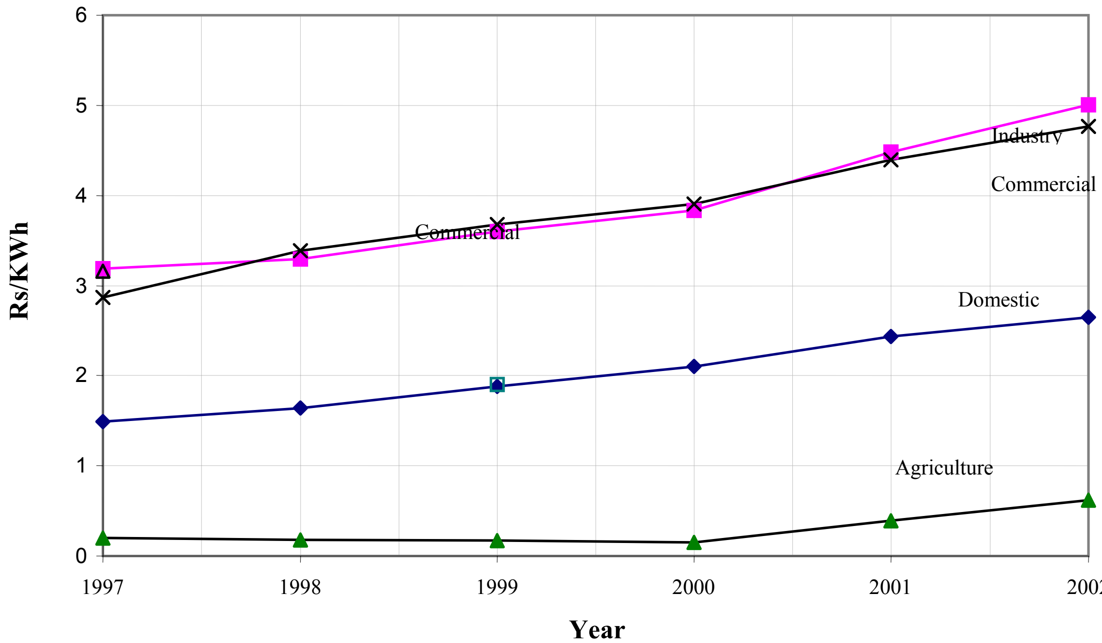
In Gujarat, the industrial and commercial users of electricity subsidize the agricultural and the domestic household users. Figure 12 shows the amount of subsidy paid to agricultural users and domestic users. This is one of the reasons why the industrial tariff is higher than the average cost of production of electricity. Figure 13 shows the electricity tariffs for different user types.

Figure 12: Subsidy received by the agricultural and domestic sector



Source: CMIE, Energy, 2002
Planning Commission, 2002

Figure 13: Consumer wise Average Tariff- Gujarat

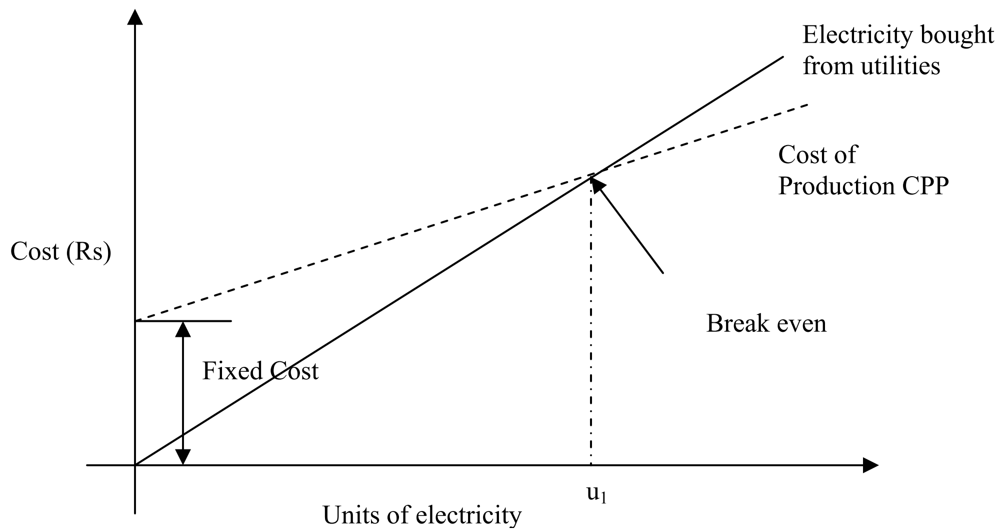


Source: CMIE, Energy, 2002
Planning Commission, 2002

Due to this distortion in the price of electricity, the industry finds it economical to invest in a captive power plant. Thus, the CPP being installed can be of very small size and might not have economies of scale, still it might work out to be economical to the industry due to the high industrial tariffs. In this occasion, the cost of generation (including the fixed cost and the variable cost component) of the captive power plant becomes much less than the tariff that the industry has to pay. In this case

∑ Electricity units consumed x Industrial Tariff ≥ Cost of Installation and other fixed costs of the CPP + ∑ Electricity produced x cost of generation.

Figure 14: CPPs for lesser electricity cost

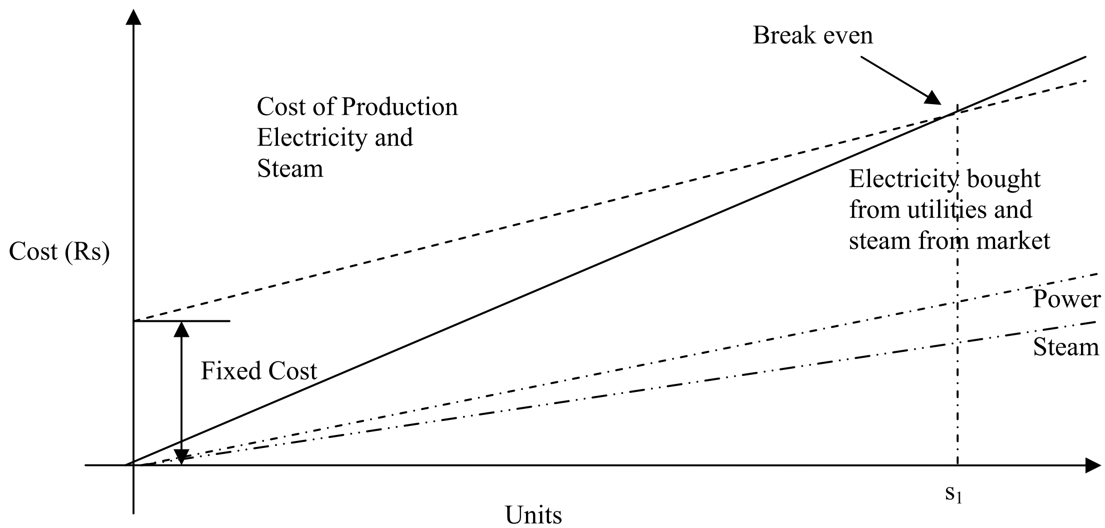


5.4 MULTIPLE BENEFITS

In certain industries like sugar mills, textiles, ceramic industries etc, steam is one of the important inputs as raw materials in the production process. In these industries, the captive power plant is used for generating both steam and electricity. The cost advantages due to this dual production of electricity and steam makes the captive power plant economically viable. The following equation explains this.

∑ Volume of Steam x unit cost of procuring steam + ∑ Electricity units consumed x Industrial tariff ≥ Installation cost and other fixed costs of the CPP+ ∑ Volume of Steam generated by CPP x unit cost of steam + ∑ Electricity units consumed x cost of generation.

Figure 15: CPP arising for multiple benefits



For example for these industries (sugar mill, ceramic, textiles etc), typically a naptha based CPP will incur Rs. 4.25- Rs 4.50 to produce electricity and steam in 2000 jointly. Since on an average the price of making steam was Re. 1.00 per unit of electricity, the effective cost of electricity for them becomes Rs. 3.25 to Rs.3.5. The industrial tariff of electricity for year 2000 was Rs.4.00. Thus, the joint production of steam and electricity together resulted to a saving on 0.5 to 0.75 rupee per unit of electricity consumed. For this reason for the sugar, textiles, ceramic etc industries the CPP becomes a financially viable option.

5.5 Electricity as an important input of production

Industries like aluminium, iron and steel etc, electricity is one of critical inputs in terms of costs. For example in the aluminum industries, the electricity cost determines around 35%-40% of the production cost. Normally these industries need a high volume of electricity. Thus, they install CPPs, which are of larger size to attain the economies of scale (Example, Essar Steel). These plants are similar to base load power plants. In doing so they are able to reduce the production cost of the products and remain competitive in the market.

In addition to the above mention factors, the ability and experience of handling power plants plays an important role also while deciding on "making or buying" decision of electricity. In many cases the learning curve plays an important role in deciding the technology and fuel to be used. For example, in Ashima Textiles, Ahmedabad workers had handled smaller diesel based power plants. Thus, when Ashima Textile commissioned the 9 MW fuel oil based power plant in the year 1997, they were confident to run it efficiently.

The industries can install a captive power plant because of any or a combination of the reasons stated above. However, the development of the electricity market in India will eliminate many of these factors. As observed in the other country experiences, with the development of the electricity markets will bring competition, electricity prices will be reduced and the quality of the product which is electricity gets better.

Moreover, though the captives by definition, looks like a homogeneous mass of plants, actually they are not. The above-mentioned factors or reasons segments the captive power plants in India into various groups. Captive power plants can be very small backup type, or it can be big power plants (installed for reducing the cost of electricity). Thus, while formulating the policy for captive power plants, the policy makers have to understand these dynamics. There is a need for formulation of different policies for different segments of the CPPs because of these differences and dynamics.

6. Conclusions

The study of the captive power plants shows that the CPPs are commissioned by the industries for various reasons. Thus, the CPPs are not a homogeneous in nature. CPPs can be segments into various categories according to the reason for which the industry installed it. The various categories the in which the CPPs can be segmented are- Back up type; CPPs for quality power; CPPs for multiple benefits and CPPs for reducing costs of production of electricity. These categories of captive power plants are fragmenting the electricity generation market of India.

Table 7: Segmentation of CPPs

Objective (Segment)	**Size**	**Preferred Fuel**	**Typical Consumer**
Hedging against interrupted power supply (Back Up)	Small	Oil (HSO, FO, LDO)	Small units (Textiles, Paints, Paper)
Better Control and reliable power (Quality power)	Small - Medium	Gas, Naptha	Facilities with sensitive equipments
Joint production of steam and Electricity (Multiple benefits)	Small - Medium	Gas, Naptha, Bagasse	Sugar mills, Cotton Textile
Reduced cost of generation below industrial tariff (Reducing cost)	Medium - Large	Coal, Gas, Naptha	Petrochemicals, Cement

The current captive power plant policy at state and central level treats the CPPs as homogeneous entities. However, there is a need to understand the dynamics of various segments of the CPPs and frame the policies accordingly. The various segments cater to different needs of the industries. Treating these segments uniformly will lead to problems because the varied characteristics (size, preferred fuel type, usage etc) of these segments.

The study of the CPPs of Gujarat reveals that the increased commissioning of the captive power plants has various positive impacts and negative impacts on the power sector as a whole. The positive aspects and the negative aspects are not essentially exclusive by themselves. These characteristics give rise to various kinds of trade offs at various levels. For example, the trade off between the power sectoral developments versus the development of overall economy, trade-off the individual company versus the power sector as a whole etc. These trades-offs gives rise to various dichotomies. An effective CPP policy will effectively address these dichotomies and trade-offs.

Reduction of burden of the government to commission additional power plants:

Most of the State Electricity Boards in India are facing a huge financial crisis. Table 8 provides the details of subsidy provided by the state to selected SEBs. In this situation the SEBs are not in a position to commission additional installed capacity. The commissioning by various industries lessens the responsibility of the SEBs to invest in the power sector to certain extent.

Table 8: Subsidy received from State Government (Rs. Billions)

SEB	**1999** (Actual)	**2000** (Provisional)	**2001** (Revised Estimate)	**2002** (Annual Planned)
Andhra Pradesh	25.492	30.644	16.263	16.263
Gujarat	16.73	12.77	13.16	13.56
Karnataka	9.139	10.506	17.512	24.265
Madhya Pradesh	1.205	4.331	4.644	4.989
Tamil Nadu	10.761	2.50	2.50	2.50

Source: Planning Commission, 2002

Additional Revenue for the state government:

In many states, the captive power plants have to pay electricity duty for installing captive power plants. In Gujarat, the industries have to pay around 20 to 70 paise[15] per unit to commissioner of electricity for the energy generated from the CPPs. This results in some extra revenue for the State Government. However, the policy for charging the electricity duty has to be framed carefully. In Gujarat, this duty is different for different customers and technologies. The least electricity duty is 20 paise per unit for cogeneration type of plants. Where as, the industries consuming high tension energy has to pay 40 paise per unit. The highest duty per unit is as high as 70 paise (Bombay Act No. XL of 1958). Many of the industries do not need steam as an input. But this distortion in duty structure has led the industries commission more of cogeneration type of plants. Out of 338 units installed in Gujarat, 202 are installed as cogeneration unit.

Additional revenue for the Transco in the form of wheeling charges:

In many cases the CPPs has to wheel the power to various industries through transmission grids. For wheeling the power, the industries have to pay per unit wheeling charges, which is around 1% to 1.5% of the cost of generation. This results in some additional revenue for the Transco.

[15] 100 paisa = 1 rupee

Though the commissioning of CPPs will lower the burden on the SEBs, will bring in some additional revenue in the form of surcharges and wheeling charges, it has its negative effects also. These trades-offs are:

Loss of Industrial customers for the State Electricity Boards:

As stated earlier, in India industrial tariff is the main source for cross subsidizing the agriculture and domestic users. With the growth of captive power plants, the state utilities are losing these industrial customers and this is affecting the revenue realized by them. Thus, the financial position of the SEBs is getting worse due to the growth of CPPs. In addition, the billing and collection is easier and more efficient in case of the industrial users. This results in lower transaction costs for the distribution companies. Due to the loss of the industrial customers, the Discoms are losing the better customers in terms of the efficient payments.

Adverse environmental impacts arising from types of fuels used and from higher emissions per unit of production:

Many of the captive power plants use oil as fuel. The emissions coefficients of these fuels are much higher in comparison to fuels such as naptha or natural gas. Moreover the distortion created due to high industrial tariffs has prompted the captive plant owners to use the oil based captive plants more since it has become economical for them to run it. This is apparent from the rising plant load factors of these plants, which became as high as 60% in many cases. This has further lead to adverse environmental consequences.

Table 9: CO_2 emissions co efficient for different fuel sources of India

Source Category	**Emission Co efficient**	
	Ton/ Ton	**Gg/ PJ**
Coal Combustion	1.76	94.7
High Speed Diesel	3.18	108.9
Light Diesel Oil Combustion	3.18	74
Fuel Oil	3.13	78
Naptha	2.57	57
Low Sulphur Heavy Stock	3.13	78
Natural Gas	1.98*	52.6

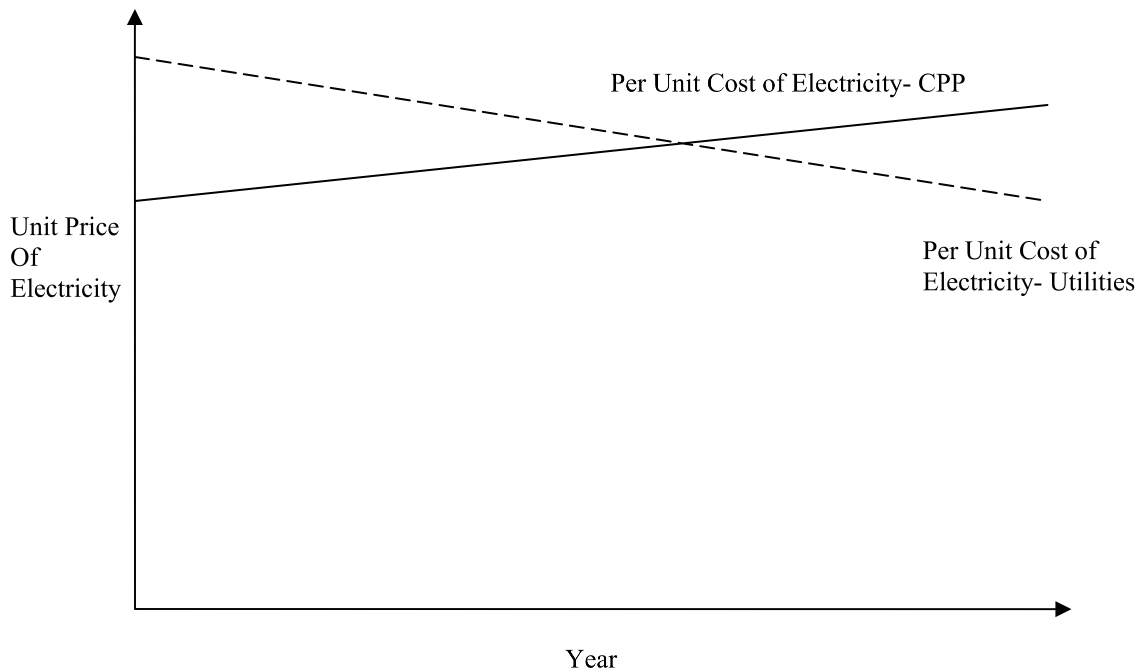
* Ton per million cubic meters

Source: P.R. Shukla and A. Garg, (2002) Emissions Inventory of India, p 56

Industries also faces the dichotomy whether to install CPPs or not. One of the main risks that the industry is perceives is the regulatory risks, which might create the stranded asset problem for them. The states in India are undergoing electricity reforms. As a part of the reform process, the states have institutionalized regulatory bodies such as State Electricity Regulatory Commission (For example, in Gujarat, the Gujarat State

Regulatory Commission). One of the objectives of these regulatory bodies is to rationalize the tariff. With the rationalization of the tariff structures, there is a possibility that the industrial tariffs become lower than the cost of generation of certain captive power plants. This can increase the payback period of the captive power plant by shifting the break- even point. Worse, it can make the whole investment uneconomical for the industry thus creating stranded assets.

Figure 16: Impact of price shocks on smaller CPPs: A Conceptual Understanding



Thus, we find that the captive power plants have both positive and negative effects on the power sector. Many states have come up with various captive power policies. However, we need to look at these policies a little more carefully. We need to frame a policy, which increases the overall benefit of the society as a whole.

From July 2003, a new act, the Electricity Act, 2003 has come into force. This act has created tremendous potential for the growth of captive power plants. The provisions like open access, third party sale etc. provided by the Electricity Act, will enhance the growth of the captive power plants. However, on the other hand state has the power of levying surcharges on the industries for the sale of power. This levy might make the third party sale uneconomical. Thus, there is a requirement of balanced captive policy. The captive policy should encourage the industries to look for newer architectures, which are in line with the overall objectives of the reforms such as lowering the cost of generation, more efficient generation etc.

In addition, the regulators should state the long-term industrial tariffs upfront as early as possible so that the various industries do not install CPPs, which might become uneconomical in the end.

Finally, there is a need for a well-integrated power policy which addresses the various issues like CPP policy, IPP policy, T&D policy, policy for private investments in power etc so that captive power investors along with the other stakeholders gain as a whole. This will ensure an overall development of the sector, which will in turn result to development of Indian economy.

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