CHAPTER 7

CONCLUSION

Chapter Objective:

- Conclusion on the basis of results.
- Implications

Power sector is considered to be the engine of economic growth for developed as well for developing economies. The chapter has been divided into sections for better understand and correlating the things. Chapter 7 deals with the summary and conclusions emerging out of the present study with possible suggestions for policy makers.

7.1 Findings and Conclusion

Previous studies carried out in power sector in India as well in abroad (discussed in chapter 2) tried to address the Technical Efficiency of power generation industry with lesser number of inputs and outputs variables for a limited period of time. Due to which uneven trend beyond the research period can hamper the outcome quality of that original piece of work. Various approaches or modified approaches are used to measure the Technical Efficiency of power utilities or power plants established in various regions. But various literatures are silent on major issues such as:-

- Operational efficiency of coal/lignite fired thermal power plants located all over the India for a period of decade.
- Are pithead power plants more beneficial as compared to other power plants?
- Whether power generating stations under GSECL are more efficient than other power plants in Gujarat Region?
- Various literatures are silent on operational efficiency of Gujarat thermal power plants.
MEASURING TECHNICAL EFFICIENCY OF GUJARAT’S THERMAL POWER GENERATION INDUSTRY USING DATA ENVELOPMENT ANALYSIS

✓ Comparison of Gujarat’s old coal fired power generation units with newly established units

✓ Is operational efficiency has impact on overall profitability of power plants?

✓ In depth analysis of State power utilities performance using financial and operational variable.

So to bridge the gaps and to give an idea about the real picture of thermal power generation industry (with special reference to Gujarat State), whole research is carried out with various input and output variables. In the background of the above discussion in various chapters, various broad objectives highlighted in chapter 3 are being studied in order to assess the Technical Efficiency of thermal power generation industry using Data Envelopment Analysis. DEA Input-Oriented Model and Malmquist Productivity Index Approach are used to study the laid down objectives. Further for better understanding whole research work is divided into sections.

Section 6.1 deals with operational efficiency of coal/lignite fired thermal power plants located all over the India. During the research period i.e. 2002-03 to 2011-12, five inputs [Capacity (Mw), Planned Maintenance (%), Forced Outage (%), Reserve Shutdown+ Low Sys Demand (%), Partial Unavailability (%)] and three output [Plant load factor (%), Operating Availability Factor (%), Generation (Mu)] variables are included in input oriented DEA model. Year wise analysis of the India’s coal/lignite fired thermal power plant is carried down under CRS and VRS assumptions.

Under CCR model, year 2002-03 has achieved the highest percentage of efficient coal/lignite fired thermal power plants i.e. 25.3%. Operational availability has positive impact on plant load factor in year 2002-03. There is also negative impact of forced outages on operational availability and plant load factor as shown in Appendix B. But year 2008-09 and 2009-10 has achieved highest Average Technical Efficiency i.e. 78.8%. But still there is
scope of further improvement by 21.2%. In year 2008-09 and 2009-10, forced outages has lesser negative impact on generation as compared to year 2002-03. Highest 44.95% of plants in year 2011-12 performed below the average line. 62.50% of plants performed above the overall average in year 2007-08. Average Technical Efficiency of Central, State and Private coal/lignite fired power plants during the research period is observed as 81.42%, 72.20% and 89.62% respectively. Private players performed better as compared to Central and State plants. There is a gap of 17.42% between the performance of Private and State plants. There is immense scope for State plants to reduce their inputs by 27.80% and operate at optimum levels. Average percentage of efficient power plants in Central, State and Private is 19.10%, 12.40% and 46.50% respectively as compared to their participation during the research period i.e. 2002-03 to 2011-12. As participation of Private sector is increased in the coal fired thermal power plant, percentage of efficient Private plants decreased considerably. In year 2011-12 Private players participation in total plants is 22.94% but percentage of efficient Private plants got decreased to 32%

Under BCC model, year 2008-09 has achieved the highest percentage of efficient coal/lignite fired thermal power plants i.e. 50.54%. But year 2008-09 has achieved highest average Pure Technical Efficiency i.e. 85.80%. But still there is scope of further improvement by 14.20%. Highest 45.63% of plants in year 2010-11 performed below the average line. 34.09% of plants performed above the overall average in year 2007-08. Average Pure Technical Efficiency of Central, State and Private coal/lignite fired power plants during the research period is observed as 87.21%, 79.92% and 92.92% respectively. Private players performed better as compared to Central and State plants. Private plants have the edge of 13% over the State plants. There is immense scope for State plants to reduce their inputs by 20.08% and operate at optimum levels. Average percentage of efficient power plants in Central, State and Private is 49.30%, 36.40%, and 62.80% respectively as compared to their
participation. As participation of Private sector is increased in the coal fired thermal power plant, percentage of efficient Private plants decreased considerably. In year 2011-12 Private players participation in total plants is 22.94% but percentage of efficient Private plants got decreased to 48%.

Year wise Scale Efficiency of coal/lignite fired power plant is measured and observed that year 2002-03 witnessed highest average Scale Efficiency i.e. 94.50%. But higher percentage of efficient unit is observed in year 2007-08 i.e. 29.55%. Highest inefficiency is noticed in year 2003-04 i.e. 8.70%. 22% of plants performed below the average Scale Efficiency in year 2009-10. Average Scale Efficiency of Central, State and Private coal/lignite fired power plants during the research period is observed as 93.75%, 91.06% and 96.48% respectively. Private players performed better than Central and State power plants. State power plants have immense potential to leverage on Scale Efficiency. Average percentage of scale efficient power plants in Central, State and Private is 20.9%, 14.3% and 50.9% respectively as compared to their participation. As participation of Private sector is increased in the coal fired thermal power plant, percentage of scale efficient Private plants decreased considerably. In year 2011-12 Private players participation in total plants is 22.94% but percentage of scale efficient Private plants got decreased to 32%. During the research period (2002-03 to 2011-12), majority of plants are suffering from Increasing Return to Scale. On an average 52.55% plants have to increase their business activities or increase their scale of operation. 29.55% of plants have to decrease their scale of operation. Remaining 17.90% should continue their operation as it is or maintain their current level of scale in order to remain efficient.

A coal/lignite fired power plant operating in Gujarat region is compared with overall performance of India. It is observed that Gujarat’s power plant have better Scale Efficiency as compared to overall performance of India. But Gujarat’s power plants in terms of TE and
PTE performed below the overall performance of India. During the research period (2002-03 to 2011-12), majority of Gujarat’s plants are suffering from Increasing Return to Scale. On an average 52.43% plants have to increase their business activities or increase their scale of operation. 27.68% of plants have to decrease their scale of operation. Remaining 19.89% should continue their operation as it is or maintain their current level of scale in order to remain efficient.

Section 6.2 deals with productivity change of coal/lignite fired thermal power plants in India. Research period is 2002-2003 to 2011-12. Number of plants studied is 74. Date Envelopment Analysis (DEA) and Malmquist Index Approach (MPI) are used to analyze the productivity change of these plants. Productivity change is divided into Technical Efficiency change (EFFCH), Technological Change (TECHCH), Scale Efficiency Change (SECH), Pure Technical Change (PECH) and Total Factor Productivity Change (TFPCH). Same input and output parameters are used in measuring the productivity change of 74 plants, which is used in Section 6.1. The study revealed that 0.70% of average annual total factor productivity (TFP) growth witnessed during the period 2002-03 to 2011-12 indicating overall progress.

Contribution of technological change in TFP growth is positive i.e. 1.3% per annum. It indicates that expansion of the efficient frontier. But decrease in TE change of -0.6% per year, indicating that adverse sign of progress.

54.05% of plants have recorded negative total factor productivity growth. Energy planners should pay attention to these plants and develop action plans for possible improvement in the days to come. Detail analysis of -0.60% overall Technical Efficiency change per annum is due to Scale Efficiency. Thus, energy planner should pay more attention to Scale Efficiency in order to improve overall scenario of power generation plants.

Central plants have shown better Technical Efficiency growth of 1.3% per annum, but lost their advantage to negative technological change of -0.3% per annum. Private plants
observed just reverse situation of Central plants. Private plants shown 5.9% of positive
technological growth per annum, but lost their advantage to negative Technical Efficiency
change of 1.2% per annum.

Central power plants has observed positive Scale Efficiency change of 0.1% per
annum but State and Private plants, both witnessed negative growth of -1% and -0.1%
respectively. Central, State and Private power plants has observed TFP growth of 0.90%, 0%
and 4.60% per annum respectively. Negative Technical Efficiency and Scale Efficiency
growth of plants in State sector is matter of concern and needs immediate attention from the
policy maker or energy planner. Four plants (Chandrapura, Dahanu, Korba-III and Unchahar)
have recorded all-round productivity growth more than unity.

In-depth analysis is done of Section 6.2 for coal/lignite fired power plants operating in
Gujarat region over a period of decade i.e. 2002-03 to 2011-12. 7 power plants operating in
Gujarat region is compared with performance of 74 power plants operating in India. It is
observed that the mean TFP change for power plants operating in Gujarat region is 0.999,
which indicates negative growth of -0.10% per annum. EFFCH and TECHCH contributed
towards the TFP growth is -1.20% and 1.10% per annum respectively. Gujarat’s power plants
have shown Scale Efficiency growth of 0.2% per annum. This means that Gujarat’s power
plants are taking the leverage of Scale Efficiency which India’s power plants missed.
Gujarat’s power plants have observed technological growth of 1.1% per annum, but unable to
beat the performance of India’s power plant.

In-depth analysis of Gujarat’s coal/lignite fired power generation units is carried out
in Section 6.3. Total 40 power generation units operating in Gujarat region are selected and
analyzed for the period one year i.e. 2011-12. Five inputs [Capacity Factor (MU), Auxiliary
Power Consumption (%), Planned Outages (%), Forced Outages (%), Partial Unavailability
(%)| and three output [Electricity Generated (MU), Operating Availability Factor (%), Plant
Load Factor (%) parameters are included in input oriented DEA model. Average Technical Efficiency of Gujarat’s power generation units is observed score of 0.877, which means that there is further scope of inputs reduction by 12.30%. In order to take full advantage of scale leverage, Gujarat’s power generation units has to improve their performance further by 7.9%. Interesting fact is that Gujarat’s Private units have outperformed in all the segments i.e. TE, PTE and SE as compared to performance of State and Central units operating in Gujarat region. Apart from that not a single generation unit is suffering from Decreasing Return to Scale. Majority of Gujarat’s generation units i.e. 67.5% needs to pay attention on Scale Efficiency and increase their scale of operation in order to uncap the potential of scale leverage.

Section 6.4 deals with Gujarat’s gas fired power generation units for the year 2011-12. Total 13 gas fired power generation units are studied. Three input parameters chosen for input oriented DEA model are: Capacity Factor (MU), Auxiliary Power Consumption (%) and Average Gas Supplied/Consumed (MMSCMD). Two output variables are as follow: - Electricity Generated (MU) and Plant Load Factor (%). From the derived results, one can conclude that there is potential to improve in TE, PTE and SE by 14.09%, 2.85% and 12.11% respectively. UTRAN-II is a role model for other units as it benchmarked highest times i.e. 6 times under CCR model. In same way under BCC model, GIPCL-I is benchmarked highest times i.e. 4 times. 53.85% of gas fired power generation units in Gujarat region needs to improve their scale of operation. The units in the Central sector performed exceedingly well as compared to units operating in State, IPP and Private sector.

Section 6.5 deals with comparison of Gujarat’s old coal fired power generation units with newly established units. Results shows that newly established power generation units performed better as compared to old ones. To cross check the results, hypothesis is formulated. Surprisingly, result accepts the null hypothesis which indicates that Technical
Efficiency of old and new power plants are not significantly different. 73.33% of old and 50% of new power generation units have to increase their scale of operation in order to become efficient. As percentage of power generation units are at higher side, urgent call should be taken by energy planners.

Section 6.6 deals with the question that: Are Gujarat’s pithead coal/lignite fired power generations units are more efficient than other power generation units in Gujarat region. Based on results, one can conclude that pithead generation units have no more edge over the simple units operating in Gujarat region. Here, focus is on operational efficiency of power generation units, not on availability of raw material resources at cheapest rate or higher cost of transportation in moving raw material resources from one place to another. Policy maker of pithead power generation units has to pay urgent attention to their Technical Efficiency and Scale Efficiency as there is immense opportunity to tap and increase their performance in coming days. To cross check the results, hypothesis is formulated. Based on the derived result, null hypothesis is accepted which indicates that Technical Efficiency of lignite and simple power plants are not significantly different.

Section 6.7 measures the impact of operational efficiency of coal/lignite fired power plants on overall profitability of that company. Four companies (GSECL, AP GENCO, MAHA GENCO and OPGCL) are selected from different region. Pure Technical Efficiency of coal/lignite fired power plant is compared with the company’s profit after tax. VRS proposed by Banker et al. (1984) has overcome the shortcoming of CRS assumptions that’s why PTE is used in this part of research. Hypothesis is formulated for all the four companies. Surprisingly results of all the four companies accepted the null hypothesis which indicates that there is no linear relationship between the Pure Technical Efficiency and profit after tax. This means that there are other factors which are influencing that profit after tax of the company.
Section 6.8 deals with financial and operational performance of State power utilities during the period 2007-08 to 2011-12. Total 53 State power utilities operating in India are included into the study. Input orientated Malmquist DEA is used to measure the operational and financial performance of State power utilities. Total 6 inputs [Power Purchased (Rs Cr), Employees Cost (Rs Cr), Operation and Maintenance Cost (Rs Cr), Aggregate Technical & Commercial Losses (%), Total Expenditure (Rs Cr), Average Cost Of Supply (Rs/kWh)] and 4 outputs [Energy Sold (M kWh), Collection Efficiency (%), Total Income (Rs Cr), Average Revenue (Rs/kWh)] are included in this part of research study. The study revealed negative growth of -2.60% per annum in TPF change. Both Technical and Technological change contributed negatively in TPF change. Scale Efficiency growth of 0.20% per annum is observed during the research period. This means that State power utilities operating in India is taking full advantage of scale leverage. More concentrated efforts are needed to put by energy planners as 71.70% State power utilities recorded average negative total factor productivity growth (TFPG). Year wise analysis shows that total factor productivity during the research period remains in negative growth only. Sikkim PD emerged as leader for other with recorded maximum growth of 35.5% per year.

In Section 6.9, State-wise comparisons of India’s coal-fired power plants for the period of 2002-03 to 2011-12 are done. Results of Section 6.2 is further analyzed and grouped into State wise outcome. In short State wise productivity change of coal/lignite fired thermal power plants of India is evaluated. The study revealed that mean TFPCH of Delhi State is highest i.e. 14.31%, followed by Chhattisgarh State. Lowest growth is reported by Madhya Pradesh i.e. -8.409% per annum, followed by Karnataka State. Performance of Gujarat State is significantly lagging behind as compared with other State’s performance. Energy planners should pay a greater attention to coal & lignite fired power plants operating
in State of Madhya Pradesh and Karnataka. There is immense scope of improvement in these two States.

7.2 Implications

Whole research is emphasising on minimizing the inputs while achieving the same level of targets. This ultimately leads to generate more profit in form of cost savings. As the investment requirement in power generation industry is huge, even a small improvement in production efficiency may result in significant benefits. In addition, study also found that maximum of the inefficient power plants/units shows Increasing Returns to Scale which indicates that the power plants are operating at lower scale than the Most Productive Scale Size. Energy planners should immediately address this issue and take appropriate steps to increase the operational level of such inefficient power plants, so that substantial level of national resources can be saved. On other hand, society at large will be benefited like more accessibility to power, availability of energy at cheaper rate, adding fuel to economic growth and improving standard of living.

This piece of work can be an eye opener for policy makers of State owned power plants/units because State has lost the ground to Private players on basis of technological change. Apart from that energy planners should pay greater attention to plants registering negative growth which ultimate add more value to whole supply chain of power generation and distribution industry. Consequently higher average productivity can be achieved with existing system. Small change in power generation industries has greater implication on overall level of economic development. Thus this empirical study may provide useful information to the policy makers and concerned authorities that have been gradually directed toward partial regulation.

7.3 Scope for Further Research
This study is an attempt to examine the performance of thermal power plants located in different parts of India with special reference to Gujarat State. The study has identified various dimensions of thermal power industry using various variables as input and output. The areas for further research in power industry are: to replicate the research work on wider scale i.e., considering a larger sample size with different variables for different period of time. Another area is to explore further in detail by using different approaches or modified approaches on same data set and then compare the results. In near further if possible to collect pricing data of various variables can highlight unique dimension for energy planner to think and act upon it, in order to have competitive advantage.