International Journal of Advanced Engineering Research and Science (IJAERS)
Peer-Reviewed Journal
ISSN: 2349-6495(P) | 2456-1908(O)
Vol-9, Issue-10; Oct, 2022
Journal Home Page Available: https://ijaers.com/
Article DOI: https://dx.doi.org/10.22161/ijaers.910.23

Regional Performance of Thermal Power Generation in India

Satvir Singh[1], Sonu Madan[2]

[1]Research Scholar, Department of Economics, IGU Meerpur, Rewari, Haryana, India
[2]AssociateProfessor, Department of Economics, IGU Meerpur, Rewari, Haryana, India

Received: 20 Sep 2022,

Received in revised form: 09 Oct 2022,

Accepted: 14 Oct 2022,

Available online: 17 Oct 2022

©2022 The Author(s). Published by AI Publication. This is an open access article under the CC BY license (https://creativecommons.org/licenses/by/4.0/).

***Keywords*—Coal Fired Thermal Power, DEA, APC, SPCC, FO, Power Generation**

***Abstract*— The present paper attempts to assess the regional performance of 75 coal fired public sector thermal power plants in India for the period 2014-15 to 2017-18 using data envelope analysis (DEA) with a single output and five inputs. The mean technical efficiency of the DMUs varied from 66.1% to over 90%. The technical efficiency of Central Government operated power plants far exceeded compared to those plants operated by the respective State governments. The region-wise efficiency measurement shows that Southern region performed better than other regions.*

I. INTRODUCTION

In the post independent India, energy was placed in priority sector as it required huge investment and the private investment was not very encouraging. As a result production and distribution of power was entrusted to public sector in India. The contribution of thermal power generation in India remained dominant in the past and so will be in future (Shanmugam & Kulshreshtha. P, 2002, 2003, 2005).Although the achievements of the thermal power generation in India has been remarkable, yet the shortage of power is no denying the fact. So there is an urgent need to identify the factors for low efficiency in thermal power generation in India. These factors include outdated technology, poor quality coal with high moisture content along with its delayed availability (Fatima. S; Barik. K,2012). Further, authorities focused on aggregate production but overlooked the inefficiency at the plant level operations (Fatima. S, 2016). The effective correction amounts to assess the thermal power generation at plant level which is considered as decision making unit (DMUs). The thrust of the present paper is to develop the benchmark of operation for the comparison of operation of the similar DMUs in the four regions mainly northern, western, southern, and eastern and find the inefficiency in the existing plants and suggesting remedial measures for improving their efficiency.

The present paper is organized as follows: Section 2 deals with profile of Indian power sector, section 3 deals with review of literature, section 4 deals with research methodology, section 5 deals with input and output variables, section 6 deals with the analysis of results and policy implication followed by conclusion.

II. PROFILE OF INDIAN POWER SECTOR

To ensure the uninterrupted supply of power, the Electricity Act, 1948 was enacted to create state electricity boards (SEBs) with the triple role of generation, transmission, and distribution of electricity which also led to the creation of central electricity authority (CEA) for policy formulation and co-ordination of the activities of multiple planning agencies. The new economic reforms necessitated the amendments in the act which came in form of the Electricity Act, 2003 which allowed the participation of private sector. In terms of resource allocation, the highest priority was given to the energy sector during the different five years plans. During 1960s, India began utilizing grid management to form four regions viz. northern, western, southern, and eastern. The maximum number of coal fired public sector thermal power plants operating in western region were 24 (20 thermal power plants operating under respective state governments and 4 thermal power plants were operating under central government) followed by 21 thermal power plants operating in northern region (14 operating under respective state governments and 7 operating under central government), 18 thermal power plants operating in eastern region (8 operating under respective state governments and 10 operating under central government), and 12 thermal power plants operating in southern region (10 operating under respective state governments and 2 operating under central government) respectively during the period of study.

As a result of collected efforts at various levels, presently India is third largest producer and fourth largest consumer of the electricity. As against the total installed capacity of 1362 MW of which 854 MW was from thermal power in December,1947, there has been substantial growth in total installed capacity to 3,86,888 MW of which 2.34,858 MW was from thermal power as on July, 2021. The contribution of coal fired thermal power in total thermal power is around 86%. The share of central government, state government, and private sector in total installed capacity is 26%, 27%, and 47% respectively. As per the estimates of International Energy Agency, India needs to add between 600gw to 1200gw of additional new power generating capacity before 2050. Keeping in view the above statistics, it is necessary not only to increase the total installed capacity of power but also to plug the inefficiencies which are inbuilt at micro plant levels.

III. LITERATURE SURVEY

There are a number of studies that employed DEA approach in the measurement of technical efficiency in India and abroad. Some are discussed briefly. Azadeh. A,et al (2007) employed BCC model of DEA for measuring efficiency of 40 power plants in Iran ; Chen,et al(2013) used DEA for comparing efficiency in Asia and Europe; Khalid,et al (2013) applied DEA for measuring efficiency of power plants in Asian countries; Shanmugam and Kulshreshtha(2002,2005), Bahera, et al (2010), Meenakshi et al (2008), Jain et al (2010), Bajpai et al (2014) employed DEA for measuring efficiency in thermal power plants in India. In the context of above literature review, it is observed that these studies have been conducted in isolation. The present study is focused on measuring regionwise performance of all coal fired public sector thermal power plants in India.

IV. RESEARCH METHODOLOGY

Data Envelopment Analysis, a linear programming technique is relatively a new approach for the performance evaluation of set of entities called Decision Making Units (DMUs). This is a benchmarking method for measuring the relative efficiency of a set of DMUs. It is a non parametric approach for ascertaining the efficient frontier. The distance to the efficient frontier determines the measure of relative efficiency of a set of homogenous firms. The present study used two models of DEA i.e. CCR model given by Charnes et. al. (1978) and BCC model given by Banker et.al (1984). The CCR model being basic model produces constant returns to scale frontier. The CCR model measures overall efficiency scores and the relative efficiency of different DMUs that lies between 0 and 1. Banker, Channes, and Cooper developed BCC model by adding convexity constraint to generate variable returns to scale (VRS) efficiency frontier. This model evaluates both technical & scale efficiency. The DMU will be efficient only in case it is technical and scale efficient. The present study has applied input-oriented approach with DEAP 2.1 version of DEA for finding the results.

V. INPUTS & OUTPUT VARIABLES

The present study measures the technical efficiency of 75 coal fired public sector thermal power plants in India for four years from 2014-15 to 2017-18. The thermal power plants included in study in all the four years are same except the increase/decrease in the number of units of Plants. In different years each plant is considered as decision making units (DMUs). The total number of DMUs in four year period of study is thus 300. The descriptive statistics of different inputs & output variables are shown in Table 2

The study used the data published by Central Electricity Authority, Government of India in the form of 'Review of Performance of Thermal Power Stations' for different years. For the performance assessment of Thermal Power Plants in India, there cannot be single performance index. Electricity generation, Installed Capacity, Maintenance Expenditure in the form of Planned Maintenance (PM), and Forced Outrage (FO), Consumption of Coal in the form of Specific Coal Consumption (SPCC) and use of electricity for the generation of electricity in the form of auxiliary power consumption (APC) are used as overall performance indicators in the present study. Electricity generation measured in million units is taken as sole output variable. Since gestation period of power plant is very long, so it is not feasible to have an explicit data on capital cost incurred. Therefore, installed capacity is considered as proxy for capital and included as input variable. The power plants has also to incur certain maintenance expenditure which is broadly of two types i.e. planned maintenance (PM) and unforeseen maintenance which may come as a result of unscheduled forced outage (FO). Loss of electricity generation due to PM and FO is considered as proxy of maintenance expenditure and thus taken as input variables. The use of specific coal consumption (SPCC) measured in kg/kwh is considered as input variable. In addition certain electricity is also consumed by power plants for the generation of electricity. This is auxiliary power consumption & is included after deducting the electricity thus used from total electricity generation. Thus, present study includes generation as output and PM, FO, Installed Capacity, APC, and SPCC are used as five input variables.

Table 2: Descriptive Statistics

Variables	N	Minimum	Maximum	Mean	Standard Deviation
Output					
Electricity Generation	**300**	**193.40**	**37496.00**	**7034.64**	**6264.63**
Inputs					
Installed Capacity	**300**	**62.50**	**4760.00**	**1253.14**	**826.40**
PM	**300**	**0.01**	**46.74**	**5.06**	**5.57**
FO	**300**	**0.25**	**79.25**	**22.89**	**20.76**
APC	**300**	**5.06**	**16.00**	**8.99**	**2.19**
SPCC	**300**	**0.52**	**1.11**	**0.72**	**0.09**

VI. RESULTS AND DISCUSSION

The present study included 30.67% and 69.33% of power plants operating under central and respective state governments where as the regional distribution of plants is northern(28%),western(32%),southern(16%),and eastern(24%) respectively. Overall number of technically efficient DMUs under CRS and scale model ranged from 9.33% to 10.67% while under VRS model it ranged between28% to 32% during the period of study. The numbers of technically efficient plants with a score of one were 8 during the assessment period except during 2017-18 when this number was 7 under CRS and scale model while under VRS model this number remained between21 to 24. Looking at the regional level, the study observed that under CRS and scale model the technically efficient DMUs ranged from 4.76% to 8.33% (northern), 12.5% to 16.67% (western), up to 25% (southern), and 5.66% to 11.11% (eastern) whereas under VRS model this range has been between 9.52% to 28.57% (northern), 29.19% to 33.33% (western), 25% to 50% (southern), and 22.22% to 44.44% (eastern) respectively. Further regional results shows that the number of technically efficient plants with a score of one were 1 to 2 under CRS and scale model while under VRS model this number remained between 2 to 5 for northern region, 3 to 4 plants (under CRS and scale model) while 7 to 8 (under VRS model) for western region, 1 to 3 plants (under CRS and scale model) while 3 to 6 (under VRS model) for southern region, and 1 to 2 plants (under CRS and scale model) while 4 to 8 (under VRS model) for eastern region respectively. It has also been observed that southern region witnessed highest percentage of technically efficient plants during 2015-16, though there was no technically efficient DMU during 2017-18. Under VRS model, the study observed percentage of technically efficient plants between 9.52% to 50% and again southern region performed better than other regions. The study also noted that central government operated plants performed better on account of availability of high quality coal, improved technology and better micromanagement at plant level.

The mean technical efficiency for the entire period of study varied between 66% to over 90%. The percentage of DMUs above their respective mean technical efficiency has been 48% to 62% (northern), 41.66% to 58.33% (western), 41.66% to 75% (southern), and 55.56% to 72.22% (eastern) region respectively. Looking at efficiency scores of individual plants, we found that only one plant i.e.Vindyachal STPS operating under Central Government remained on the frontier throughout form 2014-15 to 2017-18. The result of the study shows that the thermal power stations remained on the frontier are Singrauli during 2015-16; Rihand during 2014-15, 2016-17 and 2017-18; Sipat during 2014-15, 2015-16, 2016-17; DSPM during 2017-18; Bhusawal during 2014-15; R'Gund STPS during 2014-15 and 2015-16; Kakatiya during 2014-15and 2016-17; Tuticorn during 2015-16; Talchar during 2014-15, 2016-17, 2017-18; Mejia during 2017-18; Talchar STPS during 2014-15 and 2015-16; and Farakka STPS during 2016-17. Further, these plants operated with more than 90% efficiency during rest of the period of the study.

The results thus obtained in the study indicate that the efficient frontier for DMUs can be constructed under VRSmodel where we have ample scope for changing scale of operation. The improvement in efficiency of DMUs is possible if efforts are made at macro level towards increasing the technical efficiency by contracting the inputs, timely availability of high quality low moisture content coal; check on unwanted forced outages and better management norms.

VII. CONCLUSION

Analysis of results of the present study shows that mean technical efficiency of thermal power plants remained more or less the same but the number of DMUs above means efficiency points towards the increasing trend. Overall, the number of technically efficient DMUs under CRS and scale model ranged from 9.33% to 10.67% while under VRS model it was 28 % to 32% during the period of study. The mean technical efficiency under CRS, VRS, and scale models varied between 66.1% to over 90%. The percentage of DMUs above their respective mean technical efficiency has been 48% to 62% (northern), 41.66% to 58.33% (western), 41.66% to 75% (southern), and 55.56% to 72.22% (eastern) region respectively. The input oriented DEA shows that Vindyachal STPS remained on frontier for the entire period of study while Singrauli, Rihand, Sipat, DSPM, Bhuswal, R'Gund STPS, Kakatiya, Tuticorn, Talchar, Talchar STPS, Mejia, and Farakka thermal power plants remained on frontier for one to three years of study period. Overall, the public sector thermal power plants across India show improvement in the technical efficiency. Ownership and efficiency are found to be positively correlated. Central Government operated power plants have shown higher technical efficiency compared to the power plants operated by respective State Governments. Region-wise assessment of efficiency shows that Southern region has performed better than other region. The policy implications of the study hold that it is possible to improve the technical efficiency of thermal power plants and place them on frontier or near to it by varying the scale of operations.

REFERENCES

[1] Azadeh, Ali & Ghaderi, F &Anvari, Mehran &Izadbakhsh, Hamidreza&Dehghan, S. (2007). Performance assessment and optimization of thermal power plants by DEA BCC and multivariate analysis. *Journal of Scientific and Industrial Research*. 66, 860-872.

[2] Bajpai, K. Vijay, Singh, K. Sudhir (2014). Measurement of Operational and Environmental Performance of the Coal-Fired Power Plants in India by Using Data Envelopment Analysis. *International Journal of Social, Behavioral, Educational, Economic, Business and Industrial Engineering* 8(12), 3964-3973.

[3] Banker R.D. (1984). "Some Models for Estimating Technical and Scale Inefficiencies in Data Envelopment Analysis". *Management Science*. 30: 1078–1092.

[4] Charnes A. (1978). "Measuring the efficiency of decision-making units". *European Journal of Operational Research*. 2: 429–444. doi:10.1016/0377-2217(78)90138-8.

[5] Chen, Tser& Yeh, Tsai-Lien & Lee, Yi-Ting. (2013). Comparison of Power Plants Efficiency among 73 Countries. Journal of Energy. *Journal of Energy*, Vo. 2013, 1-8.

[6] Choukroun, S. (2001). Enron in Maharashtra: Power Sector Development and National Identity in Modern India. Philadelphia, University of Pennsylvani.

[7] Fatima, Sahba& Barik, Kaustuva. (2012). Technical Efficiency of Thermal Power Generation in India: Post-Restructuring Experience. *International Journal of Energy Economics and Policy*. 2(4), 210-224.

[8] Jain Shafali, Thakur Tripta& Shandilya Arun (2010). Cost Benchmarking of Generation Utilities Using DEA: A Case Study of India. *Technology and Investment*, 1, 229-234.

[9] K Behera, Santosh & P Dash, Ambika & Jamal Farooquie, A. (2010). Performance Analysis of Coal Fired Power Plants in India. *Proceedings of the International Conference on Industrial Engineering and Operations Management Dhaka, Bangladesh, January 9-10, 2010*.

[10] Khalid Riaz, Khan Iram, Qayyum Abdul & Khan Arooj (20123). Technical Efficiency of Asian Energy Firms: A Bootstrapped DEA Approach. *Journal of Basic and Applied Scientific Research*, 3(5), 844-852.

[11] Meenakumari, R. & Kamaraj, N. (2008) Measurement of Relative Efficiency of State Owned Electric Utilities in INDIA Using Data Envelopment Analysis, *Modern Applied Science*, 2(5), 61-71.

[12] Shanmugam, K &Kulshreshtha, Praveen. (2002). Efficiency of Thermal Power Plants in India. *Vikalpa: The Journal for Decision Makers*. 27(4), 57-68.

[13] Shanmugam, K &Kulshreshtha, Praveen. (2005). Efficiency analysis of coal-based thermal power generation in India during post-reform era. *International Journal of Global Energy Issues*. 23(1). 15-28.

[14] Monthly Report on Board Status of Thermal Power projects in the Country, May-2017 by Government of India, Ministry of Power.