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OPERATIONAL PERFORMANCE EVALUATION OF THERMAL POWER STATIONS: A CASE STUDY ON DR. NARLA TATA RAO THERMAL POWER STATION. A STATISTICAL ANALYSIS

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Abstract
Power sector is the mother sector of all other sectors. Indian power sector is witnessing major changes. The growth of Indian power sector has been noteworthy since Independence. Peak and energy shortages prevail in the country. This is due to inadequacies in generation, transmission & distribution as well as inefficient use of electricity. Among the various power generations, thermal power generation occupies lions share. The contribution of thermal power generation is around 70 per cent. Dr. Narla Tata Rao Thermal Power Station is also one among them, the station is contributing significant portion in the total thermal power generation in India as well as in the state of Andhra Pradesh. It is very essential to the any manufacturing concern to evaluate the working of the operational performance. In this paper a detailed analysis is conducted regarding the operational performance of the selected organisation, which is calculated with help of various parameters in power sector and draw the findings based on the analysis

Major findings of the study: The average coal consumption of stage IV is observed to be 639 grams per unit, which is low compared to the other stages of the plant as well as the station average. The average deemed plant load factor of the station is 87.20% during the period of study, actual PLF for the same period is 85.28%. The outages are continuously increasing since 2012-13. Though stage I and II have completed more than 35 years and 25 years respectively and still these stages are working in good condition and generating power. This is possible only because of high level quality maintenance by the organisation.

Key Words: Evaluation of Operational Performance, Plant Load Factor, Outage Hours And Analysis of Variance.

1.0 Introduction

Operations management has been recognised as an important factor in a country's economic growth. The traditional view of manufacturing management is the concept of production management with the focus on economic efficiency in manufacturing. Later the new name operations management was identified, as service sector became more prominent. Swift changes in technology have posed plenty of opportunities and challenges, which have resulted in enhancement of manufacturing capabilities through new materials, facilities, techniques and procedures. Hence, managing a service organization has become a major challenge in the global competitive environment. Operations management has been a key element in the improvement and productivity in business around the world. Operations management leads the way for the organisations to achieve its goals with minimum effort. Operations management is often used along with the production management in literature on the subject. Operations are purposeful activities which are done methodically as part of a plan of work by a process that is designed to achieve the pre-decided objectives. It indicates that operations management consists of tactics such as scheduling work, assigning resources which include people, equipment, managing inventories, assessing quality standards, process type of decisions and the sequence for making individual items is a product mix set, to put it simple.

The operational efficiency is a vital component of the operational performance of the organisation that ensures its survival and growth. The ratios in this segment involve subjective analysis and efficiency of management. The management of the organisation can takes crucial decision depending on the risk perception. It sets vision and goals for the organization and sees that it achieves them. This parameter is used to evaluate management efficiency as to maintain the better quality ones and discount poorly managed ones.

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2.0 Review of Literature

Gupta (2017) “Economic and Societal factors influence the financial performance of alternative energy firms” has studied the effects of economic and societal factors on the financial performance of alternative energy.The author finds that in countries where the technology and innovation are developed, alternative energy firms have higher benefits. Vijay H. Vyas (2015) in his study “Financial performance analysis of selected companies of power sector in India” stated that electricity is one of the most important input factors for the economic development of the country. There is huge and increasing demand of electricity in India and it is continuously increasing with the countries corporate and economic growth. Out of selected companies NTPC performance is better than other companies but overall Indian power sector needs to reduce too much dependence on coal and needs to generate more power availability, quality and reliability for successful future and growth of the country. Alexander Jeevanantham.Y, Muralidharan.S and Karthikeyan.R (2015) in their paper “Review of Power Sector Growth in India”, explained various sources of power generation in India and examine the growth of power sector during the various plan periods. Government of Andhra Pradesh (2014) "White Paper on Power Sector in Andhra Pradesh" this bulletin explicit various challenges faced by the power sector in Andhra Pradesh due to bifurcation of state and analysed proactive measures to address the issues plugging the A.P Power Sector. Rama Krishna. K (2014) in his article “Importance of Energy Savings” pointed out the importance of energy savings. Ankur Omer, Smarajit Ghosh and Rajnish Kaushik (2013) “Indian Power System: Issues and Opportunities” in their article examines the Indian power sector scenario and discuss the various problems facing by the Indian power sector and also explains the future outlook for changing Indian power sector. Shiv Pratap Raghuvanshi, Avinash Chandra and Ashok Kumar Raghav (2006) in their paper “Carbon dioxide emissions from coal based power generation in India”, pointed out that the CO2 emissions from the present energy generation and predicts the same for the next two decades and suggested the appropriate and alternative measures to reduce CO2 emission. Tulasi Das. V (1998) in his research “Performance Evaluation of Thermal Power Projects A case study of VTPS” discussed the cost and operational performance and also analyse employees perception on operational and organisational activities of the entire organisation prior reforms period.

From the review of the earlier studies, it is observed that only a few research studies have been conducted in this area but they have not provided sound theoretical and empirical explanation regarding the various stages of power generation, and which stage is performing well when compared to the other stages of the organisation. The present study is an improvement over the earlier studies, for which the following are the specific objectives of the study.

3.0 Objectives of the Study

1. To analyse the power generation of the select organization stage-wise during the period of study.
2. To examine the operational performance of the selected organisation with various inputs.
3. To draw the conclusions and offer suggestions for better performance of the organization for improving its efficiency.

4.0 Hypothesis: Over all operational performance of the selected organisation is reducing.

5.0 Methodology of the study: The study is based on the secondary data which is obtained from the records of the selected organization. The period of study is confined from 2005-06 to 2014-15. The performance of the select organisation is evaluated by computing the relevant ratios and interpreted based on analysis of variance and also ideal norms.

6.0 Evaluation of Operational Performance of Dr. NTTPS: It is necessary to any organisation to evaluate its operational performance. The success of business operations are determined by the quality of the product. Inter and intra comparison of four stages operational performance of Dr. NTTPS is evaluated with the following performance indicators and the analysis is also presented.

6.1 Power Generation: Power generation is to be effected by increasing and decreasing the demand of power. Availability of quality of coal is also one of the determining factors of thermal power generation. High quality of coal consumes less, increases the power generation vice versa. This ratio examines stage-wise power generation in total power generation during the period of study. High ratio indicates an outstanding performance and utilizing resources into optimum levels by the stages and low ratio shows that weak performance. Calculation of the ratio is given below.

$$\text{Power Generation} = \frac{\text{Stage-wise generation}}{\text{Total generation}} \times 100$$

Table-6.1: Power Generation Stage -Wise of The Selected Organisation During 2005-06 To 2014-15

Year	Stage-I Generation %	Stage-II Generation %	Stage-III Generation %	Stage-IV Generation %
2005-06	31.92	34.56	33.52	-
2006-07	32.24	33.03	34.73	-
2007-08	30.01	34.81	35.19	-
2008-09	31.48	35.03	33.50	-
2009-10	33.46	29.75	30.57	6.22*
2010-11	25.65	27.00	17.12	30.23
2011-12	23.21	24.27	23.41	29.11
2012-13	22.11	25.56	24.41	27.92
2013-14	21.39	24.67	24.48	29.46
2014-15	23.44	24.12	23.95	28.48
Mean	27.49	29.28	28.09	25.24
S.D	4.764	4.686	6.193	9.349
CAGR	-0.030	-0.035	-0.033	0.164

Source: Compiled from the Records of Dr. NTTPS*Indicates trail run of the stage

Table-6.1 explains stage-wise percentage of power generation of the selected organisation during the period 2005-06 to 2014-15. Average power generation of stage II is more during study period with 29.28 per cent in the total power generation. The same is low in the case of stage IV with 25.24 per cent, because this stage is commenced during 2009-10. The commercial operation of the stage was declared only from 29-01-2010, so in that period generation is only 6.22 per cent in total generation. The proportion of stage IV is high in the total power generation in the later years compared to the other stages. The coal supplied to the organisation is less than the prescribed standard i.e., 4,500 Kcal/kg. There is a direct relationship between coal consumption and power generation. Average percentage of stage I and III are 27.49 and 28.09 respectively during the period of study. Standard deviation and cumulative average growth rate of the selected organisation shows that the power generation at stage II is more stable and the growth rate is more at stage IV.

ANOVA						
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F crit**
Rows	655.511	9	72.83455	14.24577	1.75E-06	2.456281
Columns	16.59265	2	8.296323	1.622684	0.224944	3.554557
Error	92.02889	18	5.112716			
Total	764.1325	29				

Anova is calculated to the percentage of power generation of the selected organisation, which shows that since $p<0.05$ there is a significant difference between the years of generation and there is there is no significant difference between the stages of generation because p>0.05.The total generation is high in the beginning years. Stage II is had the highest mean generation among the all stages.

6.2 Coal Consumption: This ratio examines the quantity of coal consumption to generate one unit of power generation. Less quantity of coal consumption to generate power indicates the efficiency of the stage, at the same time high quality of coal is essential to generate power otherwise more coal is to be consumed for generation. Per unit of coal consumption is influenced by quality of the coal. High quality of GCV coal reduces less consumption per unit of power generation and low quality of coal is consumed more quantity for generation of power. The coal supplied to the organisation is less than the prescribed standard with 4,500Kcal/kg. There is a direct relationship between coal consumption and power generation. More coal consumption increases more power generation and less consumption is less generation. As per the Industrial average of thermal power generation stations, 700 grams of coal is to be used to generate one unit of power. This ratio shows how much is the coal consumed by the stages and station to generate per unit of power. This ratio is calculated in the following manner.

$$\text{Coal Consumption per unit of power generation} = \frac{\text{Coal Consumption}}{\text{Power Generation}}$$

Table-6.2: Quantity of Coal Consumption Per Unit of Power Generation-Stage-Wise of The Selected Organisation During 2005-06 To 2014-15. (Per Unit Grams)

Year	Stage-I Per Unit	Stage-II Per Unit	Stage-III Per Unit	Stage-IV Per Unit	Total Per Unit
2005-06	705	717	671	-	698
2006-07	708	706	677	-	696
2007-08	743	744	701	-	728
2008-09	710	710	685	-	702
2009-10	733	731	694	624	714
2010-11	755	751	688	605	697
2011-12	732	729	704	620	692
2012-13	783	767	754	641	732
2013-14	786	773	772	673	746
2014-15	786	781	775	669	749
Mean	744	741	712	639	715
SD	32.32	26.74	39.51	27.47	
CAGR	0.01	0.01	0.015	0.011	

Source: Compiled from the Records of Dr. NTTPS

Table-6.2 analyses the station and stage-wise coal consumption per unit of Dr. NTTPS during the study period. Stage I is consuming more coal to generate one unit of power, its average during the period is .744 grams followed by stage II and stage III of .741 grams and .712 grams respectively. Average coal consumption of stage IV is .639 grams, which is low compared to the other stages, as well as in the station average. Operating system of stage IV is designed with latest technology, hence less coal is consumed to generate one unit of power. As per CERC Industrial standard to generate one unit of power is 700 grams. Stage I and II average consumption during the study period is 106 per cent than the industry average. Stage III average consumption is a little bit more i.e., 102 per cent. GCV is also influencing factor for coal consumption per unit of power generation. Though the GCV value of coal is less than standard but organisation is generating power effectively. This indicates the organisation is utilising the coal in an efficient manner. During the period of study coal consumption to generate one unit of power is .715 grams. This exceeds 0.015 grams compared to the industrial yardstick. Standard deviation and compound annual growth rate shows that coal consumption per unit of power generation is increasing. Stage I is having highest mean consumption, which indicate stage I is consuming more coal to generate one unit of power.

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ANOVA						
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F crit**
Rows	27874.72	9	3097.192	27.623	9.49E-09	2.456
Columns	6210.63	2	3105.315	27.696	3.21E-06	3.554
Error	2018.181	18	112.1212			
Total	36103.54	29				

Analysis of variance for the quantity of coal consumption per unit of the selected organization explains since $p<0.05$ there is a significant difference between the years of coal consumption, since $p<0.05$ there is a significant difference between the stages of coal consumption.

6.3 (a) Deemed Plant Load Factor (PLF): PLF is the ratio between the actual energy generated by the plant to the maximum possible energy that can be generated with the plant working at its rated power and its duration in a year. No power plant operates 100 per cent of its capacity. Deemed PLF is to be calculated considering the installed capacity, age of the plant, past performance, planned outages and availability of resources. Following is the principle for the calculation of Deemed PLF.

$$\text{Deemed PLF} = \frac{\text{Deemed Generation}}{\text{Generation Capacity}} \times 100$$

(b) Actual Plant Load Factor: Though the plants in the stages can generate power up to the deemed generation but it is generating the power based on the instructions from the grid. When demand of power is more, plants can generate power up to the deemed generation and less when less demand. Plants are stopped by compulsion when demand falls further; it is called forced outages. As per CERC norms thermal power generation station has to achieve 75 per cent PLF. This ratio is explains whether the organisation is achieved the standard and also examine which stage is better compared to the other stages of the organisation. Calculation of the ratio is given below.

$$\text{Actual plant load factor} = \frac{\text{Actual Generation}}{\text{Generation Capacity}} \times 100$$

Table-6.3: Plant Load Factors (PLF)-Stage-Wise of The Selected Organisation.(PLF %)

Year	**Stage-I Generation Capacity 3,679 MU**		**Stage-II Generation Capacity 3,679 MU**		**Stage-III Generation Capacity 3,679 MU**		**Stage-IV Generation Capacity 4,380 MU**		**Total Generation Capacity 15,417 MU**	
	Deemed Generation PLF	Actual Generation PLF	Deemed Generation PLF	Actual Generation PLF	Deemed Generation PLF	Actual Generation PLF	Deemed Generation PLF	Actual Generation PLF	Deemed Generation PLF	Actual Generation PLF
2005-06	91.3	84.64	96.87	91.63	95.79	88.88	-	-	94.65	88.38
2006-07	88.94	87.22	91.06	89.37	95.84	93.97	-	-	91.95	90.19
2007-08	81.73	79.64	95.03	92.39	95.79	93.39	-	-	90.85	88.48
2008-09	89.07	88.48	99.08	98.45	94.70	94.16	-	-	94.28	93.69
2009-10	94.92	94.13	84.40	83.69	86.79	86.00	-	14.70	63.50	67.13
2010-11	89.10	86.52	93.29	91.06	58.85	57.76	87.01	85.64	82.29	80.49
2011-12	90.54	89.32	94.37	93.42	91.14	90.11	96.83	94.09	93.38	91.84
2012-13	81.82	80.59	94.32	93.18	89.92	88.99	88.58	85.48	88.66	86.99
2013-14	76.49	74.61	88.69	86.06	87.88	85.38	92.21	86.32	86.59	83.24
2014-15	84.45	80.95	86.35	83.31	85.54	82.71	86.85	82.63	85.85	82.41
Mean	86.84	84.61	92.35	90.26	88.22	86.13	90.30	74.81	87.20	85.28
SD	5.552	5.701	4.666	4.744	11.045	10.684	47.674	44.524	9.249	7.641
CAGR	-0.008	-0.004	-0.011	-0.009	-0.011	-0.007	-0.001	0.333	-0.01	-0.007

Source: Compiled from the Records of Dr. NTTPS

Table-6.3 explains regarding the station and stage-wise deemed plant load factor of Dr. NTTPS from 2005-06 to 2014-15. During the period of study deemed PLF of stage II is more compared to the other stages of the organisation with the PLF of 92.35 per cent, which indicates the ability of the stage, deemed PLF stage IV is also more than 90 per cent. Stage III is in third position because of more outages and stage one is in last position because of life time of the units in stage I are completed more than 35 years. Deemed PLF of the entire station during the period of study is 87.20 per cent. Average deemed PLFs of all stages of the selected organisation is more than 85 per cent only because of high quality of maintenance of the plants. So stage I is generating power even after 35 years of service.

The same table also explains station and stage-wise plant load factor and also of the entire station. Difference between deemed PLF and actual PLF is occurred because of forced outages. During the period of study plant load factor of stage II is more with a PLF of 90.26 per cent, which indicates this stage is performing outstandingly in the selected organisation. PLF of stage III in second place with a PLF of 86.13 per cent among the four stages followed by stage I and IV with PLFs of 84.61 and 74.81 per cent respectively. During the year 2009-10 stage IV operate only few hours this reflected on the entire PLF of the stage. During the study period PLF of the entire station is varying because of outages and reducing the power generation than the installed capacity. The average percentage of Dr. NTTPS during the period of study is 85.28. Industrial yard stick for coal based thermal power generation plants are 75per cent set by CERC. Average of four stages and the entire station during the period of study exceeds more than the industrial average. This shows the efficiency of the power generation of the selected organisation. Standard deviation and compound annual growth rate of plant load factors (both deemed and actual) stage-wise of the selected organisation explains the demand generation at stage II is more stable over the years.

ANOVA for Stages of Deemed Power Generation PLF

	df	SS	MS	F	Significance F
Regression	1	37.727	37.728	0.412	0.539
Residual	8	732.103	91.513		
Total	9	769.831			

ANOVA for the Stages of Actual Generation PLF

	df	SS	MS	F	Significance F
Regression	1	31.53964	31.53964	0.510899	0.495076
Residual	8	493.8692	61.73365		
Total	9	525.4088			

Anova analysis of the stages of actual plant load factor explains stage II is more stable over the years and the growth rate is high at stage IV. Low correlation is observed over the stages. Regression line of the total actual plant load factor of the entire organisation during the period of study is-0.618*year+88.68. If the same trend continues the value by the year 2020 will be 79.41. Average of four stages and the entire station during the period of study exceeds more than the industrial average. This indicates the efficiency of the power generation of the selected organisation.

6.4 Auxiliary Power Consumption: Power plants generate electricity in this process the plants consume a substantial amount of energy. It is called auxiliary consumption. National level average auxiliary consumption of power by the thermal power plants around 8%-12%. This depends upon the technology adopted and maintenance of plants by the stations. Reduction of 0.5% to 1% can result in huge savings and additional output of a few megawatts. The selected organisation is also consuming energy to operate plants and other equipment. As per the CERC norms 200MW series plants has to consume 9.5 per cent of power for auxiliary consumption and 500MW series plants consume only 6.5 per cent for the same. This ratio examines the auxiliary power consumption of various stages and also explains, whether the auxiliary consumption of stages and station is in between the national standard. The principle for calculation of the ratio is as follows.

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$$\text{Auxiliary Power Consumption} = \frac{\text{Auxiliary Power Consumption}}{\text{Actual Power Generation}} \times 100$$

Table-6.4: Auxiliary consumption of power - stage-wise of the selected organisation during 2005-06 to 2014-15.

Year	Stage-I (%)	Stage-II (%)	Stage-III (%)	Stage-IV (%)	Total (%)
2005-06	9.51	9.43	9.30	0.00	9.41
2006-07	9.10	8.88	8.56	0.00	8.84
2007-08	9.01	8.83	8.67	0.00	8.83
2008-09	8.76	8.59	8.66	0.00	8.66
2009-10	8.69	8.90	8.94	4.39	8.56
2010-11	9.08	9.13	9.41	4.43	7.74
2011-12	9.10	9.05	9.29	4.78	7.87
2012-13	9.54	9.36	9.47	4.81	8.16
2013-14	9.69	9.51	9.46	4.89	8.17
2014-15	9.60	9.85	9.86	5.22	8.48
Mean	9.21	9.15	9.16	4.75	8.47
SD	0.36	0.38	1.86	0.31	
CAGR	0.001	0.004	0.003	0.029	

Source: Compiled from the Records of Dr. NTTPS.

Table-6.4 show stage-wise and entire station auxiliary consumption of electricity for power generation by the selected organisation during the period of study. The organisation reduces auxiliary consumption by using washed coal, high quality of repairs and maintenance and adoption of new technologies in operations. These things are helpful in reduction of auxiliary consumption. Average consumption of electricity to run the plants and other operation systems of stage IV is very less when compared to the other stages as well as the yardstick in the coal based thermal plant i.e., 4.75 per cent only. The standard auxiliary consumption of this stage set by Central Electricity Regulatory Commission (CERC) is 6.5 per cent in the power generation. The average of stages - II, III, I are 9.15, 9.16 and 9.21 per cent respectively. Standard auxiliary consumption of these stages set by CERC is 9.5 per cent of the power generation. Station wise average auxiliary consumption during the period of study is 8.07 per cent. This is less when compared to the National average. This indicates the efficient utilization of resources and effective operating system of the station.

ANOVA						
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F crit**
Rows	13.1944	9	1.466044	1.299754	0.302886	2.456281
Columns	54276.48	2	27138.24	24060.01	1.43E-31	3.554557
Error	20.30292	18	1.12794			
Total	54309.98	29				

Auxiliary consumption of power at stage IV is more stable which indicates this stage is consuming less consumption of power for generation and the growth rate is more at stage IV. There is no significant difference between the years of Auxiliary consumption of power since $p>0.05$, and since $p<0.05$ there is a significant difference between the stages of auxiliary consumption of power. Stage III is having highest mean consumption because of more outages. The organisation has taken various measures to reduce auxiliary consumption of power hence this is very less compared to the national standard.

6.5 Percentage of Peak hour power generation: During the peak hour's electricity consumption is more while compared to the other hours in a day. During these hours power consumption is increased around 20 -30 per cent. So power plants have to produce power without any interruptions. This ratio shows the contribution of stage-wise and total peak hour generation in the total power generation and also examine which stage is performing better while compared to the other stages of Dr. NTTPS during the study period. This ratio is calculated with the following formula.

$$\% \text{ of Peak Hour Generation} = \frac{\text{Peak Hour Power Generation}}{\text{Total Generation}} \times 100$$

Table-6.5: Peak Hour Generation of power in the Total generation of the selected organisation during 2007-08 to 2014-15

Year	Stage-I(%)	Stage-II(%)	Stage-III(%)	Stage-IV(%)	Total(%)
2007-08	33.52	33.51	33.53	-	33.52
2008-09	33.49	33.38	33.43	-	33.43
2009-10	33.64	33.45	33.44	-	31.43
2010-11	33.99	33.67	33.55	33	33.67
2011-12	33.51	33.37	33.36	33	33.41
2012-13	33.25	33.23	33.23	33	33.20
2013-14	33.55	33.51	33.59	34	33.62
2014-15	33.75	33.47	33.55	34	33.67
Mean	33.59	33.45	33.46	33.53	33.24
SD	0.22	0.13	0.343	0.303	
CAGR	0.001	-0.000	-0.001	0.002	

Source: Compiled from the Records of Dr. NTTPS

Table-6.7 explain stage-wise and station peak hour power generation to the total generation from 2007-08 to 2014-15. During this period four stages are generated around 1/3 of power in peak hours. During 2009-10 the station average was 31.43 per cent compared to total generation because stage IV was under trial run and did not generate power during peak hours. The same was reflected even in the average of this stage. Average percentage of peak hour generation of stage I, II and III are 33.59 per cent, 33.45 per cent and 33.46 per cent respectively and station average during the period of study is 33.24%.Standard deviation and compound annual growth rate explains peak hour generation of power at stage II is more stable and the growth rate is more at stage IV.

ANOVA						
Source of Variation	**SS**	**df**	**MS**	**F**	**P-value**	**F crit**
Rows	0.130819	7	0.018688	0.230173	0.970896	2.764199
Columns	23284.66	2	11642.33	143391.4	6.61E-31	3.738892
Error	1.136698	14	0.081193			
Total	23285.93	23				

Analysis of variance for peak hour generation stage-wise of the selected organization explains since $p>0.05$ there is no significant difference between the years of Peak Hour Generation of power and also since $p<0.05$ there is a significant difference between the stages of peak hour generation of power. Stage Ihas the highest mean peak hour generation.

6.6 Outage Hours: There are two types of outages to the power generation station. They are forced outages and planned outages. Grid failures, lack of demand and instructions from grid to stop the generation are come under forced outages. Repairs and renovations, over hauling to plants are planned outages. Planned outages are essential to the thermal power stations. This outage are very much effecting the power generation. Less outages increases the power generation and more are reducing the power generation. This ratio explains various outages stage-wise

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and entire station of the selected organisation during the period of study. Computation of the percentage of outage hours is mentioned as

$$\text{Outage hours} = \frac{\text{Outage Hours}}{\text{Total Outage Hours}} \times 100$$

Table-6.6: Outage Hours of Power Generation- Stage-Wise In The Selected Organisation During 2005-06 To 2014-15

Year	Stage-I Total Outage (%)	Stage-II Total Outage (%)	Stage-III Total Outage (%)	Stage-IV Total Outage (%)	Total Outage (%)
2005-06	46.51	21.13	32.36	-	100
2006-07	32.18	40.17	27.65	-	100
2007-08	58.99	19.93	21.08	-	100
2008-09	52.39	6.85	40.76	-	100
2009-10	5.21	49.54	45.25	-	100
2010-11	12.57	10.27	69.92	7	100
2011-12	29.32	27.93	39.30	3	100
2012-13	44.37	10.39	24.80	20	100
2013-14	49.07	23.02	22.15	6	100
2014-15	31.71	29.16	26.00	13	100
Mean	1,463	1,063	1,792	448	4,587
SD	831.65	686.90	1905.58	352.34	2158.27
CAGR	-0.017	0.054	-0.009	-0.071	0.021

Source: Compiled from the Records of Dr. NTTPS

Table-6.6 examines stage-wise and total percentage of outage hours during 2005-06 to 2014-15. Forced and planned outages of four stages are fluctuating during this period. Forced outage of stage I is 42.20 per cent and planned outage is 36.48 per cent which is highest compared to the other stages of the organisation because this stage is completed more than 35 years, more outage hours are required for repairs and renovation. Stage IV planned outage and forced outage is less among the other stages, i.e., 17.45 per cent and 7.74 per cent respectively. Total average outage hours of stage III is 1,793 because of more repairs to this plants and stage I is in second position with 1,463 hours. The average outage hours of stage IV is 448 hours because this stage is designed with new technology. The total average outage hours of the entire station during the period of study are 4,587 hours. It is suggested to the management of the organisation to reduce outage hours for increasing the production.

ANOVA					
	df	**SS**	**MS**	**F**	**Significance F**
Regression	1	1984543	1984543	0.397515	0.54596
Residual	8	39938945	4992368		
Total	9	41923489			

Anova table shows that 'f' value is significant at .054596, the outage hours at stage IV is more stable over the years because this stage is designed with latest technology and the growth rate is high at stage III, which indicates this stage is having more outage hours due to more repairs of the stage. Low correlation is observed over the stages.

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With the earlier analysis it is observed that the power generation of the selected organisation is reducing. Hence the hypothesis is accepted.

7.0 Findings

The operational performance of the selected organisation is measured with coal consumption, per unit of power generation. Efficiency of the stages as well as the organisation is also measured with plant load factor, auxiliary consumption percentage of peak hour power generation in total power generation and outage hours of the stages and also the entire station. These findings are drawn based on the operational performance of the selected organisation.

1. Though stage I and II have completed more than 35 years and 25 years respectively, still these stages are working in good condition and generating power, this is possible only because of high quality maintenance by the organisation.
2. Average coal consumption of stage IV .639 grams this is low compared to the other stages as well as the station average. Operating system of stage IV is designed with latest technology, hence less coal is consumed to generate one unit of power.
3. Deemed PLF ratio indicates that stage II is performing effectively when it is compared to the other stages. The average deemed PLF of stage II during the period of study is 92.35 per cent. Average deemed PLF of Dr. NTTPS is more than 85 per cent; this is possible with the high quality of maintenance of the plants.
4. During the study period PLF of the entire station is varying because of forced outages. These outages are continuously increasing from the year 2012-13 onwards. Average PLF of Dr. NTTPS during the period of study is 85.28.
5. Station wise average auxiliary consumption during the period of study is 8.47 per cent. This is less when compared to the National average. This indicates the efficient utilization of resources and effective operating system of the station.
6. During this period four stages are generated around 1/3 of power in peak hours. Average of stage I, II and III are 33.59 per cent, 33.45 per cent and 33.46 per cent respectively and station average during the period of study is 33.24%.
7. The average outage hours of stage IV is 448 hours because this stage is designed with new technology. The total average outage hours of the entire station during the period of study are 4,617 hours. It is suggested to the management of the organisation to reduce outage hours for increasing the production.

8.0 Conclusion

The stage IV is generating more power consistently and consuming less coal, oil and water for generation of power compared to the other stages. There is a further scope to enhance its productivity of this stage because this is designed with new technology and efficient operating system. Though stage I and II have completed more than 35, 25 years respectively in power generation these stages are performing well only because of efficient maintenance of the plants. When compared the operating efficiency, stage II better than stage III. Due to the more outages in stage III the more oil and water required for generation. Average PLF of the station during the period of study is 85.28 per cent, but the industrial standard is 75 per cent. This indicates the selected organisation is working efficiently and utilizing the resources effectively. To promote the power generation in private sector, governments is forcing the organisation to reduce its power generation. Hence the percentage of total power generation of Dr. NTTPS is reducing gradually during the period of study. It is suggested to the management to reduce the outages to the possible extent; this enables to increase the power generation. It is further suggested to the Government and APGENCO to generate more power from own resources. It is the responsibility of the Government to protect and promote the public enterprises, because these organisations are working for the welfare of the society.

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