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INTERNAL FACTORS AFFECTING PRODUCTIVITY AND EFFICIENCY IN THERMAL POWER GENERATION IN KENYA

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ABSTRACT

The aim of this study was to establish the factors that affect productivity in thermal power generation plants and also to establish how these factors affect the efficiency and progressive trends in these thermal power generation plants. Data was collected using questionnaires and interview guides that were administered by the researcher. The study was conducted on workers from different levels and departments which included management, technical personnel, crafts men and finally the chief executive officers for each plant. Two large power stations at the coast region were the sampling units. The data was analyzed using descriptive and inferential statistics; the mean score of the sample for each factor was calculated. Using a 95% confidence level, the population score for each factor was determined. The results show that the major factors that affect productivity in large thermal power stations are cost of inventory, availability of spares, capacity utilization, effective capacity, technology, plant location, licensing and government regulations, ISO certification and employment incentives. From the findings in this project, it shows that higher productivity leads to higher efficiency and it is therefore recommended that policy makers should focus, analyze and manage properly the identified major factors in order to improve productivity in the thermal power generation plants. It is also recommended in this report that the stake holders in the thermal power generation stations should come with explicit policies articulating the importance of productivity analysis in the thermal power generation centers.

1.0 BACKGROUND OF THE STUDY

In 1993 the government of Kenya through KPLC projected that the maximum national demand for power would increase from 621 MW to 1837MW over a period of 20 years (1993-2013).The corresponding energy demand was projected to raise from 3,735GWhr to 10,339 GWhr annually over the 20year projections (GOK, 1993).Currently the demand stands at 5,697 GWhr annually (KPLC, 2006). The required expansion of electrical generation expansion will be achieved in a timely manner only by developing a judicious combination of geothermal, thermoelectric and hydroelectric generation stations .Both the public and private sectors should participate in the Endeavour due to the massive investments costs required (GOK , 1993).

In 1996, 87% of Kenya's power was generated by hydroelectric installations constructed between 1968 and 1991 on the Tana River and Kerio Valley. In addition, about 45MW of geothermal power generation capacity was in place around the Rift Valley at Olkaria. Conventional thermal or engine driven power plants were mostly located in Mombasa due to proximity to the ocean (a lot of water is needed for cooling, also the sea level ambient conditions

favour the efficient generation of thermal Power) and the Kenya Petroleum oil refinery. By 1993, these plants were generating a small percentage of about 10% of the national demand (KPLC, 1993). During the period of 1993-1999, Mombasa and its environs suffered from insufficient power generation capacity, particularly during extended dry periods, when supply of electricity from the Hydro-Power stations was extremely reduced. Under these circumstances, the region became increasingly dependent on the thermal plants located within the region. Since there was little reserve capacity for the peak demand, there was rampant power rationing. Many manufacturing, food storage and tourism facilities complained of losses caused by frequent power outages and rationing. To alleviate the problem of power interruptions, KPLC at that time embarked on a program to significantly expand thermal power generation capacity in the coast region (Acres International Ltd, 1996).

Productivity is the ratio of what is produced by an operation of process to what is required to produce it, or put simply the ratio of actual output to input over a period of time. Inputs might include transforming and transformed resources (such as materials, equipment, customers and staff) and the outputs are goods and services (Schroeder R.G, 1985) .Productivity improvement will decrease production cost per unit which may contribute to the consumers in terms of lower prices and more services and goods. As the level of productivity rises, output becomes more competitive, both in terms of quantity and quality. Thus better quality goods and services are made available to consumers (Prokopenko, 1997).

As a measure of improving productivity and efficiency the Chinese Government stopped subsidizing state owned power generation companies in 1980s. To obtain new funding for expansion some of these companies had to list in the stock markets and issue shares to private investors. Listing in the stock market created a big pressure on power sector to automatically improve efficiency or perish (Review of Industrial Organization 2004). The report of Singapore National Productivity Board on Productivity in 1984 says that more than half of the contribution to the increase in per capita gross domestic product (GDP) in Singapore is attributed to the labour productivity for the period 1966 to 1983 (APO News, 1984).

Productivity analysis in Thermal Power Generation is very important for productivity improvement. It is not just doing things better but doing the right things better. There are two major categories of productivity factors. External factors and internal factors, the external factors are those that are beyond the control of the individual enterprise and internal factors are those within its control. Factors external to an enterprise are of interest to that enterprise because an understanding of them can motivate certain actions which might change an enterprise behavior and its productivity in the long run (Mukherjee, Duleep Singh 1975). No study has been carried out to establish how Productivity Factors can affect net electrical output in thermal power generation in Kenya and thus this study desires to close this gap. However the scope was limited to only the two major thermal stations based at the coast region and for the operation period from 1999 to 2006.The objective of this project as a pre- requisite to productivity improvement started by establishing the factors affecting productivity in the thermal power industry and in particular the comparison of factors within Kipevu 1 and Kipevu2 and how these factors affect efficiency and the Net Electrical Out Put.

2.0 STATEMENT OF THE PROBLEM

In the KPLC annual report for the financial year 2005/2006 for its shareholders, KPLC stated that Kipevu2 produced a total of 570GWhrs while Kipevul managed only 399GWhrs and yet these two thermal plants are located in the same neighborhood and enjoy similar inputs such as fuel oil, ambient conditions (Temperatures and Pressure). Kipevul was commissioned in 1999 and Kipevu2 was commissioned in August 2001, the effective generation capacity of Kipevul and Kipevu2 is 80% and 100% respectively(KPLC,2006). The Net Electrical Out Put for Kipevul and Kipevu2 between 1999 to June 2006 was 1869GWhrs and 2308GWhrs respectively (KPLC, 2006) there is need to understand why there is a disparity in Net Electrical Power output between Kipevul and Kipevu2 and yet kipevul started its full commercial operations two years earlier than Kipevu2.There is an impression that Independent Power Producer Tsavo Power operations of KIPEVU2 is better than the KENGENS operations of KIPEVU1 why? Was it possible that effective management of the factors affecting productivity has caused the disparity? There was an existing gap of knowledge about Productivity factors in the Thermal Power Generation Plants. There is no information available of any study about the factors affecting Productivity in the Thermal Power Generation sector in Kenya. The proposed study and subsequent comparison of public utility Kipevul and IPP Kipevu2 was to close this gap.

3.0 OBJECTIVE OF THE STUDY

Productivity analysis in Thermal Power Generation is very important for productivity improvement. It is not just doing things better, but doing the right things better. There are two major categories of productivity factors. External factors and internal factors, the external factors are those that are beyond the control of the individual Power Stations and internal factors are those within its control. The main objectives of this study were:

- To establish the factors that affect productivity in thermal power generation.
- To establish how the factors affecting productivity affect the efficiency, effectiveness and progressive trends in thermal power generation and the net electrical output.

4.0 LITERATURE REVIEW

The significance of productivity in increasing national welfare is now universally recognized. There is no human activity that does not benefit from improved productivity. This is important because more of the increase in gross national income, or GNP, is produced by improving the effectiveness and quality of manpower than by using additional labour and capital. In other words, national income or GNP grows faster than the input factors when productivity is improved. Productivity improvement, therefore, results in direct increases in the standard of living under conditions of distribution of productivity gains according to contribution. At present it would not be wrong to state that productivity is the only important world-wide source of real economic growth, social progress and improved standard of living (Dolenga, 1985). For example, the report of the Singapore National Productivity Board on a productivity survey (1984) says that more than half of the contribution to the increase in per capita gross domestic product (GDP) in Singapore is attributed to the labour productivity for the period 1966-83. This means that labour productivity has been the main factor in the rise in Singapore's standard of living, as attested by a fourfold increase over the past 17years(APO News, 1985).

At the same time, we can easily see the effect of low productivity in the Philippines. The Vast majority of increases in the country's total output (97.7 per cent) from 1900 to 1960 are due to increases in the extensive more resources) and only 2.3 per cent can be attributed to productivity.

This highlights a key defect in the process of long-term economic growth in the Philippines -the fact that it has been input-intensive (Manila, Business day corporation 1984).Thus, changes in productivity are recognized as a major influence on many social and economic phenomena, such as rapid economic growth, higher standard of living, improvements in a nation's balance of payments, inflation control and even the amount and quality of these changes influence wage levels cost/price relationships, capital investment needs and employment. Productivity also largely determines how competitive a country's products are internationally (Scott, 1985).

Productivity measurement helps identify factors affecting income and investment distribution within different economic sectors and helps to determine priorities in decision-making. Productivity indices are also used by local and central authorities to detect problem areas and to evaluate the impact of national development programmes. They provided valuable, objective information for direction public resources. In enterprise productivity is measured to help analyses effectiveness and efficiency. Its measurement can stimulate operational improvement, the very announcement, installation and operation of a measurement system can improve labour productivity, sometimes by 5 to 10 per cent, with no other organizational change of investment (Prokopenko, 1997).Productivity indices also help to establish realistic targets and check-points for diagnostic activities during an organization development process, pointing to bottle-necks and barriers to performance. Furthermore, there can be no improvement in industrial relations or proper correspondence between productivity, wage levels and gains-sharing policies without a sound measurement system. Productivity indices are also useful in inter-country and inter-firm comparisons designed to detect factors accounting for economic growth.

Productivity appraisal at the macro-level means measurements of the absolute level of productivity and its historical trends expressed through a series of indices. Without such a measurement Gross Domestic Product (GDP), Gross National Product (GNP), National Income (NI) or value added (VA) may not reflect a true picture of the nation's or sectors economic health. For example, GDP may increase year after year, but productivity may actually be on the decline when cost of input has increased faster than output (Martin and Home 2001).

5.0 METHODOLOGY

5.1 RESEARCH DESIGN

The project was a comparative study of two thermal power generation stations located in Kipevu area adjacent to the Port of Kenya in Mombasa County. Comparability is a guide to organizational performance, since productivity ratios alone tells us little without some form of comparison (Lawlor, 1985). Each of the two Power Stations formed as an independent sampling unit. A combination of methods were undertaken to collect data on productivity factors (both internal and external factors) from various levels of operations and management in each station.

6.0 Results

Table 1 Kipevu 1

Score Factor	**5**	**4**	**3**	**2**	**1**	**Total score (f)**	**Average score**	**Standard deviation**
Cost of Inventory	4	6	4	-	1	57	3.8	1.05
Capital Utilization	10	2	1	2	-	65	4.33	0.89
Effective Capacity	12	1	1	1	-	69	4.6	0.88
Availability of Spares	11	4	-	-	-	71	4.73	0.97
Quality of Fuel	-	10	4	1	-	54	3.6	0.61
Effective Teamwork	8	1	-	1	5	51	3.4	1.8
Qualifications	5	10	-	-	-	65	4.33	0.47
Management Styles	2	2	10	-	1	49	3.27	0.80
Dispatch Procedures	-	10	-	5	-	50	3.33	0.94
Technology	10	2	1	2	-	65	4.33	1.07
Procurement Procedures	2	-	10	2	1	45	3.00	0.82
Plant Location	11	3	-	1	-	69	4.6	0.8
Plant Availability	15	-	-	-	-	75	5	0
Licensing & Govt Regulation	10	5	-	-	-	70	4.67	0.47
IS0 Certification	4	7	4	-	-	60	4.0	0.73
Employment of Experts	-	-	14	-	1	44	2.93	0.25
Equipment & Tools	10	5	-	-	-	70	4.67	0.47
Employment Incentives	15	-	-	-	-	75	5	0

The sample means score for the cost of inventory at Kipevu l is 3.8. This score suggests that cost of inventory is a strong factor, Using a 95% confidence level the mean score P for the whole population at Kipevu 1 for this factor is given by the formula Population Mean Score $P = X \pm Z (S/VN)$. Where at 95% confidence level, Z is 1.96 and X is the mean score. S is the sample standard deviation and, N the size of the sample. The sample standard deviation is 1.05; therefore, the population mean score P at 95% confidence level for cost of inventory factor is $P= 3.8 \pm 1.96xl.05/\sqrt{l5.} = 3.8\pm 0.53$. This means that the minimum scores a member of the population can give on this factor at 95% confidence level is 3.27which is greater than 3. Therefore, this is a strong factor that will affect productivity significantly.

The sample mean score for capacity utilization is 4.33 this score suggests that capacity utilization is a strong factor. Using a 95% confidence level the mean score P for the whole population at Kipevu 1 for this factor is $P= 4.33 \pm 1.96x\ 0.89/\sqrt{l5.}= 4.33\pm 0.45$ This means that the minimum score a member of the population can give on this factor at 95% confidence level is 3.88 which is greater than 3. Therefore, this is not a strong factor that will affect productivity significantly.

The sample mean score for effective capacity is 4.6. Using a 95% confidence level the mean score P for the whole population at Kipevu 1 for this factor is $P= 4.6 \pm 1.96x\ 0.88/\sqrt{l5}= 4.6\pm$ 0.45. This means that the minimum score a member of the population can give on this factor at 95% confidence level is 4.15 which is greater than 4. Therefore, this is a very strong factor that will affect productivity significantly.

The samples mean score for availability of spares is 4.73. Using a 95% confidence level the mean score P for the whole population at Kipevu 1 for this factor is p= 4.73 ± 1.96x 0.97/√15 = 4.73± 0.49. This means that the minimum score a member of the population can give on this factor at 95% confidence level is 4.24 which is greater than 4. Therefore, this is a very strong factor that will affect productivity significantly.

The sample mean score for quality of fuel oil is 3.6. Using a 95% confidence level the mean score P for the whole population at Kipevu 1 for this factor is P= 3.6 ± 1.96x 0.61/√l5. = 3.6± 0.30. This means that the minimum score a member of the population can give on this factor at 95% confidence level is 3.3 which is greater than 3. Therefore, this is a strong factor that will affect productivity significantly.

The sample mean score for effective teamwork is 3.4. This score suggests that it is a strong factor, using a 95% confidence level the mean score P for the whole population at Kipevu 1 for this factor is P= 3.4 ± 1.96x 1.8/√l5 = 3.4± 0.9. This means that the minimum scores a member of the population can give on this factor at 95% confidence level is 2.5 which is less than 3. Therefore, this is not a strong factor that will affect productivity significantly.

The sample mean score for qualifications of personnel is 4.33. Using a 95% confidence level, the mean score P for the whole population at Kipevu 1 for this factor is P= 4.33 ± 1.96x 0.47/√l5= 4.33± 0.24. This means that the minimum scores a member of the population can give on this factor at 95% confidence level is 4.09 which is greater than 4. Therefore, this is a very strong factor that will affect productivity significantly.

The sample mean score for management style is 3.27. Using a 95% confidence level, the mean score P for the whole population at Kipevu 1 for this factor is P= 3.27 ± 1.96x 0.8/√l5= 3.27± 0.4. This means that the minimum scores a member of the population can give on this factor at 95% confidence level is 2.87 which is less than 3. Therefore, this is not a very strong factor that will affect productivity significantly.

The sample mean score for dispatch procedures is 3.33. Using a 95% confidence level, the mean score P for the whole population at Kipevu 1 for this factor is P= 3.33 ± 1.96x 0.94/√l5=3.33± 0.48. This means that the minimum score a member of the population can give on this factor at 95% confidence level is 2.85 which is less than 3. Therefore, this is not a very strong factor that will affect productivity significantly.

The sample mean score for technology is 4.33. Using a 95% confidence level, the mean score P for the whole population at Kipevu 1. For this factor is P= 4.33 ± 1.96x 1.07/√l5= 4.33± 0.54 This means that the minimum score a member of the population can give on this factor at 95% confidence level is 3.79 which is greater than 3. Therefore, this is a strong factor that will affect productivity significantly.

The sample mean Score for procurement is 3. Using a 95% confidence level, the mean score P for the whole population at Kipevu 1 for this factor is P= 3 ± 1.96x 0.82/√15= 3± 0.41. This means that the minimum scores a member of the population can give on this lactor at 95%

confidence level is 2.59 which is less than 3. Therefore, this is not a very strong factor that will affect productivity significantly.

The sample mean score for plant location is 4.6. This score suggests that it is a strong factor. Using a 95% confidence level, the mean score P for the whole population at Kipevu 1 for this factor is P= 4.33 ± 1.96x 0.8/l5.= 4.6± 0.40.This means that the minimum score a member of the population can give on this factor at 95% confidence level is 4.2 which is greater than 4. Therefore, this is a very strong factor that will affect productivity significantly.
The sample mean score for plant availability is 5. Using a 95% confidence level, the mean score P for the whole population at Kipevu 1 for this factor is P= 5± 1.96x 0/√l5= 5. This means that the minimum score a member of the population can give on this factor at 95% confidence level is 5. Therefore, this is an extremely strong factor that will affect productivity significantly.

The sample mean Score for licensing and government policies is 4.67. Using a 95% confidence level, the mean score P for the whole population at Kipevu 1 for this factor is P= 4.67 ± 1.96x 0.47/√l5.= 4.67± 0.24. This means that the minimum score a member of the population can give on this factor at 95% confidence level is 4.43 which is greater than 4. Therefore, this is a very strong factor that will affect productivity significantly.

The sample mean score for ISO certification is 4. Using a 95% confidence level, the mean score P for the whole population at Kipevu 1 for this factor is P= 4. ± 1.96x 0.73/√15 = 4.± 0.37. This means that the minimum score a member of the population can give on this factor at 95% confidence level is 3.63 which is greater than 3. Therefore, this, s a strong factor that will affect productivity significantly. The sample mean Score for 31 employment of experts is 2.93. Using a 95% confidence level, the mean score P for the whole population at Kipevu 1 for this factor is P= 2.93 ± 1.96x 0.25/√15= 2.93± 0.13. This means that the minimum scores a member of the population can give on this factor at 95% confidence level is 2.8 which is less than 3. Therefore, this is not a very strong factor that will affect productivity significantly.

The sample mean score for tools and equipment is 4.67. Using a 95% confidence level, the mean score P for the whole population at Kipevu 1 for this factor is P= 4.67 ± 1.96x 0.47/√1= 4.67± 0.24. This means that the minimum scores a member of the population can give on this factor at 95% confidence level is 4.43 which is greater than 4. Therefore, this is a very strong factor that will affect productivity significantly.

The sample mean score for employee's incentives is 5. Using a 95% confidence level, the mean score P for the whole population at Kipevu 1 for this factor is P= 5± 1.96x 0/√l5 = 5. This means that the minimum scores a member of the population can give on this factor at 95% confidence level is 5. Therefore, this is an extremely strong factor that will affect productivity significantly.

6.1 DISCUSSION OF THE FINDINGS

Inventory carrying costs vary with the level of inventory. There are some fixed costs that make the initial inventory carrying costs high. However, as the level of inventory increases the average carrying costs per unit will decrease to a minimal level. The economic quantity level is the level when the inventory carrying costs are at their lowest. Therefore, each plant should endeavor to

keep its inventory levels at economic quantity level. Plant productivity as a function of inventory levels is highest at the economic quantity levels.

In any power station, there are fixed costs that are incurred whether the plants run at full capacity, partial capacity or, zero capacity. The plant capacity productivity falls as the capacity utilization drops. High productivity Capacity Utilization should be at 100%. As the Capacity drops blow 100% Utilization the productivity also falls.

The installed capacity at Kipevu 1 is 75MW. However, its effective capacity is only 60MW. This implies that Kipevu 1 is operating at 75% Capacity. This implies that its productivity, when all factors are fixed, is 75% of maximum productivity. The installed capacity at Kipevu 2 is 74MW and its effective capacity is 74MW. This means that if all factors remain constant the productivity is at its maximum. This means that the maximum productivity reduces proportionally, to the ratio of effective capacity and installed capacity.

Availability of spares affects the maintenance of efficiency of the plants. Lack of these spares reduces productivity due to loss of overall output generation. Spares have to be available at all times to maintain high productivity. Modem technology improves on efficiency. For example, Kipevu 1 operations are in analogue mode while Kipevu 2 operations are purely electronic. For these reasons Labour force at Kipevu 1 is 150 employees while at of Kipevu 2 it is only 48 employees. Putting all factors constant, then, productivity level at Kipevu 1 is equal to 0.5MW/employee while at Kipevu 2 is 1.5MW/employee. Therefore, improvement of technology improves productivity.

The location of a thermal power station is very important because of the inputs needed to achieve the required outputs. For example, a lot of fuel is needed, and transportation of this fuel oil is extremely expensive if the plant is located far from the refinery. When the cost of fuel oil increases overall operations costs also increase. The operations costs also increase. A rise in operations costs means a rise in production costs and a reduction in productivity levels.
A plant cannot operate unless all the licenses and government regulations are fulfilled. When the plant does not operate, then, productivity is zero.

Effective Capacity of Kipevu 1 as at 2003 was 50%. However, after 2004 Kipevu 1 was ISO Certified and the effective capacity improved continuously it now stands at 75%. Kipevu 2 was ISO 9000 Certified in 2002 and its effective capacity has steadily remained at 100% to date. ISO Certification involves continuous improvement activities hence it actually improves and maintains productivity at high levels.

High employment incentives improve and maintain labour morale. High morale improves labour productivity and low morale can seriously reduce productivity levels. Productivity must be considered in both social and economic terms. Attitudes towards work and achievements can be improved through employee's participation in planning goals, implementing processes, and through sharing productivity gains. Productivity gains can only be achieved effectively where employment incentives are favorable to employee.

7.0 CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

Factors affecting productivity were identified through the literature review based on different research in the fields of construction by Motwani (2005). The researcher identified Eighteen factors at the power generation plants. The respondents were required to rate, using their own experience in the power generation industry, how the 18 factors affect productivity with respect to time, cost and quality. The survey was carried out using questionnaires and interview guides. The responses were received over a period of 3 months.

When the data were analysed, it was realized that the most significant factors that would affect productivity in a power plant are: Availability of spares, plant availability, plant location, tools and equipment, effective capacity, employment incentives , technology, qualification of works, cost of inventory licensing and, government regulations and capacity utilization of the plant.
Management of these factors in both plants contributed immensely to the overall efficiency in either plant. The overall efficiency in Kipevu2 was higher than the efficiency at Kipevu 1 because these factors were managed better. This may be due to the ownership structure that allows Kipevu 2 a free hand in managing and controlling these factors.

7.2 Recommendation

The stake holders in thermal generation projects should come up with explicit policies articulating the importance of productivity analysis in the thermal power generation centres in Kenya.

- Institutionalized capacity building programmes geared towards making the people understand the importance of productivity analysis should be put in place.
- Thermal generation companies should strive to adapt the potential of the new technologies in order to improve production.

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