

# **FACTORS AFFECTING PRODUCTIVITY IN THE LARGE THERMAL POWER GENERATION STATIONS IN KENYA**

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A Research Project Submitted in Partial Fulfillment of the Requirements for the Award  
of the Degree of Master of Business Administration, School of Business, University of  
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# DECLARATION

This research project is my original work and has not been presented for any degree in any other University.



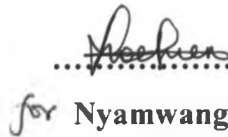
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## **DEDICATION**

This work is dedicated to my wife Susan Mwaka whose moral and financial support has enabled me to reach this far. I would like to dedicate this work to my daughters Faith, Eunice and Lucy. I sincerely believe that this dedication will inspire them to work hard.

## 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 stakeholders in the thermal power generation stations should come with explicit policies articulating the importance of productivity analysis in the thermal power generation centers in Kenya.

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## ABBREVIATIONS

MANOVA	Multivariate Analysis of Variance
KPLC	Kenya Power and Lighting Company Limited
KENGEN	Kenya Generation Company
TPC	Tsavo Power Company
GOK	Government of Kenya
ISO	International standards organization
ILO	International Labour Organisation
NESG	National Economic and Social council
GDP	Gross Domestic Product
APO	Asia Productivity Organisation
GNP	Gross National Product
NI	National Income
VA	Value Added
MW	Megawatts
KW	Kilowatts
NEO	Net Electrical Output KJ/KWhr
KJ	Kilojoules
KWhr	Kilowatt hours
GWhr	Gigawatt hours



# CHAPTER ONE INTRODUCTION

## 1.1 Background

In 1993 the government of Kenya through KPLC projected that the maximum national demand for power would increase from 621MW 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).

By 1997 Kengen was carved from the larger KPLC and undertook the construction of Kipevu1 Thermal Power station (installed capacity 75MW). Kipevu 1 was commissioned and started operations in 1999(Kengen, July 1999). Due to the massive investment costs, Kipevu 2,a plant of similar capacity was awarded to a private investor. Tsavo Power is a special purpose company established under the laws of Kenya to build, own and operate Kipevu2. Investment cost of Kipevu2 was US\$ 86,000,000 the capital structure of Tsavo Power was 30%equity and 70% debt (ESG International, July 1999). Kipevu2 was commissioned and started commercial operations in August 2001.Kipevu1&2 are of comparative size and use the same fuel oil and are located within the same area. Fuel cost is passed to the customer and it is envisaged that if the factors affecting productivity in power generation are determined and effectively managed then the operation costs can be reduced hence bringing down the ever increasing cost of electricity. Despite the importance of productivity to many service organisations it is surprising that there is relatively little empirical research on this topic. There appears to be a degree of confusion over the concept and definition of productivity (Mahoney, 1988). Productivity means

different things to different people (Prokopenko, 1997) and there are different or even conflicting definitions and perceptions of productivity (Pickworth, 1987). For instance productivity has been approached as an umbrella concept including utilization, efficiency, effectiveness, quality, predictability and other performance dimensions, as well as a narrower concept reflecting only production efficiency. In order to develop a model of service productivity, it is important to provide some clarity and distinction between these terms.

Utilisation is the ratio of actual output of a process or operation to its design capacity. However, it is rare for processes or operations to operate at design capacity due to planned losses such as maintenance and planned shut downs, and avoidable losses such as breakdowns. Efficiency is the ratio of actual output to effective capacity (Slack et al 2001)

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). For all organisations, especially those engaged in manufacturing the productivity of production systems is an important component of overall productivity

.Productivity depends on the design of the product or service, the design of the process and the operation of the process. Control of production processes involves both the operational control and financial control information is used to ensure that operational activity conforms to planned levels and also to aid in decision making for development projects (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 Kipevu1 and Kipevu2 and how these factors affect efficiency and the Net Electrical Out Put.

## **1.2 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 Kipevu1 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).Kipevu1 was commissioned in 1999 and Kipevu2 was commissioned in August 2001, the effective generation capacity of Kipevu1 and Kipevu2 is 80% and 100% respectively(KPLC,2006). The Net Electrical Out Put for Kipevu1 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 out put between Kipevu1 and Kipevu2 and yet kipevu1 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 Kipevu1 and IPP Kipevu2 was to close this gap.

### **1.3 Objectives 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.

### **1.4 Importance of the Study**

- Electricity is a major/strategic input of economic growth; effective management of the factors affecting productivity can reduce cost of operations and production and hence reduce the cost of electrical energy to the consumer and at the same time assist to close the gap between supply and demand of electricity. Productivity largely determines how competitive a country's products are internationally (Scott,1985)
- The Government of Kenya created an economic growth team/committee to develop strategies that can transform Kenya into a middle income country by the year

2030(NESC, 2006). Vision 2030 achievement is based on rapid growth of six key sectors, which include manufacturing, tourism, wholesale and retail, financial intermediation agriculture and business process (GOK, 2007). Electrical energy is a critical component in the development of all these sectors. In this perspective effective management of productivity factors can be seen as an appropriate tool to maximize efficiency in the power generation industry with a view of maximizing operations costs and maximizing on effective capacity.

- The data generated from this project could be used by power generation firms to improve on efficiency and Productivity, analysis and conclusions in the project could be used for further academic research. The project findings have useful policy issues and or implications in the thermal energy sector. The recommendations that have emerged from the project could be useful for designing/formulating wiser policies in the energy sector.

# CHAPTER TWO: LITERATURE REVIEW

## 2.1 Productivity Defined

A general definition is that productivity is the relationship between the output generated by a production or service system and the input provided to create this output. Thus, productivity is defined as the efficient use of resources, labour, capital, land, materials, energy, and information –in the production of various goods and services (Katzell, 1975). Higher productivity means accomplishing more with the same amount of resources or achieving higher out put in terms of volume and quantity for same input .Thus

$$\text{Productivity} = \text{Output/Input.}$$

Productivity can also be defined as the relationship between results and the time it takes to accomplish them .Time is often a good denominator since it is a universal measurement, and it is beyond human control. The lesser the time taken to achieve the desired result, the more productive the system (Prokopenko, 1978).

Regardless of the type of production, economic or political system, the definition of productivity remains. Thus, though productivity may mean different things to different people, the basic concept is always the relationship between the quantity and quality of goods or services produced and the quantity of resources used to produce them. Productivity is a comparative tool for managers, industrial engineers, economists and politicians. It compares production at different levels of the economic system (individual and shop-floor, organizational, and national with resources consumed (Prokopenko,1975) Sometimes productivity is viewed as a more intensive use of such resources as labour and



machines, which should reliably indicate performance or efficiency if measured accurately. However, it is important to separate productivity from intensity of labour; the essence of productivity improvement is working more intelligently, not harder. Real productivity improvement is not achieved by working harder; this results in very limited increases in productivity due to man's physical limitations.

## **2.2 Productivity concepts**

The International Labour Organization( ILO) has for many years promoted an advanced view of productivity which refers to the effective and efficient utilization of all resources, capital, land, materials, energy, information and time, in addition to labour. In promoting such views, one must combat some common misunderstandings about productivity (Vora, 1999).

First, productivity is not just labour efficiency or "labour productivity"-although labour productivity statistics are still useful policy-making data. The false conclusions which may be drawn from analyses of single factor productivity are demonstrated by major British productivity success story agriculture. Because of improvements in breeding, fertilizers and sprays, land and technology, labour productivity in agriculture rose 60per cent between 1976 and 1982 as did yield per hectare. But one unit of energy (which includes fertilizers) grew less wheat in 1983 than in 1963. A more appropriate yardstick of efficiency is then, the yield produced for each monetary unit spent. Hence the emerging importance of multi – (if not total) factor productivity. Productivity is now much more than just labour productivity and needs to take into account the increase in

cost of energy and raw materials along with a growing concern for unemployment and the quality of working life (Katzell,1975).

The second misconception is that it is possible to judge performance simply by output. The latter may be rising without an increase in productivity if, for instance, input costs have risen disproportionately. Moreover, increase in output compared with previous years should take into account price increases and inflation. Such an approach is often the result of being process-oriented at the expense of paying attention to final results. This is common in any bureaucratic system.

The third problem is confusion between productivity and profitability. In real life profit can be obtained through price recovery even though productivity may have gone down. Conversely, high productivity does not always go with high profit since goods, which are produced efficiently, are not necessarily in demand. Hence there is one more misunderstanding – confusing productivity with efficiency. Efficiency means producing high-quality goods in the shortest possible time. But we have to consider if these goods are needed. A fifth mistake is to believe that cost cutting always improves productivity when done indiscriminately; it can make matters worse in the long term (Hubert, 1984). Another myth, which causes damage, is that productivity can only be applied to production. In reality, productivity is relevant to any kind of organization or system, including services, notably information. With the changing structure of occupations, information specialist has become a new target for productivity drives. Information technology itself gives new dimensions to productivity concepts and productivity measurement. In these days of flexible automation, microprocessors, just-in-time manufacturing and distribution systems, and mixed-flow production systems, work-hours

are less relevant as a measure of effectiveness than in the past. In fact, in industries and regions where “steel-collar” workers or robots are replacing blue-collar workers, the productivity of capital or other expensive, scarce resources such as energy or raw materials is of far more concern than labour productivity (Gerog, 2002).

The concept of productivity is also increasingly linked with quality of output, input and the process itself. An element of key importance is the quality of the workforce, its management and its working conditions, and it has been generally recognized that rising productivity and improving quality of working life do tend to go hand in hand.

In this sense, productivity must be considered in both social and economic terms. Attitudes towards work and achievement may be improved through employees’ participation in planning goals, implementing processes, and through sharing productivity gains (Ducker,1989).The importance of the social side of productivity has increased considerably. A study among managers and trade unions in some American firms shows that most managers (78 per cent) and union leaders (70 per cent) do not employ quantitative definitions of productivity. They prefer a broader, more qualitative conception, related to the organization concerned. By productivity, management and union policy-makers refer, essentially, to the overall effectiveness and performance of individual organizations. This includes less tangible features such as the absence of labour stoppages, rate of turnover, absenteeism and even customer satisfaction. Given this broad concept of productivity, it is understandable that policy-makers see a link between worker satisfaction, customer satisfaction and productivity. It is therefore, important to define effectiveness as the degree to which goals are attained. This concept, based on systematic and comprehensive approach to social and economic development, permits us to work out productivity definitions suitable for any given enterprise, sector or

nation. A complication arises, however, because the numerator and denominator for effectiveness comparisons may be quite different, reflecting specific features such as organizational structures and the political, social and economic goals of the country or sector (Kendrick, 1988).

The definition of productivity is complex and it is not only a technical and managerial problem. It is a matter of concern to government bodies, trade unions and other social institutions. And the more difference their goals, the more different their definitions of productivity will be. But if all social groups agree on more or less common goals, the definition of productivity for the country, even for different segments of the economy, will have more common features. Hence, the main indicator of improving productivity is a decreasing ratio of input to output at constant or improved quality. If productivity is defined for the individual worker as the relation of the volume of specific work done the potential capacity of the worker (in numerical, cost or time terms), then for the enterprise or sector, it can be expressed as the relation between value added and the cost of all input components. For example, in an enterprise of shop-floor dealing with homogeneous products, productivity can be defined as the relationship of output expressed in physical terms (in tones or numbers of goods produced) to input even the amount and quality of leisure. 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. If labour productivity into the country declines in relation to productivity into other countries producing the same goods, a competitive imbalance is created. If the higher costs of production are passed on, the country's industries will lose sales as

customers turn to the lower cost suppliers. But if the higher costs are absorbed by industries, their profit will decrease. This means that they have to decrease production or keep production costs stable by lowering real wages (Peters, 1982). Some countries that fail to keep pace with the productivity levels of competitors try to solve their problems by devaluing their national currencies. But this lowers real income in such countries by making imported goods more expensive and by increasing domestic inflation. Thus, low productivity results in inflation, an adverse balance of trade, poor growth rate and unemployment. It is clear then that the vicious circle of poverty, unemployment and low productivity can be broken only by increasing productivity. Increased national productivity not only means optimal use of resources but also helps to create a better balance between economic, social and political structures in the society. Social goals and government policy largely define the distribution and utilization of national income. This in turn influences the social, political, cultural, educational and motivational work environment, which affects the productivity of the individual and the society (Scott, 1985).

## **2.3 Productivity Improvement Factors**

Productivity improvement is not just doing things better; more importantly, it is doing the right things better. This chapter aims to identify the major factors, or “right things” which should be the main concerns of productivity program managers. Before discussing what to tackle in a productivity improvement program, it is necessary to review the factors affecting productivity. The production process is a complex, adaptive, ongoing social system. The inter-relationships between labour, capital and the socio-organizational environment are important in the way they are balanced and co-

coordinated into an integrated whole. Productivity improvement depends upon how successfully we identify and use the main factors of the socio-production system. It is important in connection with this, to distinguish three productivity factor groups; job-related, resource-related and Environment-related. Since our main concern here is the economic analysis of managerial factors rather than productivity factors as such, we suggest a classification which will help managers distinguish those factors which they can control. In this way, the number of factors to be analysed and influenced decreases dramatically. The Classification suggested here is based on a paper by Mukherjee and Singh (1975).

There are two major categories of productivity factors and these are;

- External (not controllable)
- Internal (controllable)

Thus, it can be clearly seen that the first step towards improving productivity is to identify problem areas within these factor groups. The next step is to distinguish those factors, which are controllable. Factors which are external and not controllable for one institution are often internal to another. Factors external to an enterprise, for example could be internal to governments, national or regional institutions, associations and pressure groups. Governments can improve tax policy, develop better labour infrastructure, price policy and so on but individually organizations cannot. 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's behavior and its productivity in the long run. We suggest the following integrated scheme of factors constituting a major source of productivity improvement.

Expressed in work-hours. At the national level, productivity is the relationship of national income to total expenditure (or labour costs if we are interested only in labour productivity). Generally, productivity can be considered as a comprehensive measure of how organizations satisfy the following criteria;

- Objectives; the degree to which they are achieved
- Efficiency; how effectively resources are used to generate useful output
- Effectiveness; what is achieved compared with what is possible
- Comparability; how productivity performance is recorded over time

Though there are many different definitions of productivity, the commonest approach (not a definition) to designing a productivity model is to identify the right output and input components in accordance with the long, middle and short-term development goals of the enterprise, sector or country.

## **2.4 The Importance and Role of Productivity**

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)

## **2.5 Productivity Analysis**

Productivity analysis is important for productivity improvement. Even as a separate element, it is a very effective tool for decision-making at all economic levels. The success



of productivity measurement and analysis depends largely upon a clear understanding by all parties concerned (enterprise managers, workers, employers, trade union organizations and government institutions) of why productivity measurement is important for the effectiveness of the organization. The answer is that it indicates where to look for opportunities to improve and also shows how well improvement efforts are faring. At the national and sectoral levels, productivity indices help us evaluate economic performance and the quality of social and economic policies. These policies influence such diverse matters as the level of technological development, the maturity of management and the labour force, planning, incomes, wages, and price policies and taxation. 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 directing public resources. In enterprise productivity is measured to help analyse 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. Further more, 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. That is why productivity measurement should be among the first priorities for any productivity

improvement project manager, both at the national and enterprise level. To achieve a balance between productivity, profits and prices, a sound productivity measurement system must be an integral part of the management information system (Morris and Johnston 1988).

## 2.6 Productivity Appraisal

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 Horne 2001). The formula below is used to measure productivity at all economic levels.

$$\text{Total Productivity} = \frac{\text{Total Output}}{\text{Total Input}} \quad (1)$$

Total productivity can be measured by the formula:

$$P_t = \frac{O_t}{L+C+R+Q} \quad (2)$$

Where;  $P_t$  = total productivity

$O_t$  = total output

$L$  = labour input factor

$C$  = Capital input factor

$R$  = raw material and purchased parts input

$Q$  = other miscellaneous goods and services input factor

## 2.7 Comparing and Analyzing Productivity

International and intersectional productivity comparisons help nations or sectors learn from each other. Central governments, for example, are interested in the level and rate of change of per capita income compared with that of other countries. In designing a national economic plan it is important to consider the background of such comparisons (i.e. the structural situation of industrial productivity for each industry) (Lawlor, 1985).

In connection it is useful to point out some of the main sources of productivity variations in comparisons. The most obvious elements to analyse are the volume and composition of the output, the variety of products and the degree of vertical integration in processing; the availability and nature of raw materials and components and their sources; the availability and use of energy; the volume and composition of labour input; the state of technology; the volume and composition of capita output'; the impact of scale of production; the nature and location of markets, impact of tariffs, taxation, ownership, standards and government regulations. The most significant characteristics of labour input are the number of white-collar and production workers, production work-hours, basic average hourly earnings and salaries, total compensation including overtime and the composing of the labour force, i.e. skilled, semi-skilled and professional workers, their age and turnover. The education and training of the workforce, both blue-and white-collar, is of obvious importance as well. There are many approaches to productivity measurement and analysis in enterprises. This is because different groups of people are concerned with the enterprise (managers, workers, investors, customers, trade unions) and these groups have different goals. Some simple and practical approaches to productivity analysis are:

1. Measurement of worker's productivity

2. Measurement of systems for planning and analyzing unit labour requirements
3. Measurement systems of labour productivity aimed at the structure of labour resource use (Martin and Horne 2001).

## **2.8 Thermal Power Generation and Efficiency (Productivity)**

### **2.8.1 The Diesel Cycle**

The diesel cycle describes the thermodynamic process within diesel engines. The diesel engine is an internal combustion engine, where ignition starts by injecting high pressure oil into the cylinder and ignition occurs as a result of the high temperatures of the compressed air in the cylinder. This will result in movement of the reciprocating rods and rotating shafts and eventual production of electricity in the generator. The mechanical efficiency coupled with the generator efficiency will lead to the overall efficiency, in this case called the thermal productivity

### **2.8.2 Thermal Efficiency $\eta_e$**

$$\eta_e = P_g/Q_f$$

Where:  $P_g$  is the generator actual output in megawatts (MW) or (MJ/S).  $Q_f$  is fuel input in megawatts (MW), which is measured using the lower Heat values of Fuels (LHV). The units of LHV are Joules/kg of fuel used. For example assuming we use  $Q$  Joules of fuel oil to produce 1Mwhr at the generator set, 1Mwhr is equivalent to 3600MJ of electricity, then at 40% efficiency  $Q$  will be 9000MJ. This means it takes 9000MJ of Fuel oil to produce 3600MJ of electricity when the plant runs at 40% efficiency. This can also be

expressed as 9000KJ/Kwhr (in this case called the heat rate). The heat rate is the average value of Fuel expressed in joules to produce one Kwhr of electricity at the generator.

According to the ISO standards the parasitic consumption of a power plant should be between 2%- 9% of the output depending on the size and type of power plant.

### **2.8.3 Actual Efficiency**

The actual efficiency values for large Thermal Power Plants are within the 40% to 45% range. The actual efficiency is a function of several other factors that occur during the operations and maintenance phase of a power plant and is as a result of site conditions.

### **2.8.4 Factors Affecting Productivity in Thermal Power Plants**

The main factors affecting thermal productivity are deterioration and part load factors others will include labour, materials, Capital investments(installed capacity) and technology.

Deterioration factor is a function of maintenance procedures and designs, with sound (world class) maintenance plans and there implementation the deterioration of the plant will be minimal and this factor will be kept close to unity.

Part load factor is a function of maintenance and operations procedures with good maintenance and operations procedures that avoid part load production this factor can be kept close to unity.

It is important to not that when the engines are newly installed the Deterioration and part load factors are assumed to be unity.

Continuous monitoring and analyzing of productivity factors in power plant assists in maintaining part load factors to unity.

# CHAPTER THREE: RESEARCH METHODOLOGY

## 3.1. 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 District. 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.

## 3.2 Respondents

The proposed project targeted workers from different levels and departments that include: Management, Technical Personnel, Crafts Men, Casuals/Contractors and finally the Chief Executive Officers of both Institutions. Combinations of sampling methods were used to select people from management, technical departments, casuals, and contractors. Specifically purposive sampling was the main technique used to choose the people to be interviewed by the researcher, while cluster in combination with random and systematic methods was used to select the people to complete the questionnaire.

## 3.3 Data Collection

A combination of methods were used to source for information to establish the possible factors of productivity at each power station from different groups. Questionnaires, interview guides, group discussions and data from secondary sources. All these were

administered by the researcher. The questionnaire was used to determine the labour productivity factors and also determine the score level of all the other factors. The interview guide and personal observations by the researcher was used to determine all the other factors of productivity. The data developed enabled the researcher to determine the objectives, efficiency, effectiveness and progressive trends of each power station and eventually determine all the factors affecting productivity and how these factors can be managed to improve performance and productivity in thermal power generation stations.

### **3.4 Data Analysis**

Once the data was collected and gleaned it was subjected to various statistical techniques and processed into meaningful output results. Various methods were applied such as; descriptive and inferential statistics. A 95% confidence level was used to determine the mean score of each factor that affects productivity in the power station, from the sample mean and sample standard deviation of each factor. Bar charts were used to confirm the relationship between the productivity factors within the two power stations, With an aim of establishing the main factors that eventually affect efficiency and Net Electrical Output.



## **CHAPTER FOUR: DATA PRESENTATION, ANALYSIS AND INTERPRETATION.**

### **4.0 Introduction**

The data collected using questionnaires was analyzed using descriptive statistics and summarized in tabular form. This method was deemed appropriate due to the qualitative nature of the study. The data was then presented in the form of bar charts. The data analysis and presentation took into considerations of the objective of the study that focused on establishing the main factors that would affect productivity in a large thermal power generation station and how these factors can affect the productivity.

Using stratification sampling, followed by simple random selection, fifteen questionnaires were given out to selected groups at both Kipevu 1 and Kipevu 2 power stations. On a scale of one to five, each person would rate each factor proposed in the questionnaires and give a score ranging from five to one. Factor five being a score of extremely strong factors in the way it affects productivity in terms of time, cost and quality and one least important factor. The information was summarized in a table format for Kipevu 1 and Kipevu 2.

The score analysis was done separately for both Kipevu 1 and Kipevu 2 so that the comparison of the score on both power plants could be correlated. The mean score for the sample of each station was calculated and eventually the populations mean score was determined assuming a 95% confidence level. All factors with a mean minimum score

above 3 were considered and selected as strong factors that would affect the productivity of the plants.

#### **4.1 Factors Affecting Productivity**

15 questionnaires were administered at each power station by the researcher with 100% success. Using the information from previous research work in the literature review, 15 factors were identified as possible factors that would affect productivity. These were listed by the researcher and became part of the questionnaire. Each respondent was required to judge each factor and give it a score of 5, 4, 3, 2, or 1. 5 being an extremely strong factor that would affect productivity strongly in terms of time quality, and operations cost, a score of 4 means very strong factor, a score of 3 means a strong factor, a score of 2 means a weak factor (not a significant figure) and a score of 1 means no effect factor. The total score was then computed, in the table below and the mean score determined using the normal statistical methods. The standard deviation of each factor was computed to see the variability of the responses. Using the standard deviation, and mean score values for each factor, the population score was estimated for each factor using a 95% significant level. When the population minimum level is above a score of 3 then that factor is considered as a strong factor that would affect productivity.

##### **4.1.1 Population Sores at Kipevu1**

The sample means score for the cost of inventory at Kipevu1 is 3.8. This score suggests that cost of inventory is a strong factor, Using a 95% confidence level the mean score P

**Table 4.1 Kipevu 1 Score Table**

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
Capacity 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 team work	8	1	-	1	5	51	3.4	1.8
Qualifications	5	10			-	65	4.33	0.47
Management Style	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	0.82
Plant location	11	3	-	1	-	69	4.6	0.8
Plant Availability	15	-	-	-	-	75	5	0
Licensing & Govt. Regulations	10	5	-	-	-	70	4.67	0.47
150 Certification	4	7	4	-	-	60	4	0.73
Employment of experts	-	-	14	1	-	44	2.93	0.25
Equipment and Tools	10	5	-	-	-	70	4.67	0.47
Employment incentives	15	-	-	-	-	75	5	0

Source: Research Data

for the whole population at Kipevu 1 for this factor is given by the formula Population Mean Score  $P = X \pm Z (S/\sqrt{N})$ . 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  $P = 3.8 \pm 1.96 \times 1.05 / \sqrt{15} = 3.8 \pm 0.53$ . This means that the minimum score a member of the population can give on this factor at 95% confidence level is 3.27 which 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  $P = 4.33 \pm 1.96 \times 0.89 / \sqrt{15} = 4.33 \pm 0.45$ . 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  $P = 4.6 \pm 1.96 \times 0.88 / \sqrt{15} = 4.6 \pm 0.45$ . 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  $P = 4.73 \pm 1.96 \times 0.97/\sqrt{15} = 4.73 \pm 0.49$ . 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  $P = 3.6 \pm 1.96 \times 0.61/\sqrt{15} = 3.6 \pm 0.30$ . 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  $P = 3.4 \pm 1.96 \times 1.8/\sqrt{15} = 3.4 \pm 0.9$ . This means that the minimum score 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  $P = 4.33 \pm 1.96 \times 0.47/\sqrt{15} = 4.33 \pm 0.24$ . This means that the minimum score 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  $P = 3.27 \pm 1.96 \times 0.8/\sqrt{15} = 3.27 \pm 0.4$ . This means that the minimum score 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  $P = 3.33 \pm 1.96 \times 0.94/\sqrt{15} = 3.33 \pm 0.48$ . 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  $P = 4.33 \pm 1.96 \times 1.07/\sqrt{15} = 4.33 \pm 0.54$ . 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  $P = 3 \pm 1.96 \times 0.82/\sqrt{15} = 3 \pm 0.41$ . This means that the minimum score a member of the population can give on this factor 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  $P = 4.33 \pm 1.96 \times 0.8/\sqrt{15} = 4.6 \pm 0.40$ . 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  $P = 5 \pm 1.96 \times 0/\sqrt{15} = 5$ .

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  $P = 4.67 \pm 1.96 \times 0.47/\sqrt{15} = 4.67 \pm 0.24$ . 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  $P = 4 \pm 1.96 \times 0.73/\sqrt{15} = 4 \pm 0.37$ . 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 is a strong factor that will affect productivity significantly. The sample mean Score for

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

$P = 2.93 \pm 1.96 \times 0.25/\sqrt{15} = 2.93 \pm 0.13$ . This means that the minimum score 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  $P = 4.67 \pm 1.96 \times 0.47/\sqrt{15} = 4.67 \pm 0.24$ . 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 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  $P = 5 \pm 1.96 \times 0/\sqrt{15} = 5$ . 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.

## **4.2 Kipevu2 Data Presentation and Analysis**

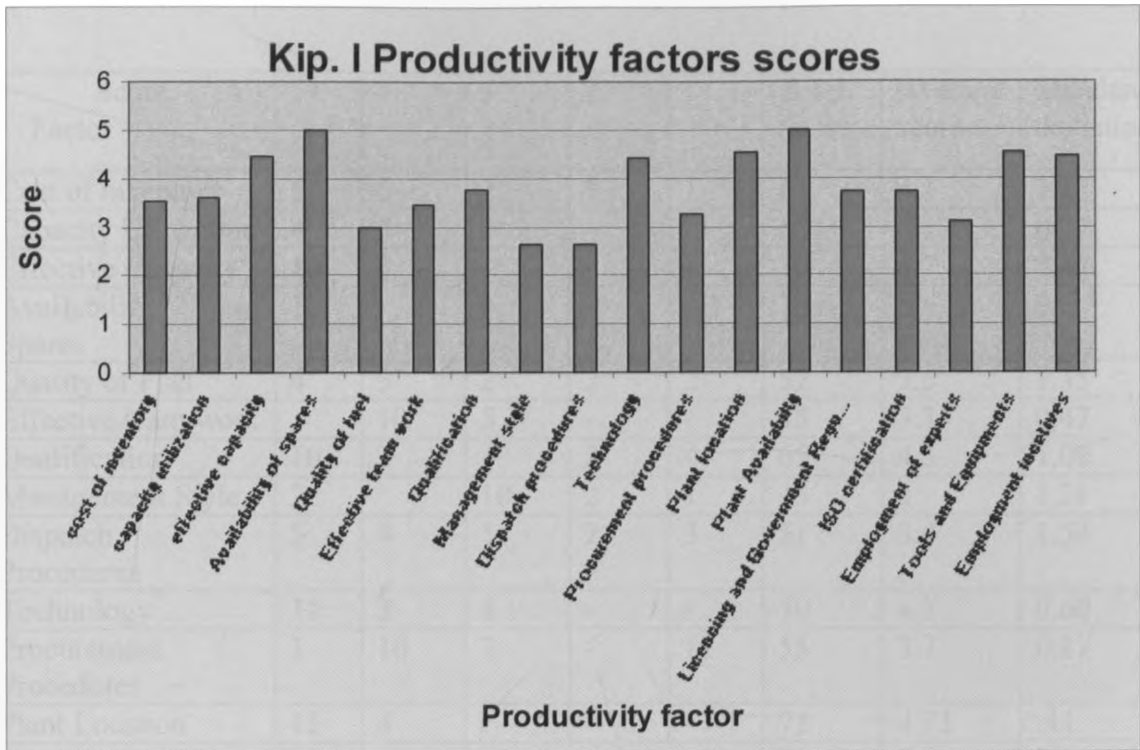
As was the case at Kipevu1, Using the information from previous research work in the literature review, 18 factors were identified as possible factors that would affect productivity.



**Table 4.2 Table of Population Factors Scores Arranged from the Strongest to the Weakest**

Score Factor	Average minimum score for the population at Kipevu 1	Level of Score
Plant Availability	5	Extremely strong factors
Employment incentives	5	
Licensing & Govt. Regulations	4.43	Very Strong factors
Equipment and Tools	4.43	
Availability of spares	4.27	
Plant location	4.2	
Effective capacity	4.15	
Qualifications	4.09	
Capacity utilization	3.88	Strong factors
Technology	3.79	
150 Certification	3.63	
Quality of fuel	3.3	
Cost of inventory	3.27	
Management Style	2.87	Insignificant factors
Dispatch Procedures	2.85	
Employment of experts	2.8	
Procurement Procedures	2.59	
Effective team work	2.5	

**Figure 4.1 Productivity Factor Scores**



These were listed by the researcher and became part of the questionnaire. Each respondent was required to judge each factor and give it a score of 5,4,3,2,or 1. 5 being an extremely strong factor that would affect productivity strongly in terms of time quality, and operations cost. A score of 4 means very strong factor, a score of 3 means a strong factor. A score of 2 means a weak factor (not a significant figure) and a score of 1 means no effect factor. The total score is then computed, in the table below and the mean score determined using the normal statistical methods. The standard deviation of each factor is computed to see the variability of the responses. Using the standard deviation, and mean score values for each factor, the population score is estimated for each factor using a 95% significant level. When the population minimum level is above a score of 3, then that factor is considered as a strong factor that would affect productivity.

**Table 4.3 Mean Scores and Standard Deviation for the 15 Respondents at Kipevu2**

Score Factor	5	4	3	2	1	Total Score	Average score	Standard deviation
Cost of inventory	5	6	2	1	1	61	4.1	1.17
Capacity Utilization	4	7	4	-	-	60	4	0.77
Effective Capacity	10	5	-	-	-	70	4.7	0.47
Availability of Spares	15	-	-	-	-	75	5	0
Quality of Fuel	4	5	2	2	2	52	3.5	1.35
Effective team work		10	5	-	-	55	3.7	0.47
Qualification	10	2	1	2	-	65	4.3	1.08
Management Style	2		10	2	1	45	3	1.21
Dispatch Procedures	5	4	1	2	3	51	3.4	1.54
Technology	11	3	1	-	-	70	4.7	0.60
Procurement Procedures	1	10	3	-	1	55	3.7	0.87
Plant Location	11	4	-	-	-	71	4.73	.44
Plant Availability	15	-	-	-	-	75	5	0
Licensing Govt. Regulations	11	-	3	-	1	65	4.3	
150 Certification	10	1	3	1	-	65	4.3	1.19
Employment of experts.	-	10	4	1	-	54	3.6	0.61
Equipment and Tools	11	4	-	-	-	71	4.73	0.44
Employment incentives	14	-	1	-	-	73	4.87	0.85

#### 4.2.1 Population Sores at Kipevu2

The sample mean score for the cost of inventory at Kipevu2 is 4.1. 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 2 for this factor is given by the formula, Population Mean Score  $P = X \pm Z (S/\sqrt{N})$ . 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  $P = 4.1 \pm 1.96 \times 1.17 / \sqrt{15} = 4.1 \pm 0.59$  this means that the minimum score a member of the population can give on this factor at 95% confidence level is 3.51 which is greater than 3. Therefore, this is a strong factor that will affect productivity significantly.

The sample mean score for capacity utilization is 4.0. 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 2 for this factor is  $P = 4 \pm 1.96 \times 0.77 / \sqrt{15} = 4 \pm 0.39$ . This means that the minimum score a member of the population can give on this factor at 95% confidence level is 3.61 which is greater than 3. Therefore, this is a strong factor that will affect productivity significantly.

The sample mean Score for effective capacity is 4.7. Using a 95% confidence level, the mean score  $P$  for the whole population at Kipevu 2 for this factor is  $P = 4.7 \pm 1.96 \times 0.47 / \sqrt{15} = 4.7 \pm 0.24$ . This means that the minimum score a member of the population can give on this factor at 95% confidence level is 4.46 which is greater than 4. Therefore, this is a very strong factor that will affect productivity significantly.

The sample mean score for availability of spares is 5. Using a 95% confidence level, the mean score  $P$  for the whole population at Kipevu 2 for this factor is  $P = 5$ . This means that the minimum score a member of the population can give on this factor at 95% confidence

level is 5 which is equal to 5. Therefore, this is an extremely strong factor that will affect productivity significantly.

The sample mean score for quality of fuel oil is 3.5. Using a 95% confidence level, the mean score P for the whole population at Kipevu 2 for this factor is

$P = 3.6 \pm 1.96 \times 1.35/\sqrt{15} = 3.6 \pm 0.68$ . This means that the minimum score a member of the population can give on this factor at 95% confidence level is 2.98 which is less than 3. Therefore, this is not a strong factor that will affect productivity significantly.

The sample mean Score for effective teamwork is 3.7. This score suggests that it is a strong factor. Using a 95% confidence level, the mean score P for the whole population at Kipevu 2 for this factor is  $P = 3.7 \pm 1.96 \times 0.47/\sqrt{15} = 3.7 \pm 0.24$ . This means that the minimum score a member of the population can give on this factor at 95% confidence level is 3.46 which is greater than 3. Therefore this is a strong factor that will affect productivity significantly.

The sample mean score for qualifications of personnel is 4.3. Using a 95% confidence level, the mean score P for the whole population at Kipevu 2 for this factor is  $P = 4.3 \pm 1.96 \times 1.08/\sqrt{15} = 4.3 \pm 0.54$ . This means that the minimum score a member of the population can give on this factor at 95% confidence level is 3.76 which is greater than 3. Therefore, this is a strong factor that will affect productivity significantly.

The sample mean score for management style is 3. Using a 95% confidence level, the mean score P for the whole population at Kipevu 2 for this factor is

$P = 3 \pm 1.96 \times 1.21/\sqrt{15} = 3.27 \pm 0.61$ . This means that the minimum score a member of the population can give on this factor at 95% confidence level is 2.65 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 3.4. Using a 95% confidence level, the mean score P for the whole population at Kipevu 2 for this factor is

$P = 3.4 \pm 1.96 \times 1.54/\sqrt{15} = 3.4 \pm 0.78$  This means that the minimum score a member of the population can give on this factor at 95% confidence level is 2.62 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 4.7. Using a 95% confidence level, the mean score P for the whole population at Kipevu 2 for this factor is

$P = 4.7 \pm 1.96 \times 0.6/\sqrt{15} = 4.7 \pm 0.3$ . This means that the minimum score a member of the population can give on this factor at 95% confidence level is 4.4 which is greater than 4. Therefore this is a very strong factor that will affect productivity significantly.

The sample mean score for procurement is 3.7. Using a 95% confidence level the mean score P for the whole population at Kipevu 2 for this factor is

$P = 3 \pm 1.96 \times 0.87/\sqrt{15} = 3.7 \pm 0.44$ . This means that the minimum score a member of the population can give on this factor at 95% confidence level is 3.26 which is greater than 3. Therefore this is a strong factor that will affect productivity significantly.

The sample mean score for plant location is 4.73. This score suggests that it is a strong factor. Using a 95% confidence level, the mean score P for the whole population at Kipevu 2 for this factor is  $P = 4.73 \pm 1.96 \times 0.44/\sqrt{15} = 4.73 \pm 0.22$ . This means that the minimum score a member of the population can give on this factor at 95% confidence level is 4.51 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 2 for this factor is

$P = 5 \pm 1.96 \times 0/\sqrt{15} = 5$  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 4.3. Using a 95% confidence level, the mean score P for the whole population at Kipevu 2 for this factor is

$P = 4.67 \pm 1.96 \times 1.19/\sqrt{15} = 4.3 \pm 0.6$  this means that the minimum score a member of the population can give on this factor at 95% confidence level is 3.7 which is greater than 3. Therefore, this is a very factor that will affect productivity significantly.

The sample mean score for ISO certification is 4.3. Using a 95% confidence level, the mean score P for the whole population at Kipevu 2 for this factor is  $P = 4.3 \pm 1.96 \times 1.19/\sqrt{15} = 4.3 \pm 0.6$ . This means that the minimum score a member of the population can

give on this factor at 95% confidence level is 3.7 which is greater than 3. Therefore, this is a strong factor that will affect productivity significantly.

The sample mean score for employment of experts is 3.6. Using a 95% confidence level, the mean score P for the whole population at Kipevu 1 for this factor is

$P = 3.6 \pm 1.96 \times 0.61/\sqrt{15} = 3.6 \pm 0.50$ . This means that the minimum score a member of the population can give on this factor at 95% confidence level is 3.1 which is greater than 3. Therefore, this is a strong factor that will affect productivity significantly.

The sample mean score for tools and equipment is 4.73. Using a 95% confidence level, the mean score P for the whole population at Kipevu 2 for this factor is

$P = 4.73 \pm 1.96 \times 0.44/\sqrt{15} = 4.73 \pm 0.22$ . This means that the minimum score a member of the population can give on this factor at 95% confidence level is 4.51 which is greater than 4. Therefore, this is a very strong factor that will affect productivity significantly.

The sample mean score for employees incentives is 4.87 Using a 95% confidence level the mean score P for the whole population at Kipevu 2 for this factor is

$P = 4.87 \pm 1.96 \times 0.85/\sqrt{15} = 4.87 \pm 0.43$ . This means that the minimum score a member of the population can give on this factor at 95% confidence level is 4.44. Therefore, this is a very strong factor that will affect productivity significantly.

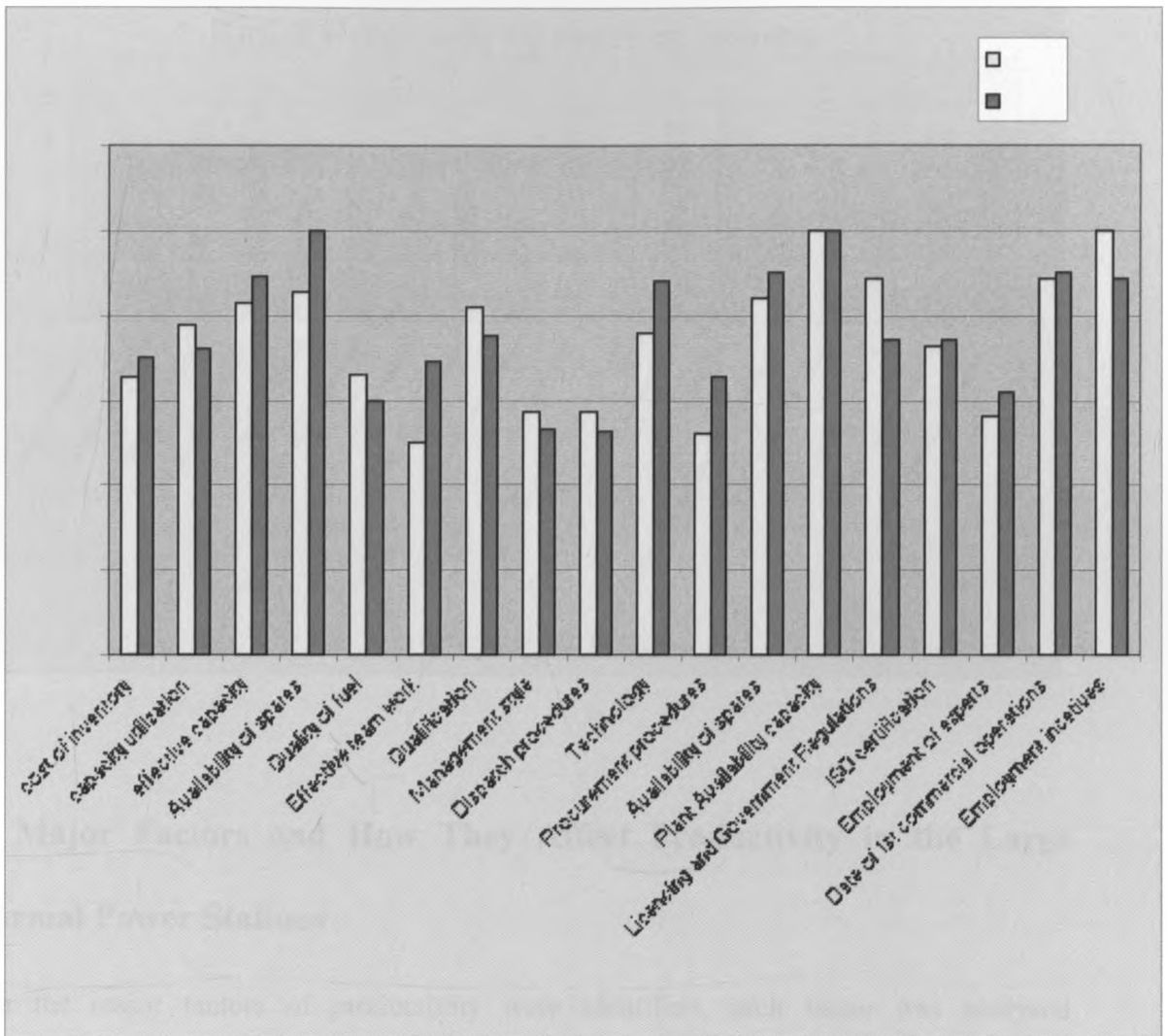


**Table 4.4 Population Factors Scores Arranged from the Strongest to the Weakest**

Score Factor	Average minimum score for the population at Kipevu 2	Level of Score
Availability of Spares	5	Extremely Strong Factor
Plant Availability	5	
Plant Location	4.51	Very Strong factors
Equipment and Tools	4.51	
Effective Capacity	4.46	
Employment incentives	4.44	
Technology	4.4	
Qualification	3.76	
Licensing Govt. Regulations	3.7	
150 Certification	3.7	
Capacity Utilization	3.61	
Cost of inventory	3.51	
Effective team work	3.46	
Procurement Procedures	3.26	
Employment of experts.	3.1	
Quality of Fuel	2.98	Insignificant factors
Management Style	2.65	
Dispatch Procedures	2.62	

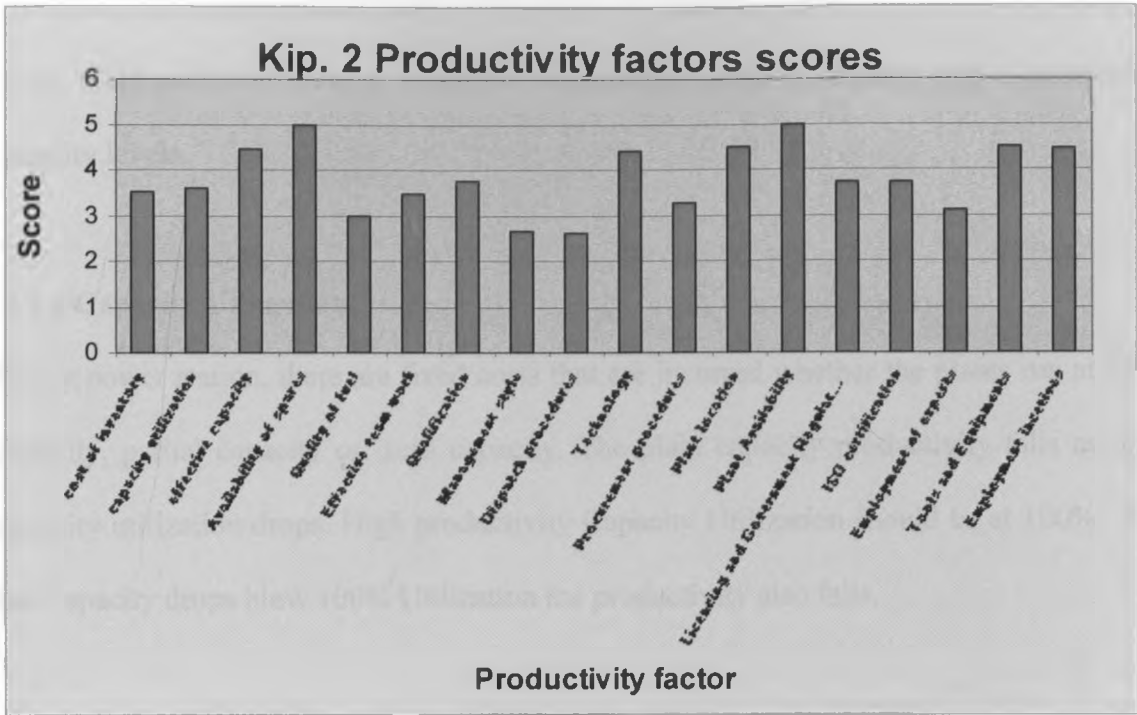
**Figure 4.3. Comparison of Kipevu 1 and Kipevu 2 productivity Factors**

Score:



From visual analysis of the bar chart, there exists a relationship in the scoring pattern for all the productivity factors at both Kipevu 1 and Kipevu 2 which are the only large thermal power stations in Kenya. Both are located near the port of Mombasa. Therefore, the factors identified are being said to represent the actual factors that can affect productivity in a large thermal power station.

**Figure 4.2 Kipevu 2 productivity Factors Scores**



### **4.3 Major Factors and How They Affect Productivity in the Large Thermal Power Stations**

After the major factors of productivity were identified, each factor was analysed individually to check on the effect it has on the overall productivity in reference to time, cost and quality of out puts:

#### **4.3.1 Cost of Inventory.**

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.

#### **4.3.2 Capacity Utilization.**

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 below 100% Utilization the productivity also falls.

#### **4.3.3 Effective Capacity**

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.

#### **4.3.4 Availability of Spares.**

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.

#### **4.4.5 Technology.**

Modern 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.

#### **4.4.6 Plant Location.**

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.

#### **4.4.7 Licensing and Government Regulations.**

A plant cannot operate unless all the licenses and government regulations are fulfilled. When the plant does not operate, then, productivity is zero.

#### **4.4.8 ISO Certification.**

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.

#### **4.4.9 Employment Incentives.**

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.

# CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS.

## 5.1 Summary

The objective of the research study was to determine the factors that would affect productivity in the large thermal power stations. The study went further to establish how these factors affect productivity in these power stations. All the factors that can affect productivity were identified using descriptive Statistics. The factors include: Cost of Inventory, Capacity Utilization, Effective Capacity, Availability, Licensing of Government regulations, ISO Certification and Employment Incentives. Measurement of all the factors could help to identify critical areas that can help improve performance.

Specifically, productivity measurements help in:

- i) Determining priorities in decision making.
- ii) Detecting problem areas and evaluating their importance on overall plant performance.

At the power stations, productivity should be continuously measured to help in improving effectiveness and efficiency. Productivity measurements also help in establishing realistic targets and check points for diagnostic activities during an organization development process, by pointing to bottle-necks and barriers to higher performance. From the findings in this project, it shows that higher productivity leads to higher efficiency.

## 5.2 Conclusion

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.

When these factors are monitored and controlled with respect to time, cost and quality the productivity levels can be improved and maintained at high levels as in the case of Kipevu2.



### **5.3 Recommendations**

The following recommendations have been made in the light of the study findings:

- 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.

### **5.4 Limitations.**

The research study covered only two thermal power stations, these are the only existing large thermal power stations in Kenya. Productivity analysis is a new concept in the thermal generation stations in Kenya, therefore making people understand its importance is extremely difficult. All the books about productivity literature could only be found at the Productivity Centre Library at the ministry of Labour.

### **5.5 Suggestions for further research**

Each of the Major factors identified can be observed over time to see how it would affect productivity with respect to time alone, cost alone, and quality alone when all other factors remain constant. A similar research should be done on medium size thermal stations.

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## **APPENDIX I**

Mwaka Mungatana

P.O. Box 95817

Mombasa.

Dear Respondent

### **REF: FACTORS AFFECTING PRODUCTIVITY IN THE LARGE THERMAL POWER GENERATION IN KENYA**

I am currently pursuing a course of Master of Business Administration at the School of Business University of Nairobi. It is a requirement to write a report as a partial fulfillment of the course. I am currently conducting the above mentioned research project.

The information you will provide in the questionnaire will be treated in confidentiality.

Please assist in filling in the questionnaire and provide other valuable information as asked by the researcher.

I thank you in advance for your cooperation and participation.

Yours faithfully,

Mwaka Mungatana.

**APPENDIX II**  
**QUESTIONNAIRE**

**Section A: Background Information**

1. Respondent Gender

Female

Male

2. Level of Education

None

Primary

Secondary

Tertiary (College)

University

Any Other \_\_\_\_\_

3. Technical qualifications

Craft

Technician

Engineer

Administration

Store

Any other \_\_\_\_\_

4. Average training opportunities attended in the last five years \_\_\_\_\_

5. a). Were you sponsored by the company

No

Yes

b). If No, specify the sponsor \_\_\_\_\_

**Section B 1:**

**The following is a list of factors related to your job. You are kindly requested to tick most appropriate number that best shows how important the factor is to the overall**

productivity of the plant.5 means the factor is most important and 1 the factor is least important.

Score Factor	5	4	3	2	1
Cost of inventory					
Capacity Utilization					
Effective Capacity					
Availability of Spares					
Quality of Fuel					
Effective team work					
Qualification					
Management Style					
Dispatch Procedures					
Technology					
Procurement Procedures					
Plant Location					
Plant Availability					
Licensing Govt. Regulations					
150 Certification					
Employment of experts.					
Date of 1 <sup>st</sup> Commercial expert					
Employment incentives					

**INTERVIEW GUIDE TO BE ADMINISTERED BY THE RESEARCHER**  
**PLANT STATISTICS/PRODUCTIVITY ISSUES**

**An Internal issues**

1. First commercial operation date \_\_\_\_\_
2. Total installed capacity (Mw) \_\_\_\_\_
3. Total number of engines installed \_\_\_\_\_
4. Make of engines \_\_\_\_\_
5. Inputs to engines (specify) \_\_\_\_\_
6. Capacity output during installation \_\_\_\_\_
7. Effective capacity of each engine in the last five years \_\_\_\_\_
8. Capacity utilization \_\_\_\_\_
9. Specific fuel consumption in the last five years \_\_\_\_\_
10. Monthly generation in the last five years \_\_\_\_\_
11. Are spares readily available      a). No [ ]                      b). Yes [ ]
- 12 Fuel Specifications defined and strictly followed
- 13 Is Heat rate performed and how frequent?
- 14 Which operations or activities have been out sourced?
- 15 a). Is the plant ISO 9,000 certified a). No [ ]                      b). Yes [ ]  
    b). If yes, when \_\_\_\_\_
16. Is the plant ISO 14,000 certified a). No [ ]                      b). Yes [ ]  
    b). If yes, when \_\_\_\_\_
- 17 . Have you been involved in any continuous improvement plans/process for the plant?  
    No [ ]                      b). Yes [ ]  
    b). If yes, how \_\_\_\_\_

**B External Factors**

1. Licensing and Government regulations
2. Payment Procedures for power generated
3. Dispatch arrangements with KPLC
4. Power Purchase Agreement in Place
5. Any other issues