THE INFLUENCE OF WIND POWER GENERATION ON DEVELOPMENT OPPORTUNITIES: A CASE OF NGONG AND MARSABIT WIND FIRMS IN KENYA

BY

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DECLARATION

This research project is my original work and has not been presented for academic award in any other university or academic institution.

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DEDICATION

I dedicate this research work to my daughter Undisa, my Wife Emma, who have been a source of joy and strength throughout my academic journey; they have encouraged me when the academic journey seemed to be tough and tough. Their prayers and love has brought me this far, my parents, Ndula and Mabiro and not forgetting my step mum Mmbone who have educated me in spite of the poverty situation we went through. I would like also to send my gratitude to my grandparents and siblings, who passed on a love for reading and respect for education. Not forgetting my friends who tearlessly encouraged me to take this course and soldier on even with the busy and demanding job schedule that I do have. I do pray that God's mercy should reign upon you and be blessed abundantly in all your undertakings.

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LIST OF ABBREVIATIONS

AC	Alternative Current
ADB	African development bank
ANOVA	Analysis of Variance
AWEA	American Wind Energy Authority /Association
BC	Before Christ
CWEA	Chinese Wind Energy Association
DC	Direct Current
DDPG	Direct Drive Permanent Generator
DDPM	Direct Drive Permanent Magnet
DDPMT	Direct Drive Permanent Magnet Technology
DFIG	Double Fed Induction Generator
ERC	Energy Regulatory Commission
ERCT	Electricity Reliability Council of Texas
GE	General Electric
GW	Giga Watts
GWEC	Global wind energy commission
GWh/yr	Gigawatt hour per year
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
IQPC	International Quality and Productivity Center
KENGEN	Kenya Electricity Generating Company
KPLC	Kenya Power and Lightening Company
KM	Kilometer
KM2	Kilometers Squared
KWH/M2/Day	Kilowatt Hour per Meters Squared per day
LTWP	Lake Turkana Wind Power
M/S	Meters per Second
MW	Megawatt
No	Number
PM	Permanent Magnet

PMG	Permanent Magnet Generator
PTC	Production Tax Credit
Q	Quarter/Quartile
REA	Rural Electrification Authority
REN	Renewable energy network
REN21	Renewable Energy Policy Network for the 21st century
SPSS	Statistical Program for Social Sciences
SWERA	Solar and Wind Energy Resource Assessment
UK	United Kingdom
UNDP	United Nations Development Programme
USA	United States of America
WB	World Bank
WREG	Wound Rotor Excitation Generator
WRDD	Wound Rotor Direct Drive
WT	Wind Turbine
WTG	Wind Turbine Generator
%	Percentage

ABSTRACT

This study aimed at investigating the influence of wind power generation on development opportunities: A case of Ngong and Marsabit wind firms in Kenya.

Global and regional literature revealed that quality and quantity of wind power produced (power ration, blackout, power surge, equipments used, production), market demand/consumption (no. of connection, inquires for connection, alternatives, awareness, literacy level), accessibility of the power to the customer/market (distance, transmission media, available infrastructure) are important determinants of development opportunities (reduced insecurity, employment, good infrastructure, improved living conditions, enhanced education) from wind energy generation projects. These factors were evaluated by this study for the case of Kenya.

Causal and descriptive designs were followed to conduct a survey from 275 heads of households from Ngong and Marsabit regions and other stakeholders (heads of wind energy at Kengen and Kenya Power) selected using stratified random sampling method. Qualitative and quantitative techniques were followed in analyzing the data.

Results revealed that wind firm generation results in development opportunities for both Ngong and Marsabit. But one key determinant of location of such projects is the speed of wind and we suggest that government should plan to exploit wind in wind intense areas, especially North and Upper East of the country. Other factors constraining development of wind and other renewable energy include demand and inertia of the Kenyan grid. This also needs to be enhanced through initiatives that elevate purchasing power of citizens, developing energy infrastructure and interconnecting with neighboring states (Tanzania, Uganda, Zambia, Rwanda, Burundi, Ethiopia and Sudan) in the long term. Finally, wind is seen to be one among other crucial forms of energy – like geothermal and solar – which Kenya can focus on in the coming days. Relevant government ministries should develop a business operating environment that is conducive for private sector investment in wind and other renewable forms of energy.

CHAPTER ONE

INTRODUCTION

1.1 Background of the study

It can be said that wind power is not a new phenomenal in the history of Kenyan energy sector. Wind power has been used since the coming of the white settlers. Although wind power had not been given a lot of emphasis world wide it was still used at domestic level for pumping water from wells to be used in irrigation, electricity generation, supplying livestock with water and other domestic use (Doig, Rees, Anderson and Khennas, 1999). Example being that we have close to one million mechanical wind pumps in Argentina and more than three hundred thousand all over the world, South Africa taking the lead (REN21, 2005). With the crisis emanating from the shooting oil prices, the global warming and the emission of the green house gases the world had to rethink on how to cut down the crisis from these effects, and thus the recommendation of using green energy (renewable energy) came into force. Most of the electrical energy does come from fossil fuel and with their limitation the future world will face fuel crisis/catastrophe (IEA report, 2009).

Most countries thus started developing their green energy capacity and putting more effort on the wind energy which is said to be in abundance and environment friendly. The commercialization of wind energy technology has grown tremendously than other technologies like wave/tide power, fuel cells and solar power, still with less expenditure in research and development (Paul & Hendry, 2009). It is being encouraged that each country should have at least twenty percentage of its total energy consumption coming from renewable energy (wind power being a major player). According to Fridleifsson (2001) it is expected by 2100 the renewable energy sources will have tremendously increase (30-80 %). Thus, most countries have come up with policies on how to implement the twenty percent requirement in their national grids. Policies like trading systems, tax credits, pricing laws have been adopted to champion the use of renewable energy (Kisse & Krauter, 2006), the main agenda being to reduce overdependence on fossil fuels, cutting on environmental impacts from the energy industry and steering new industrial technological developments (Lipp, 2007). In a recent survey carried out by the international quality and productivity center (IQPC), 2754 energy sector respondents were sampled, 64.28%

of the sampled populations agree that wind energy is the sole principle to meet Africa's growing energy demand.

By June 2010, the world production of wind energy had exceeded 180GW, the global wind energy council had predicted that the world production will be at 200GW by the end of 2010, this shows that the amount of energy produced from wind is increasing at a high pace; this is so as a result of the total commitment of the highly industrialized countries who are taking a lead in the consumption of energy. Steve sawyer the secretary general of GWEC emphasis on the growth by saying "as wind power becomes very competitive, it is rapidly expanding beyond the traditional markets in North America and Europe. In fact, around half of the growth is now happening in emerging economies and developing countries". China's double digit economic growth has had a huge implication on china's energy consumption and environmental impact for the past two decades (Martinor, 2001). This can be seen by the ranking of China as the world second carbon emitter (environmental polluter) just after the US (Sinton & Friday 1999, 2000). Thus, china may be one of the worst impacted countries in the world if climate changes as had earlier been predicted (Zeng, Ding, Pan & Wang, 2008). The cited example being global warming could make China's agricultural output reduce by (5-10%) by 2030 (IPCC Climate Change, 2007).

Currently China has overtaken the United States of America in wind power production and thus being called the wind power base. In China wind resources are found in the northern part stretching from Xinjiang autonomous region through Gansu Province to Imar, and in the southeast, along the coastline (Lew, 2000) which has been estimated to have a potential exploitation of 253GW (Dai & Twidell, 1988). By the end of 2011 it is projected that China will have installed a capacity of more than 55GW while the United States of America (USA) will have installed more than 45GW. In early 2009 the US had close to 28GW of wind power from 2.5GW they had in 1999 (AWEA 2009 PTC report). In Kenya, wind power resources can be termed as mature and viable source of renewable energy for commercial engagement, but there is little experience in using wind power energy. Further research have shown that close to 4 million households live in areas with wind speed of 4m/s and below which are considered as low wind power potential, close to 2.5millions households stay in areas with wind speed of 4-7m/s which is considered to have good potential for wind power and 130 thousand households staying in areas with wind speed more than 7m/s which are considered to be areas with excellent wind power potential. From these demographic patterns it can be seen that there is room for development of large commercial viable wind farms as there would be less or minimum human interference in Kenya.

Kengen which has the responsibility of developing and harnessing energy for the nation has started a wind firm in Ngong which currently is producing 5.1MW of wind power for the initial first phase, plans are underway for the second and third phase (6.8MW and 13.6MW respectively) which will see the wind firm producing a total of 25.5MW (Ministry of Energy Kenya, 2010). Wind energy has also attracted the private sector section (isolated/independent power plants) and they are planning to inject 610MW of wind power to the market, (300MW to be produced by Lake Turkana, 100MW to be produced by Aeolus Ngong wind, 60MW to be produced by Osiwo Ngong wind, 60MW to be produced by Aperture Green Ngong wind, 60MW to be produced by Aeolus Kinangop wind and 30MW to be produced by Daewoo Ngong wind) currently a lot of efforts are placed on local production and marketing of small wind generators (Ministry of Energy Kenya, 2010) . The government is putting a few pilot projects for the same under considerations. Some research done shows that, the best wind sites in Kenya are Marsabit, Ngong hills, parts of Laikipia, Nyandarua, Meru north, Nyeri and Samburu. Other areas that have shown some interesting wind patterns include; Lamu, Offshore of Malindi, Narok plateau and Loitoktok at the foot of Kilimanjaro. Various research studies related to wind energy resources and its development have been carried out in various parts of the world. El-osta and Califa (2003) carried out a feasibility study for a wind firm of 6MW capacity in Tripoli, Libya, and Zwara. Their result showed that the project was viable. Moran and Sherrington (2003) carried out a study on the economic viability of large scale wind farm project in Scotland. Krokoszinski (2003) conducted research on the efficiency and effectiveness of wind farms development. The outcome of the project showed that the operations and maintenance cost was the key to the economic feasibility of large offshore wind farms planned over the world. Marafia and Ashour (2003) carried out an economical feasibility study and assessment of the potential of off-shore/on-shore wind energy as a renewable energy in Qatar and the results of the study indicated the suitability of utilizing small to medium-size wind turbine machine. In Kenya no major research has been done on the development of wind power energy and thus, a need to carry out more research in this field of renewable energy.

Currently, a lot of fund is put in further research on various ways of efficiently harnessing of wind energy as a source of green/renewable energy in the world. The aims of this research it to see various development opportunities that can be provided by wind power production or generation in Kenya a case in point being Ngong wind firm. In Kenya some of the research that have been undertaken in wind energy as a source of green/renewable energy include; design for windmills for Kenyan market (Hilton and Chipeta, 1974), Potential of wind power resources in Kenya (Golding and Denton, 1950s and 1960s), Research proposal on wind energy in Kenya presented in a conference in Arusha Tanzania in September 1979 (Opondo and Carson, 1978) Improving the efficiency of windmills (Misango, 1985). All these research looked at wind production not at commercial level but at domestic level, thus the need for more research on wind power at commercial level.

Notwithstanding all the benefits about wind power needless not to say that this section of renewable energy also experience some challenges although wind power has been advocated as environmental friendly it has some impact on the ecosystem by killing flying birds and bats although this impact on wildlife is considered to be low, the proponent of wind power, claims that birds still hit even stationary objects and thus their case need more considerations and consultation (Langston & Pullan, 2003). On the other hand, it is argued that bats have advantage over birds because they do not hit/collide with stationary rotors of wind turbines (Kerns *et al.*, 2005). The second challenge is visual impairment at a range of 2km-8km this makes the wind turbines appear in otherwise structure less landscape thus could cause accidents to flying objects (Henderson *et al.*, 2001). The third challenge can be seeing as the aerodynamics noise produced by the turbines and the moving shadow being thrown by the turbines, this noise (whooshing, sizzling, and buzzing) depends on the model/type of the turbine being used and the wind speed (Albert, 2006). Last but not least, most of the sites for wind farms are located in areas that are remote and thus pose a challenge for developing of infrastructure and the transmission line for the power generated to reach the consumer and this makes the initial cost of bringing up a wind farm to be very expensive. This research is aimed at seeing the opportunities that can be explored with now wind power being produced at commercial level.

1.2 Problem Description

This section is divided in two parts, first dealing with background of the problem and second statement of the problem.

1.2.1. Background of the problem

In Kenya, the vision 2030 has got three pillars that will help in the realization of a middle class country by 2030. This blue print covers a duration of 32 years starting 2008, the three pillars include; economic pillar, political pillar and social pillar, the entire three pillar should create a conducive environment for the country vision to be realized. Under the economic pillar which is our area of focus in this research area, efficient energy production is mandatory. in Kenya energy cost are far high than its competitors in the neighboring region thus for Kenya to attract more investors in the country it has to produce more power at lower cost and thus boost its developmental agenda. This will reduce the cost of production and thus attracting more investors both local and foreigners. The sessional paper no. 4 of 2004 on energy recognizes and emphasizes on affordable, quality and cost effective energy services as a prerequisite of attainment of accelerated social economic growth and development. Thus to reduce the reliance of thermal energy and hydro energy which is more expensive the ministry of energy under its sole producer Kengen has ventured into renewable energy which is cheap and environmental friendly.

As per the current statistics hydro and thermal energy account for close to 80% of the total power produced in Kenya and thus making it very expensive because of the huge investment required to run and maintain the power generation plants (Kengen/energy ministry Kenya). The area of interest in renewable energy which the government is putting a lot of emphasis and several infrastructure has been put in place or are still being put into place to harness the enormous energy required to propel the nation to a middle level class of citizen, wind energy, solar energy, nuclear energy, and geothermal energy. As the global warming effect and the greenhouse gases effects are being felt all over the world it is becoming a requirement for all nations to establish a given percentage of the green energy into their national grid and thus Kenya is no exceptional.

1.2.2. Statement of the Problem

Wind provides cheap power compared to other sources of energy (hydro and thermal being an example for comparison). Wind is in abundance in Kenya hence is one of the renewable energy in which the government is making vast investment plans. Unfortunately, literature is lacking on research findings on how wind power generation affects development opportunities thus this research aim is to reduce the gap that do exist on the literature regarding development opportunities brought about by wind power generation, which is the aim of this study.

1.3 Purpose of study

The purpose of this study was to establish the various development opportunities brought by wind power generation with a focus on Ngong and Marsabit wind firms in Kenya.

1.4 Objective of the study

The research was guided under the following objectives to:

1. Establish whether the quality and quantity of wind power generation influence development opportunities.
2. Determine how development opportunities are affected by customers wind power consumption/demand (awareness & knowledge level).
3. Investigate how customer accessibility to the wind power generated relates to development opportunities.

1.5 Research questions

The research was taken under the following questions as guideline

1. How does the quality and quantity of wind power generated influence development opportunities?
2. What relationship exists between the consumption (demand) of wind power generated by customers and development opportunities?
3. To what extent does customer accessibility to wind power generated, affects development opportunities?

1.6 Significance of the study

Wind power is becoming a worldwide phenomenal that has wide interest in the energy sector all over the world. Because it is readily available and non-exhaustive it is believed to be the most environment friendly source of energy and thus making the advocacy for the environment to strongly recommend it as a source of cheap renewable energy. This study looks at the benefit of the wind energy in the development of the economy and how the surrounding community benefit from wind power generation a case tabled being Ngong and Marsabit wind firms where Kengen is already harnessing more than 5MW from the said wind firm. This study will help also in the planning of energy harnessing and distribution by various players and stakeholders in the energy industry. Furthermore the study will educate the common public on the high potential of wind power in the country and thus enlighten the general public on the cheap power that can also be tapped at individual level and be used at home in area with good wind speed. In Kenya less has been done in wind energy it's a new technology that is taking momentum and thus we believe this research will give a detailed account of wind energy in the country and thus an avenue for further research on wind power generation.

1.7 Description of Study Areas

Kajiado County is at the southern tip of the former rift valley province. It is bordered by Kiambu County (to the north), Narok County (to the west), Taita Taveta County (to the south east), Machakos County (to the east), Nairobi County (to the north east) and Tanzania (to the south west) through the border town of Namanga. It has an area covering 21,105 square kilometers (km^2) and a population of more than 400,000 according to 1999 population census report. Kajiado North District which is part of the said Kajiado County has a population of 387,583 according to 2009 population census report. Ngong Division which is in Kajiado North District has a population of slightly above 237,000 and covering an area of 716.7 square kilometers according to 2009 population census report. Kajiado landscape consists of plains and some volcanic valleys and hills which are characterized by long dry spell which make it to be designated as semi-arid. Kajiado County has attractive sites which include Amboseli game reserve, Lake Magadi, Chulu hills and Ngong hills in Ngong Division which is the focus of this study.

In the Ngong Hills, Vestas, a Danish company has already put up six 50m turbines which added 5.1 MW to the national grid from August 2009. The work started in January the same year with another dozen turbines to be added at the site in the next few years. The Dutch consortium behind the Lake Turkana Wind Power (LTWP) project has leased 66,000 hectares of land on the eastern edge of the world's largest permanent desert lake.

Marsabit is a town in northern Kenya, located 170 km east of the center of the East African Rift at 37°58' E, 2°19' N (37.97°E, 2.32 N). It is located in the Eastern Province and is almost surrounded by the Marsabit National Park and Reserve. It serves as the capital of Marsabit District, and lies southeast of the Chalbi Desert in a forested area known for its volcanoes and crater lakes. The town of Marsabit is an outpost of urban civilization in the vast desert of northern Kenya. The town is situated on an isolated extinct volcano, Mount Marsabit, which rises almost a kilometer above the desert.

The hills here are heavily forested, in contrast to the desert beyond, with their own "insular" eco-system. The North West of the country (Marsabit and Turkana districts) and the edges of the Rift Valley are the two large windiest areas (average wind speeds above 9m/s at 50 m high). Kenya's second wind power generator, Gitson Energy, plans a 300 megawatts (MW) wind farm in Bubisa, Marsabit and a further 50MW from a solar project in the same area. Lake Turkana Wind Power's line will be a 428 km long 400 kV Double Circuit line from its site to Suswa, about 100 kilometres from the capital Nairobi at a cost of Sh14 billion. Gitson Energy's is a 200 kilometres transmission line from Marsabit to link to the one for Lake Turkana line. Thus Marsabit forms an excellent second spot on which data on development impacts of wind energy generation will be felt by the surrounding community.

1.8 Limitation of the study

As stated earlier in the subtopic, area of study; the population of the two regions under study is too big that may not be economical to study the all population, thus a sample of the target population was taken and made to be true representative of the target population. Secondly, the road network is not good and thus can prove to be challenging and impassible during rainy season thus it is recommended to carry out the project in the sunny season or weather. Financial constrain due to the higher inflation rate we are facing in the country and thus it is important to work within the budget. Most of the occupant in the region are masaai's who are pastoralists and most of the population is uneducated thus may cause some language problems, thus need to use the language that is comfortable with them (mother tongue). High rate of insecurity in the region may also present a big challenge to the study and need for arrangement for provision of security services at a fee from the security forces.

1.9 Assumptions of the study

It was assumed that the sample used in the research project was the true representative of the target population, and thus the sample population chosen would be willing and voluntarily participate in the research project and upholding the research ethics of being honest in their response and be able to understand the questions in the various research instrument used and respond to them objectively without biasness or prejudice. That most of the questionnaires if not all will be answered correctly and truthfully and returned back on time as per the planning of the research project team. It was also assumed that the entire data collection instrument to be used in the research project will be valid and reliable and thus be able to measure the desired constructs as per their design. Last but not least it was also assumed that (after being briefed on the aim of research) the respondent will fully understand that this work is fully academic and is not going to be used to degrade their economic and social status in any way or enrich the researcher at their expense.

1.10 Definitions of significance terms

Development opportunities: benefits that come along with the production of electricity from wind (enhanced education, good infrastructure, reduced insecurity, better living conditions)

Wind power generation: electricity produced from wind (moving air) and used either domestically or on commercial scales.

Wind energy: power/electricity tamed from moving masses of air.

Wind policy: these are rules or guidelines that directs or spearhead the growth of wind power in a region, country or worldwide.

Wind turbines: these are machines (generators) that are used to convert the kinetic energy in moving air (wind) to electricity which is in turn used for various purposes (lighting, cooking, and heating and other domestic/industrial use).

Windmills: small machines that are driven by wind, and were mainly used to draw water from wells, aid in sailing of ships, rural home lighting and other related domestic chores.

1.11 Summary

The chapter introduces the reader under the background of the study to renewable energy and wind power being the subject of the research has taken a considerable share in the world as we fight with the repercussions of the global warming and the effect of the green house gases in the entire planet. The chapter looks at the history of wind power in details from the various places surrounding the globe and how wind power has grown to date. The chapter also looks at the statement of the problem of the study, the purpose of the same study, its objectives, the questions guiding the research, the importance of the already mentioned research, the delimitation and the limitation of the study, the assumptions made during the study and finally the definitions of the significant terms and abbreviations used in the research project. We hope the readers will be varnished with relevant, authoritative and detailed information about the research topic from this arrangement.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

In the era of human kind it can be said that the invention of energy (fire) was the greatest invention and a big advancement in the technological world. Human being uses various forms of stored energy every day for various energy requirements. Each kind of energy has got its source, for example, paraffin comes from crude oil, firewood comes from trees, and mains electricity comes from geothermal plants, hydropower stations or diesel run generator plants. Energy can be constantly be replaced as it is being used or constantly being depleted as they are being used. Thus, we can say energy is grouped into two categories that are renewable energy and non-renewable energy, sometimes referred as conventional or alternative energy (Rathore & Panwar, 2007). In the year 2007, it had been estimated that the renewable electricity generation capacity would reach a high of 240GW worldwide that being 50% increase from 2004, and the reason behind this increase being environmental awareness and technological advancement (Renewable Global Status Report, 2008). In the same year wind power had reached a record 94.1GW, with an addition of 20GW for the year 2007 (Dorn, 2008).

2.2 Non renewable sources of energy

They include fossil, nuclear power and some types of geothermal power. Fossil fuels are made of carbon compounds from organisms which have ceased to exist. It dates back to several thousand years, due to the changes in the structure of the earth surface these fossils (biomass) are under high pressure and changed into petroleum compounds. Geothermal power is heat energy obtained from the mantle of the earth stored underground at high temperatures which is tapped and used to drive turbines which in turn produces electricity. This steam can also be used to provide heat for drying or other industrial purposes. Geothermal energy can only be tapped in certain areas where there has been history of volcanic activities. Nuclear is harnessed from the nucleus of some radioactive element like uranium which is the raw material for nuclear energy. Nuclear power plants produce immense amount of electricity but the technology involved is very expensive and thus not affordable by mostly developing countries this type of plants produce hazardous radioactive substances which is difficult to dispose and thus not environmentally friendly.

2.3 Renewable sources of energy

Fourteen percentage of the world energy demand is supplied by renewable energy (UNDP, World Energy Assessment, 2000). All renewable energy can be traced back to the sun because the sun powers all the weather cycle on the earth. The constant various forces that work on/in our environment results in renewable energy, for example the rain water in gauges, streams, springs water fall moving down the hill have immense power which is released on their trip to lakes and oceans. Tree and crops capture a lot of energy through photosynthesis and stores them in form of chemical energy in wood and food crops. The direct sun rays from the sun which is directed to the earth and felt as heat. The sun heating also causes difference in air density (heating and cooling of the earth atmosphere by the sun) which causes movement of high energy wind. Biomass energy is high energy sugars stored in organic material; examples of biomass fuel include animal waste, wood and charcoal. Solar energy comes from solar radiations that falls on earth surface and heats it thus producing energy. Countries that are located on the equator have greater potential of solar energy. Hydropower is also equally important source of renewable energy; the water circle has got great potential of energy. The sun heats water in seas, lakes, and oceans which evaporates to form energy stored in clouds which then condenses in the form of rain water and falls down back to the sea, lakes and the oceans. This moving water has great energy which can be harnessed in huge applications. More than twenty percentage of world electricity is produced by major scale hydropower stations (UNDP, World Energy Assessment, 2000). Wind energy is formed as a result of the movement of the atmosphere when uneven heating and cooling of the earth surfaces occurs, due to the expansion and warming of the atmosphere on the side that is heated by the sun rays and the contraction and cooling of the atmosphere on the dark side of the earth that is not heated by the sun rays a stream of air masses (heating and cooling air masses)interact on the oceans and continent which in turn produces moving currents of air which contain large amounts of energy. We will concentrate more on wind energy because it's our area of interest for this research project.

2.4 Kenya's natural resources

2.4.1 Hydro resources

The total electricity generated in Kenya, 50% comes from hydro resources (Ministry of energy Kenya 2010). It is estimated that Kenya hydro resources has a capacity of close to 3000-

6000MW of which only slightly above 750MW has been exploited. It is estimated that 1449MW of hydro power is untapped, currently we have major five hydro stations namely Tana Basin (570MW), Athi River Basin (84MW), Lake Victoria Basin (295MW), Rift Valley Basin (345MW), Ewaso Ng'iro North River Basin (146MW). The table below shows the major hydro potential in Kenya

2.4.2 Major hydro potential

Table 2.1 Major Hydro Potential

River basin	Potential capacity (MW)	Average energy (GWh/yr)	Firm energy (Gwh/yr)
Tana	570	2490	1650
Lake Victoria	295	1680	1450
Ewaso Ngi'ro North	155	675	250*
Rift Valley	345	630	300*
Athi Basin	84	460	290

Source: Kenya National Power Development Plan (1986-2006), *Estimates

2.4.3 Geothermal resources

In Kenya, geothermal systems have been associated with the volcanism and faulting which has been active in the east African rift. Some of the geothermal prospects that have been identified in Kenya include; Namarunu, Lake Baringo, Korosi, Paka, Suswa, Longonot, Olkaria, Eburru, Arus-Bogoria, Lake Baringo, Lake Magadi, Badlands, Silali, Emuruangogolak, Menengai, Olkaria and barrier geothermal prospects. Extensive researches have been carried out by the government through the ministry of energy, Kengen and other development partners, World Bank (WB), African development bank (ADB) on some of the promising geothermal prospects and the result received were encouraging, the results showed that 4000-7000MW can be generated from the high temperature resource areas in Kenya.

2.4.4 Coal reserves resources.

Mui basin in Kitui and Mwingi districts have potential of producing coal similar to the one in South Africa used for generation of electricity. The government is currently undertaking coal exploration in the following areas; Zombe, Kabati, Itiko, Mutitu, Yoonye, Kateiko, Isekele and Karunga sub-basins all found in Mui basin which is roughly 500 square kilometers. The government has contracted some experts in coal exploration to investigate the quality, quantity and commercial viability of the project in Mui Basin, there also plans to engage the private sector developers to take concession in some of the sub basin. Taru basin in Kwale district has also the potential of coal exploitation.

2.4.5 Biomass resources

Wood use in Kenya account for close to 70% of the total primary energy consumption thus putting biomass as the most widely used form of energy in Kenya. Biomass resources come from closed forest, animal waste, municipal waste, agricultural industrial residues, farmlands, bush lands, woodlands and plantations. This shows that their exist substantial potential for electricity generation using the available biomass resources such as animal waste for agro based industries, baggasse from the sugar industries (Mumias sugar has already implemented) and municipal waste from the local authority, this can be used or utilized locally or be exported to the national grid for national consumption.

2.4.6 Solar resources

The strategic location of Kenya on the global map (located near the equator) makes it prime for harnessing of the solar energy. The insulation level is estimated to be 4-6KWH/M2/day. Currently most of the solar energy is used primarily for lighting and powering television sets which represent close to 1.2% of households in Kenya. At this point solar energy has not yet been exploited commercially, but with the trend of the rising oil prices and the continuous emission of pollutants to the air, solar energy is among the renewable energy that will play a crucial role in fulfilling the world energy demand.

2.4.7 Wind resources

Currently, we have three operational wind generating firms, two are in Ngong (supplied and installed by Vestas Denmark world leader in manufacture of wind turbines) owned by KenGen with a total capacity of 5.45MW and one in Marsabit (supplied and installed by Vergent France who are the world leaders in the manufacture of mid-scale wind turbines) owned by Kenya Power and Lightening Company with a total production of 0.55MW. Proposals have been made for additional wind farms with a production capacity of 625MW as shown in the table below.

2.4.8. Potential wind firms/plants

Table 2.2 Potential wind firms/plants

PLANT/FARM	CAPACITY(MW)
Lake Turkana Wind	300
Aeolus Ngong Wind	100
Aperture Green Wind	60
Aeolous Kinangop Wind	60
Osiwo Ngong Wind	60
Daewoo Ngong Wind	30
KenGen Wind	15
TOTAL	**625**

Source: Kenya National Power Development Plan (1986-2006)

2.5 History of wind power (energy) in the world

Wind power has been in use since ages, but it got more emphasis in the 20th century. Our fore fathers used wind power for various activities, this include grinding, sailing, drawing water from wells, and furthermore irrigation purposes. In the history of mankind dated back 2000 BC the Babylonians and Chinese used wind power for irrigation of their farms for agricultural produce. For many years the United States of America has been using wind power not only for irrigation but also for other farming activities in their firms and ranches. Sailing boats and ships have been using wind power for over 5000 years; the Egyptians were the inventers of the wind powered sail ships and boats at around 3600 BC, which has been the primary source of human transport using water. The Egyptians also used wind power to grind corn and irrigation.

During the era of heron Alexander, wind power was used to blow a musical organ and also drive a wind wheel which was the first machine to be known as driven by wind power. The Persians also at around this period used wind power to irrigate their farm produce and ground corn. At around 2000 BC and 1500 BC the Mesopotamia plains were irrigated using wind power by the Hammurabi as the available literature details. In the 11th century Middle East had a lot of its food production from wind power. The Dutch made their own wind mills for drainage of lakes, marshes and seabed and in turn the land is used for farming and food produce to cater for their agricultural needs. Travelling was revolutionized by sailing boats thus the Romans and the Greeks could expand and spread their culture across the Nile region, the Mediterranean Sea and beyond; all this was possible because of the wind power. In Baghdad and Abbasid palace wind power was used to turn around statues at the gates of the palace and the entire palace region, which were believed to be pointing at the enemy and scare the enemy away (Doig, Rees, Anderson and Khennas, 1999).

At around 3200 BC, the Romans had huge fleet of ships that could carry several tons of cargo and a number of passengers, this fleet used wind power. The inventers of windmill as per available literature are the Chinese at around 200BC. At around 1200 BC to 1500 BC wind power was also being used in France and England for irrigation purposes and feeding the water fountains. It was believed that the crusaders who were coming back to Europe from Asia are the ones who came back with the idea of wind power after seeing what was happening in Asia and Far East. Still Europe was already in the wind power industry but with a different model of wind mill not similar to the ones in Middle East or Far East (Park, 1981). The first horizontal shaft windmill was introduced by the Dutch in the 12th and 13th century and was used in grain grinding, pump water and used in to operate sawmills in the medieval period (Park, 1981). In Holland wind power was used to drain land below sea level and convert the land for agriculture, a new dimension was seen in Netherlands when wind power technology was advanced from the usual wind mill to wind turbines or generators this was a breakthrough in the wind power industry.

Wind power was also introduced in Germany and Italy in the 14th century, and 16th century in Spain. Wind power was also used in sawing wood, extracting oil, grinding stones and in paper making, for many years the wind power has been used on Greek islands like the Rhodes and Crete in pumping water. In America the English people were the ones responsible with the introduction of wind power in the 17th century. Wind power in America can be traced many years back even before the discovery of the known grate continent we can trace wind energy history from the days of the Columbus when they used wind power in their tobacco farm and sugar plantation. The American ranchers who used to live on the prairies of Kansas and Nebraska used wind power to get water for irrigation and animal use in their various lands. During the American Revolution, wind power was used to pump water for salt making in the Cape Cod and Bermuda Island. In the American mid-west arid areas and the Australian outback, wind power was used to provide water for livestock and steam engines. As we have seen wind power has been in existence for several centuries, although there was no adequate physics to explain what was happening in those eras.

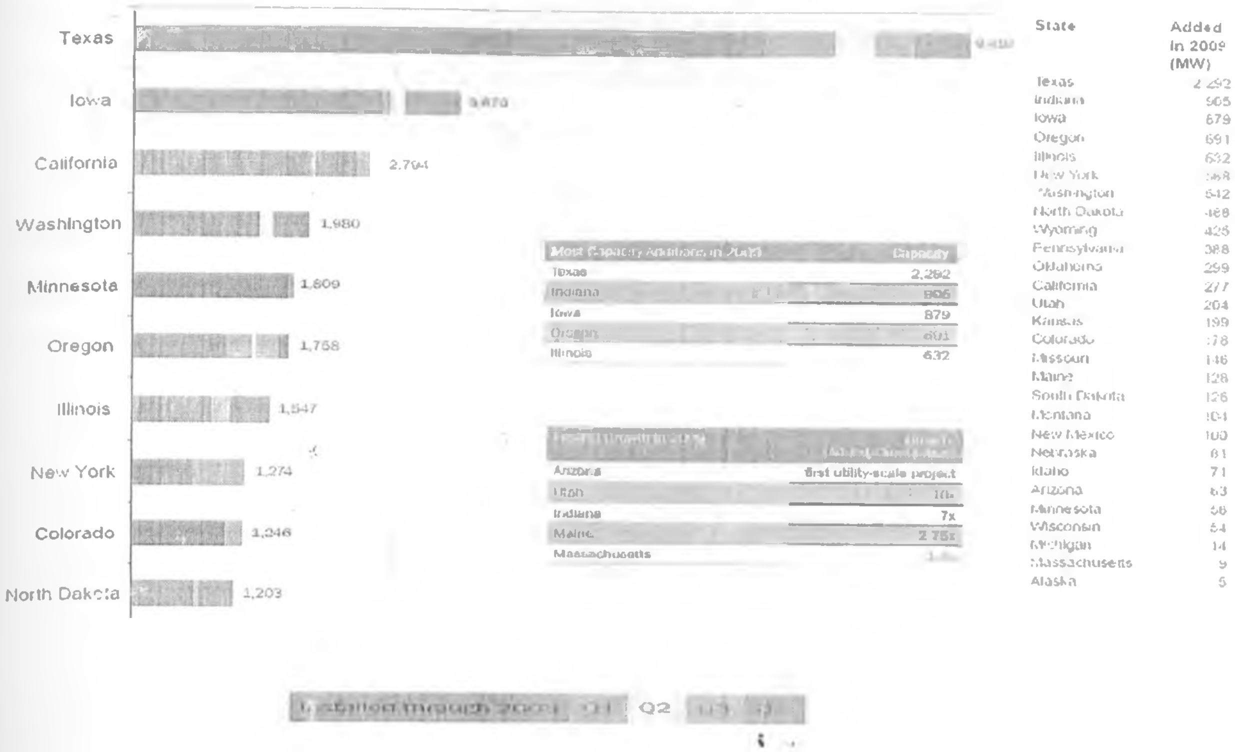
The earlier wind mills were small in size and built of wooden and clothing (reed matting) material the first wind mills which had presence in middle east, central Asia, India and China had vertical axle and drive shaft, with blades that are rectangular shaped and had six to twelve sails made of clothing material, which gave the rise of the name vertical axle windmill. In northwestern Europe the mostly wide spread used windmills were horizontal axle windmill and to date many Dutch horizontal axle windmills still exists. Today, the wind power industry has greatly changed and many thanks to the advancement made in wind turbine technology. With a lot of investment in research and design Denmark introduced wind turbine (generator) for electricity production in 1854. They made 120 pieces of wind turbines ranging from 5 to 25kw. In the late 19th century the Americans successfully generated electricity using multi blade wind turbines.

The United States oil embargo in 1970 lead to a serious crisis in the oil market and caused a serious shortage which necessitated other countries to think outside the box and see how to cater for the shortage in oil energy which was highly used by then and thus commercial interest in wind energy started. California took a broad step and started manufacturing wind turbines in 1980 for domestic use (converting wind energy to electricity). Today, the competitive nature of wind power cost in comparison with oil has given a very good promising present and future exploitation of wind power. This has led to the renewed interest of wind power in most countries, China and the United States being the leaders. China and the United States has vast area of great wind potential that if properly harnessed can supply the demand of their energy requirements.

Due to drastic change to weather patterns and greenhouse gas emissions increase in renewable energy is the way to go, by improving on the technological advancement and reduction of prices due to competition in the renewable energy and optimization of the energy grid by most governments will lead o greater degree of energy independence. For poorer and developing countries, wind power will provide a clean and cheap reliable source of alternative power to traditional source of energy like fossil fuel (paraffin). The global economic crisis was destabilize to most countries economy but this did not deter the wind power section, in 2009 the world installation rise to a whooping 38GW, which accounted for 41 percentage increase as compared to the year 2008 (Global Wind Report, 2009; World Wind Energy Report, 2009). This brought to 159GW the global production of wind power, China represented more than a third of the world market in wind power installation in the year 2009 (Chinese wind energy association (CWEA)).

This was the fifth year when China was doubling its wind power production (2004-2009) which made it to be the largest world installer of wind power in the year 2009 as per the available literature (CWEA). In the same year the United States added slightly over 10GW of wind power to arrive at a cumulative total of 35GW, way above the China's total production in the same year (2009). In the United States every state has installed wind power led by Texas which had more than 10GW of installed wind power (Electricity reliability council of Texas (ERCT)).

Figure 2.1: Wind project installations by top ten states



Source: American wind energy authority/association 2010 (AWEA)

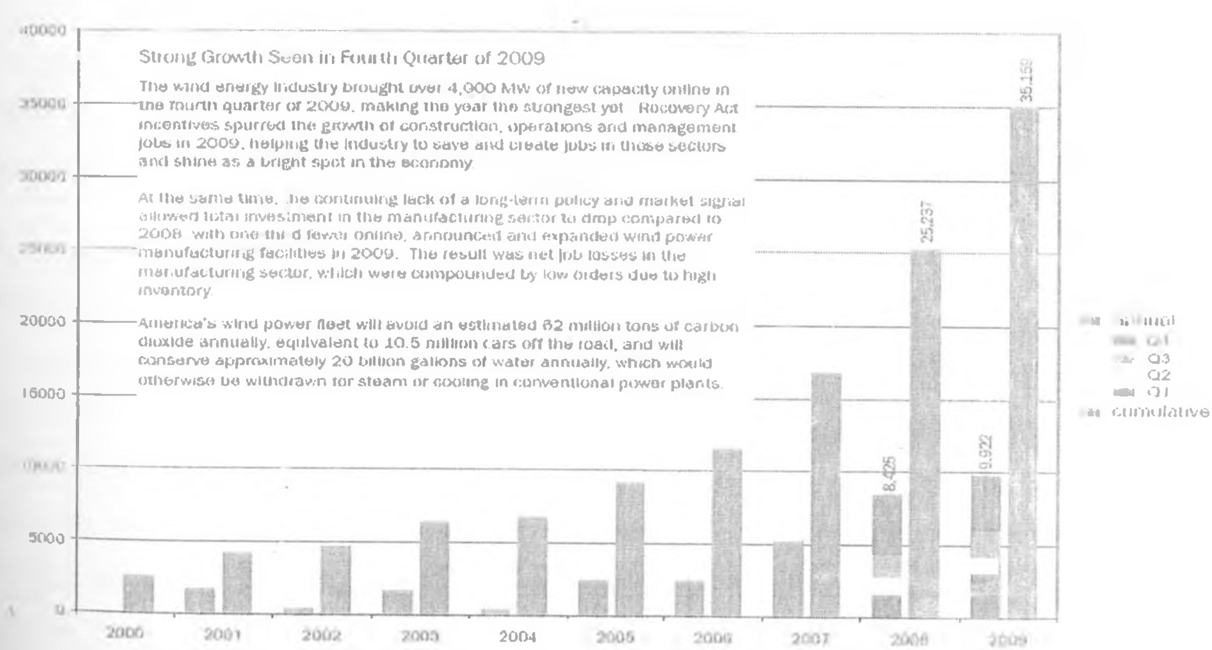


Fig 2, Source: American wind energy authority /association 2010 (AWEA)

Thus, we can say Texas has a capacity that can fully supply 220,000 homes per year. In Europe the wind power installation is being spearheaded by Germany. In the year 2009 Germany added on its grid 1.9GW of wind power making it the leader in European continent and third position in the world after the United States and china respectively. For the year 2009 Germany had installed capacity of slightly below 25.8GW of wind power, for the same year Spain outdid Germany by installing 2.5GW wind power which enabled it to maintain its fourth position globally. Italy, United Kingdom (UK) and France were other significant contributor to the global market by each installing more than 1GW of wind power in Europe for the same year (2009). In the Asian region India was still fighting for its fifth position by installing 1.3GW for the same year. The year 2009 can be termed as a blessing to the Canadians because most of the territories if not all in the provinces were able to produce electricity from wind power; they were able to inject a cumulative total of 950MW of wind power to the grid.

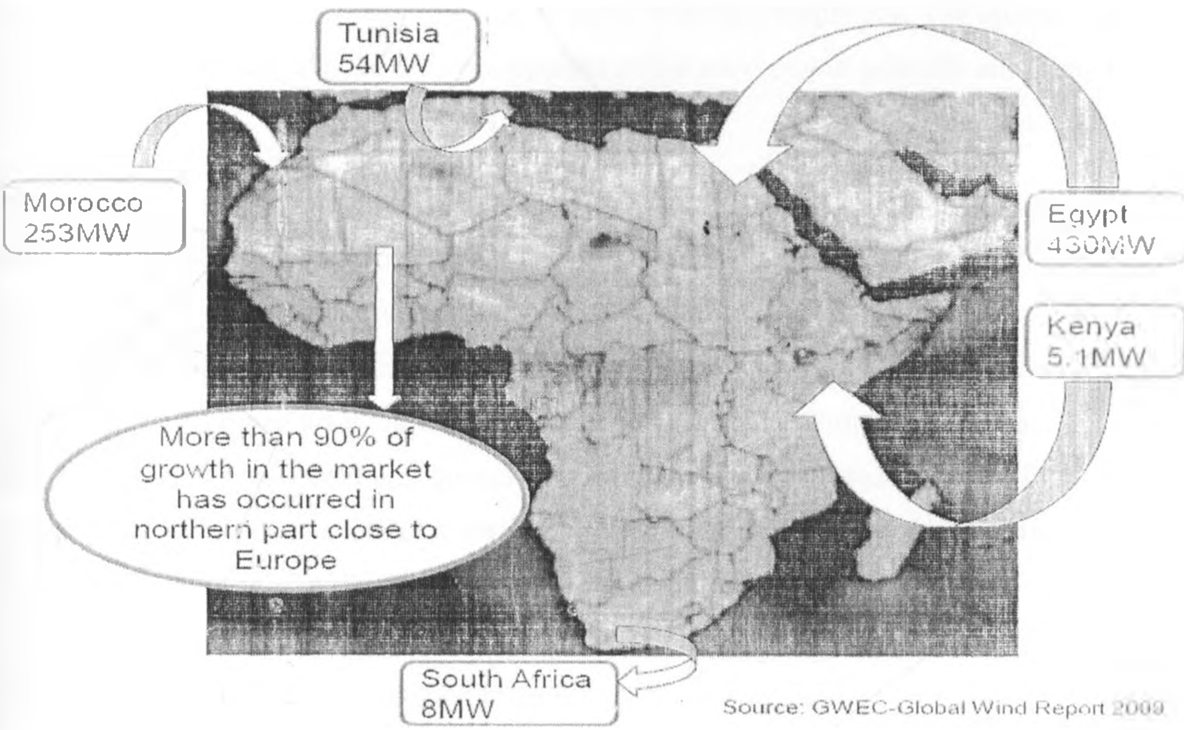
In 2009 Africa and Latin America proved to be vibrant wind power market, Nicaragua (40MW) and Kenya (5MW) worthy of installation joined the list of countries with viable commercial wind energy making the number to be 82 countries. Offshore wind power generation is taking center stage as the onshore space availability continue to decrease, in 2009 offshore section added 641MW of wind power thus bringing the total of offshore to slightly above 2GW, most of the offshore plants are in Europe (united kingdom, Spain, and Denmark), china and united states. Turnkey wind power projects are under way in Middle East, North Africa, India, Paraguay, Argentina, Peru and Uruguay. By establishing a "wind power base" China has become the world leader in wind power generation by overtaking United States.

2.5.1 A short history of wind power in Africa

Various parts of Africa with great potential of wind power have made huge use of the energy. By the year 1960 South Africa which is known for its great potential in wind energy had installed close to 150,000 windmills, which were used to pump water for their cattle and homestead use in their ranches. The Sao Vicente and the Cape Verde from the islands off the west coast Africa had more than 100 windmills (both locally made and others imported) for pumping water for their domestic use and irrigation. Zambia, Ethiopia, Zimbabwe and Tanzania had also windmills that were used in water pumping and grinding maize in rural areas. By now most African countries that have great,enormous wind power potential are now developing their wind energy resources.

In Africa by 2009 wind power plants had already been installed in various countries including; Egypt (430MW), Morocco (253MW), Tunisia (54MW), South Africa (8MW), Kenya (5 .1MW) and Algeria (70KW). There are a lot of interests in Africa with more wind power projects taking place to mention a few, 100MW wind power firm being constructed in Ethiopia, 10MW wind power firm in Nigeria, proposed 300MW wind power firm in Kenya and many others which are at advanced stage of implementation.

Figure 2.2: Wind power production in some selected African states



2.5.3 Wind power history in Kenya

Wind power harvesting is not a new thing to Kenya, it started way back more than a century ago. It was introduced by the colonialists (the white settlers) who were practicing farming by then. They introduced windmills in their settlement schemes (regions), and ranches for pumping water for domestic use and irrigation purposes. Some of the areas where windmills were installed include; Laikipia, Ngong, Nyanyuki, Eldoret, Kilifi, Ukunda, Thika, Turkana, Mbooni, Garissa, and Amboseli. The wind power was widely used by the white settlers after their introduction in Kenya by them. It was until late 1950s and early 1960s when their usage reduced drastically, this was so because the price of petroleum products had immensely reduced and thus forcing people to shift to engines that were running out of diesel and petrol. The other reason that reduced the usage of the wind mill was that the spares were not readily available because they were to be imported from America or united kingdom and this proved to be a white elephant because of the taxes the farmers and other people were using the windmills by then were to incur. Furthermore importation of new windmills was so expensive, the expertise required was not readily available and the few who had hands on experience were also expensive. All this factors led to reduced use of windmills and thus many broke down or stopped working completely. The up and down of oil market price contributed a lot to the development of the wind power globally and Kenya was not left behind.

The rise of oil products prices in 1970s made it impossible to continue using the diesel and petroleum engines because it proved to be very expensive and unsustainable. At this time the few broken imported windmills were revived, sending a strong message to the local people and the government to begin to recognize the immense potential of wind power. In the 1970s various projects on wind power were initiated by schools, private individuals, government, churches, hospitals, volunteers, development agencies and the universities. Most of these institutions had the idea of building local windmills for self-reliance and also reduce the cost incurred during importation of these windmills. The dream was not fully realized because some of the projects did not succeed due to various reasons among them were; no adequate research had been done for the design and manufacturing of the windmills, the workshop were not equipped adequately to handle the magnitude of the work that was to be done, lack of well trained personnel for the maintenance of the machines after commissioning, among others. Golding and Denton (1950s and 1960s) carried out some research on the potential of wind power resource in Kenya, the results obtained were not adequate enough because it was indicated that there were some underestimates of the wind energy, and thus no doughty that good sites with wind power resources could have been overlooked.

This necessitated another research that was carried out by Hilton and Chipeta from the university of Nairobi mechanical engineering department in 1974. They were given the responsibility of documenting reliable data that could help in the accurate design of wind mills for the Kenyan market and thus reduce reliance on foreign importation of the same. They were also to look at the viability of wind power in Kenya and suggest the way forward for the wind energy industry in Kenya and East Africa in general. They found that the wind mills for pumping water had high demand than other wind driven electric generators. From their investigations they also concluded that there may be scope for two types of machine; that is fully factory made and the second one would have its vital parts made in the factory and the remaining parts be made locally (at home/not from factory) and this could play a positive part in the reduction on the pricing of the windmills. In 1975, Hilton obtained a grant from the university of Nairobi research grant committee and constructed three prototypes for field tests and analysis. Two of the prototypes were 8 bladed fan wind pump with a rotor of 8 meters diameter and each mounted on a 6 meters tower, one of them was mounted in the main campus of the university and the other one was mounted in a farm in Garissa County. The remaining prototype was a 4 bladed cretan-type cloth sail rotor of 6 meters diameter, mounted on a tower of 6 meters they were also erected in Garissa and the main campus of the University of Nairobi as the first two prototypes. Other wind pumps (Cretan sail type) were installed in various other places (Turkana, Rhamu, Lang'ata and Lokori) and successfully executed their functions for irrigation purposes as per the expectations.

In 1979, Opondo and Carson from the same department wrote a paper "research proposal on wind energy" which was presented in a conference held in Arusha Tanzania in September 1979. The paper emphasized the need to reduce the cost of windmills by doing research on various aspects of enhancing productivity of wind mills if the wind power section was to remain attractive and competitive. Despite the problems there were some progress made, in 1980 the government of Kenya got some help from Netherlands who were by then experts and leading in the wind power technology. The wind experts were to assess the progress made by Kenya in the field of wind energy and suggest recommendations on the way forward for wind power in Kenya. The group made a conclusive study and reported on various wind mills (power) projects that had been undertaken and recommended the ones that were worthwhile. With assistance from various development agencies (e.g. intermediate technology and development group) machines of good quality with experts' recommendation were manufactured. Companies such as Bobs Harries Engineering Ltd (Thika), Pwani Fabricators ltd (Mombasa), Sound Communication Ltd (Nairobi) had perfected the art of wind mills design and by 1986 they had produced over 200 working windmills mainly for pumping water and they had made a catch by selling them to lodges, missions, schools, settlement schemes and ranches.

2.5.4 Wind Resource Site Locations in Kenya

Figure 2.3: Wind resource sites in Kenya

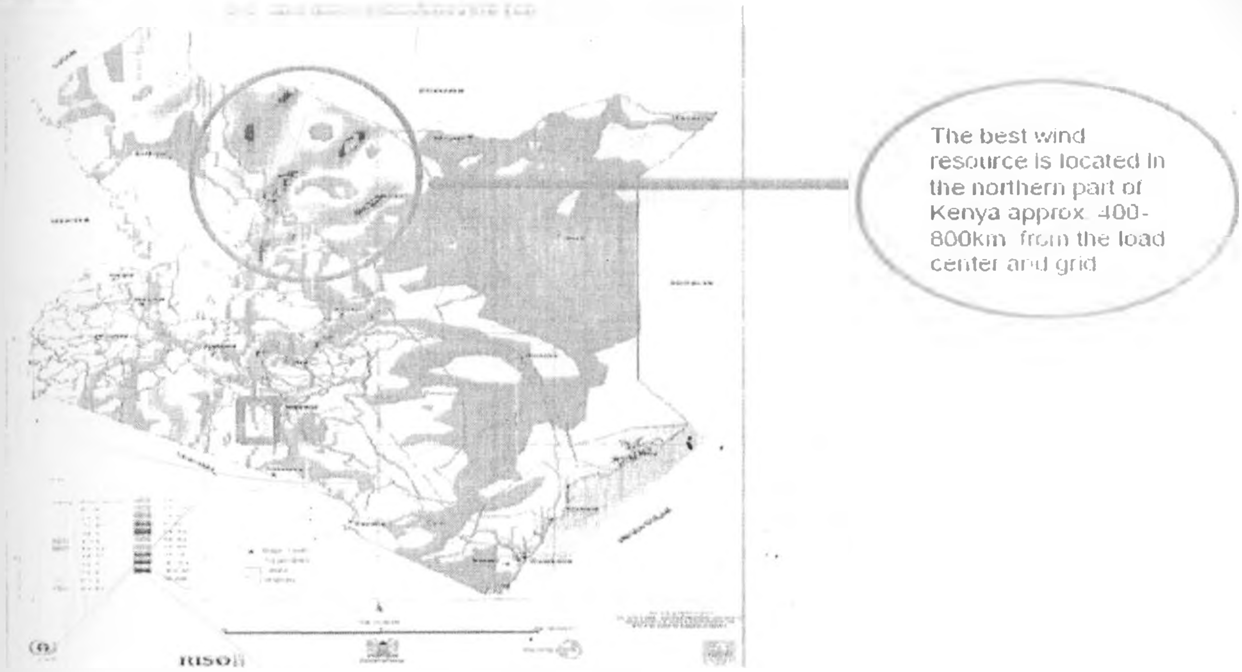


Fig 4, Source: SWERA, 2008

2.6 Major Trends in Wind Turbines Technology

The cost of wind energy has become more cost competitive as a result of improved and advanced technology applied in this field. The sudden rise in fossil fuel and other natural gas prices has also contributed to the rise of wind energy. It has been agued by experts that if environmental and health costs caused electricity generation using nuclear and coal are included, the cost of those sources of energy would one and half to two times the cost of their normal production (Jacobson & Masters 2001). The use of permanent magnet in wind turbine generators rotor has come with sigh of relieve (good news) to the manufactures of wind turbines. Their use removes the need for the excitation of the slip rings, the rotor windings, the brushes and the associated maintenance for the same. The permanent magnet changes the design of the turbines from the usual bulky physical structure to a smaller physical structure thus, reducing the weight of the structure (turbine) and makes it easier and convenient for transportation. Thus, we can basically say direct drive permanent magnet (DDPM) generator has the following advantages;

- External diameter of wind turbine generator (WTG) is smaller than the wound rotor design.
- Simple, appealing and compact design which makes it to be lightweight.
- Multi- polar, low-speed.
- High power to weight ratio.
- No requirement of the excitation of rotor windings, brushes and slip rings

Figure 2.4: Rotor diagrammatic representation

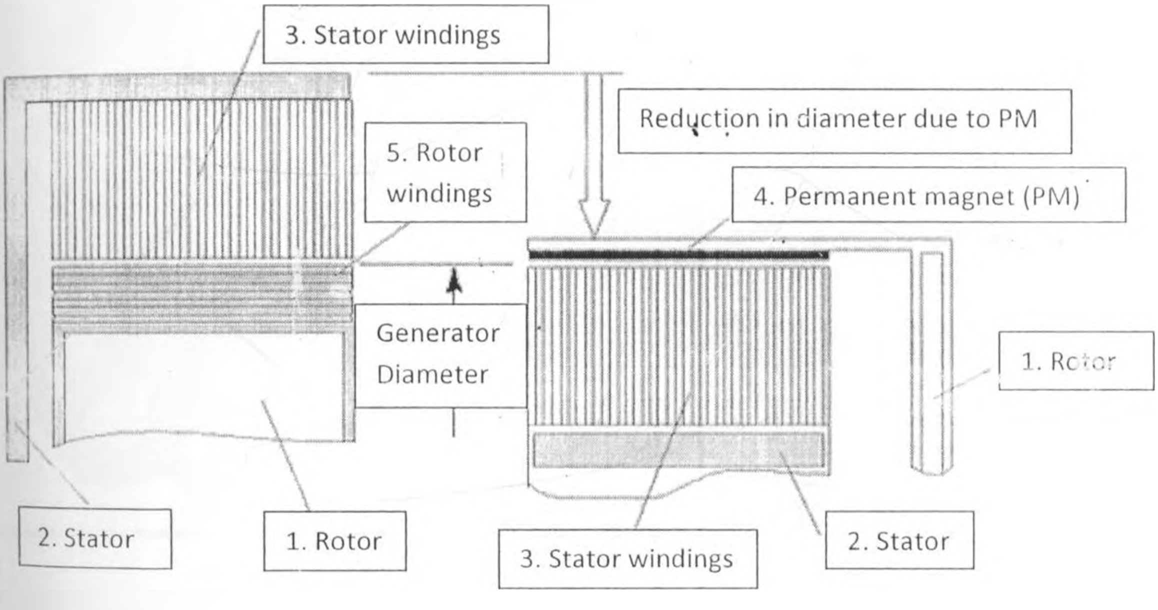
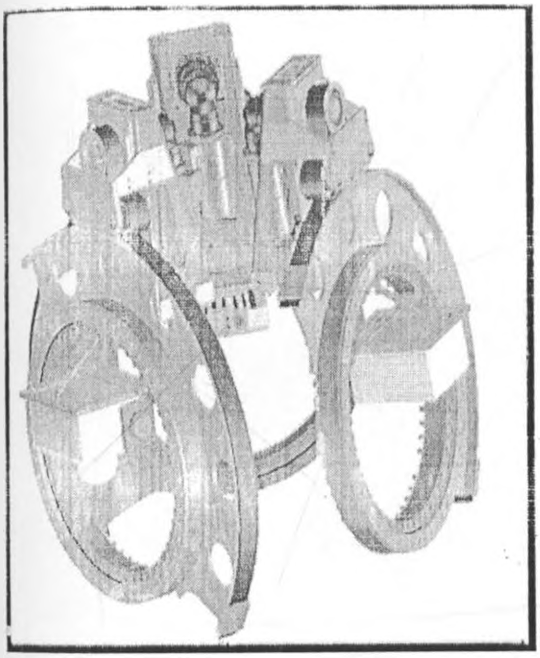


Fig 5 Source: Gold Wind Company.

Wound Rotor Excitation (WRE), Permanent Magnet Generator (PMG), Generator (WREG)

The blade pitch system in direct drive permanent magnet (DDPM) hub is designed to be maintenance free. This necessitated the following design changes which were to be different from the normal common pitch systems, where frequent maintenance was the order of the day and a compulsory assignment for the survival of the wind turbines generators (WTG).

- Double -Fed Induction Generator (DFIG) used spur gear in their pitch system. But with the introduction of Direct Drive Permanent Generator (DDPM), toothed belts are now replacing the spur gear in the pitch systems.
- DC motors have been used in DFIG but now they are being replaced by AC pitch drives.
- Ultra capacitors are used in place of lead acid or gel cell batteries for the emergency stop/over speed safety system.



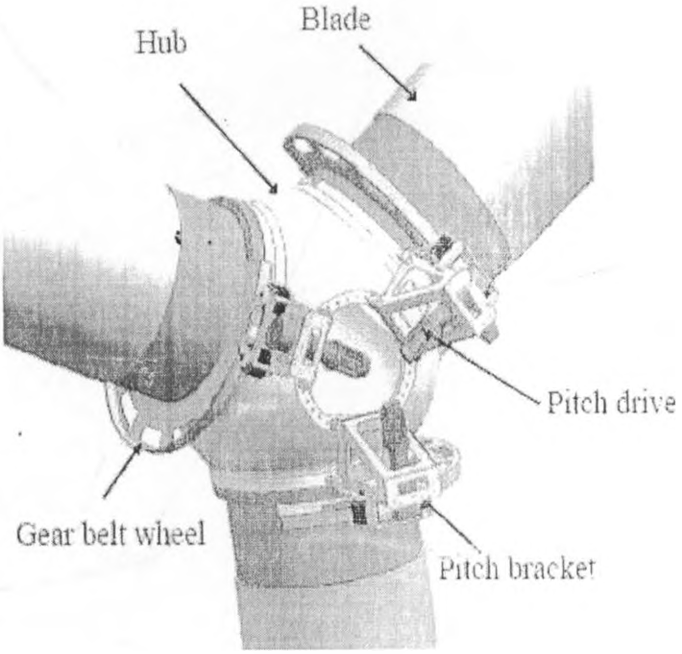


Fig 6, Source: Gold Wind Company.

Fig 7, Source: Gold Wind Company.

The incumbent technology DFIG (double fed induction generator) had various problems from its 30 percentage capability of power conversion from the full rating. The power conversion (30% of full rating) was not grid friendly because could not meet the grid codes requirements. It was not possible to have adequate control and operational flexibility. With the introduction of direct drive permanent magnet generator technology (DDPM Technology), it came with various goodies among them being the elimination of the gearboxes failure, elimination of the gearbox energy losses, reduction on the number of spare parts required due to wear off, better fault ride through/zero power requirement to energize, elimination of secondary winding losses, elimination of slip rings and associated maintenance, grid friendly, more control and operational flexibility and meet future grid codes and requirements.

Figure 2.5: Sample 2.5 Megawatt Direct Drive Permanent Magnet (DDPM) Wind Turbines.

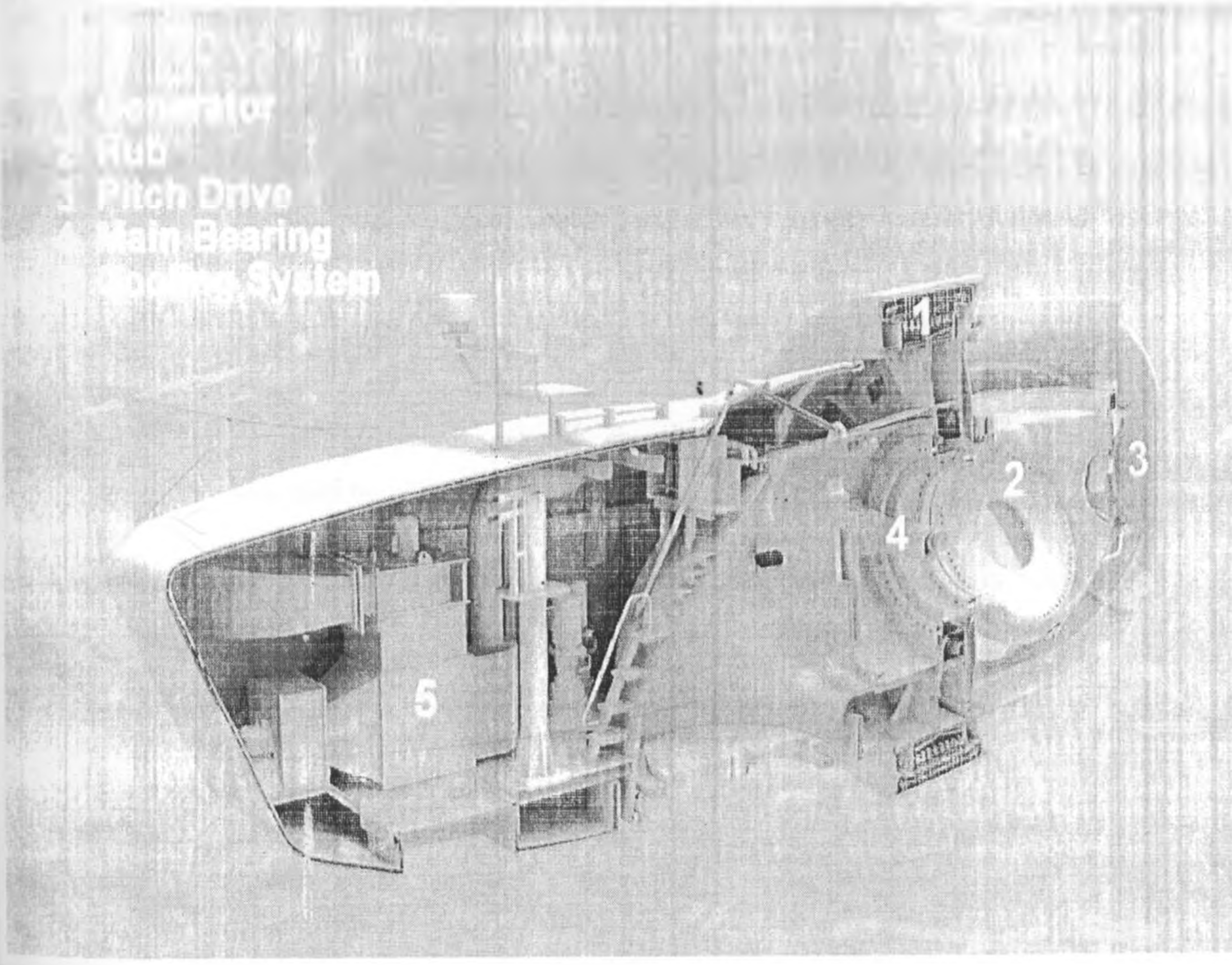


Fig 8, Source: Gold Wind Company.

The international expansion of wind power can only be driven by wind turbine manufactures that are willing to develop and utilize advanced technology in their plants. Countries such as China, United States of America, Germany, France, Denmark and Spain have the best practices, expertise and the technology required in this field of wind energy (power) generation, which should be embraced by other countries in the world for wind energy to succeed and meet the energy requirement from renewable energy set by the Kyoto protocol to curb the effects of climatic changes and the effects of greenhouse gas emissions. Thus, why wind energy is said to be sustainable, meaning we can meet the society current needs as per now without destabilizing or harming the future generations (Engardio, 2007). The price of wind power in kilowatt per hour has drastically reduced from 35cents in 1980 to 3-5cents today and it is anticipated to still reduce down the trend. All this is attributed in the technological advances in the wind power industry. In 1980 the largest wind turbine was rated at 55kw, this has increased from that to around 5MW in 2005 and a father 7MW which is under test to be installed by 2011. Production of electricity from wind largely depends on the size of the turbine. Erection of tall towers some as tall as 100meters high, put turbines at very high height that makes the turbines to make use (utilize) of the strong and less turbulent winds find at this high elevations (Jonathan & Anand, 2009). With the introduction of the use of materials such as polyester/E-glass allow blade length of more than 50meters compared to earlier types of blades that were very short (15ft in 1980). This is very important because the capability of a turbine to provide electricity depends on the diameter of the rotor (the square of the length of the blade dictates the amount of power/electricity generated by a wind turbine).

2.8 The ten top wind turbines manufactures with the current and future technological trends.

Table 2.3: The ten top wind turbines manufactures with the current and future technological trends.

COMPANY / FIRM	MANUFACTURED/ PRODUCTION TURBINES			TECHNOLOGICAL HISTORY	INDICATED FUTURE TECHNOLOGY TRENDS
	Direct Drive	Permanent Magnet	Full Power Converter		
Vestas	No	Yes	Yes	Gearbox DFIG	Gearbox driven PM full power converter
Goldwind	Yes	Yes	Yes	3years of DDPM full scale production 7years of 1MW+DDPM testing	DDPM
Siemens	No	Yes	Yes	Gearbox DFIG	DDPM

Dong Fong	No	No	No	Gearbox DFIG	DDPM
Gamesa	No	Yes	Yes	Gearbox DFIG	Unknown
Repower	No	No	No	Gearbox DFIG	Unknown
GE	No	Yes	Yes	Gearbox DFIG	DDPM
Sinovel	No	No	No	Gearbox DFIG	Unknown
Enercon	Yes	No	Yes	Wound Rotor DD	Wound Rotor DD
Sulzon	No	No	No	Gearbox DFIG	Unknown

Source: Gold Wind Company (Egypt International Wind Conference, 2010).

Larger and more efficient wind turbines are being manufactured by companies such as General Electric in USA, Siemens in Germany, Gamesa in Spain, Repower in China, Vestas in Denmark, Vergent in France. In 2005, General Electric (GE) supplied 2400MW of wind turbines all over the world, which was equated to nine fossil fuel generation power plants, but in 2008 the story was different as GE was almost out of business and had nearly sold out of wind turbines through the year (Ryan, 2006). The above condition/situation was caused by the capital cost inflation that most companies face and need to be addressed by the concerned parties. All the firms (companies) mentioned above manufactures turbines with a rotor consisting of three blades with an exception of Vergent Company which manufactures turbines with a rotor consisting of two blades. The reason behind this is that Vergent considers a 2 blade rotor to be lighter, easier to install and easier to tilt down for routine maintenance or for hurricane protection.

The tilting capability allows the turbines to be serviced easily and quickly on the ground not needing heavy hoisting machines, for the lifetime of the wind turbines. In their design, the rotating-hub technology and the latest technological advances in the aeronautics industry allows the forces exerted on the structure to be considerably reduced, furthermore the drive train and structure elements are consequently much lighter and more durable over time. It should be noted, that the power generated by the wind turbines does not depend on the number of blades the turbine has but on the rotor diameter and therefore on rotor swept area. Hence, we can say that a two blade rotor generate the same amount of power as a three blade rotor of the same rotor diameter.

2.9. Theoretical and conceptual framework

This helps us, as researchers to be able to visualize the research problem title, with its various variables (dependent, independent, intervening, extraneous and moderating variables), hence one can be able to see or picture the all project in one page. It's the foundation of a research project/problem. The following are the variables that helped us construct a conceptual framework.

Dependent Variable

Development opportunities

Independent Variables

Quantity and quality of wind power generated

Market demand/consumption (knowledge and awareness of customers)

Accessibility of wind power (how close wind energy is to the consumer, distance covered)

Moderating Variables

Types of wind turbines (generators) installed

Technology used

Transmission losses

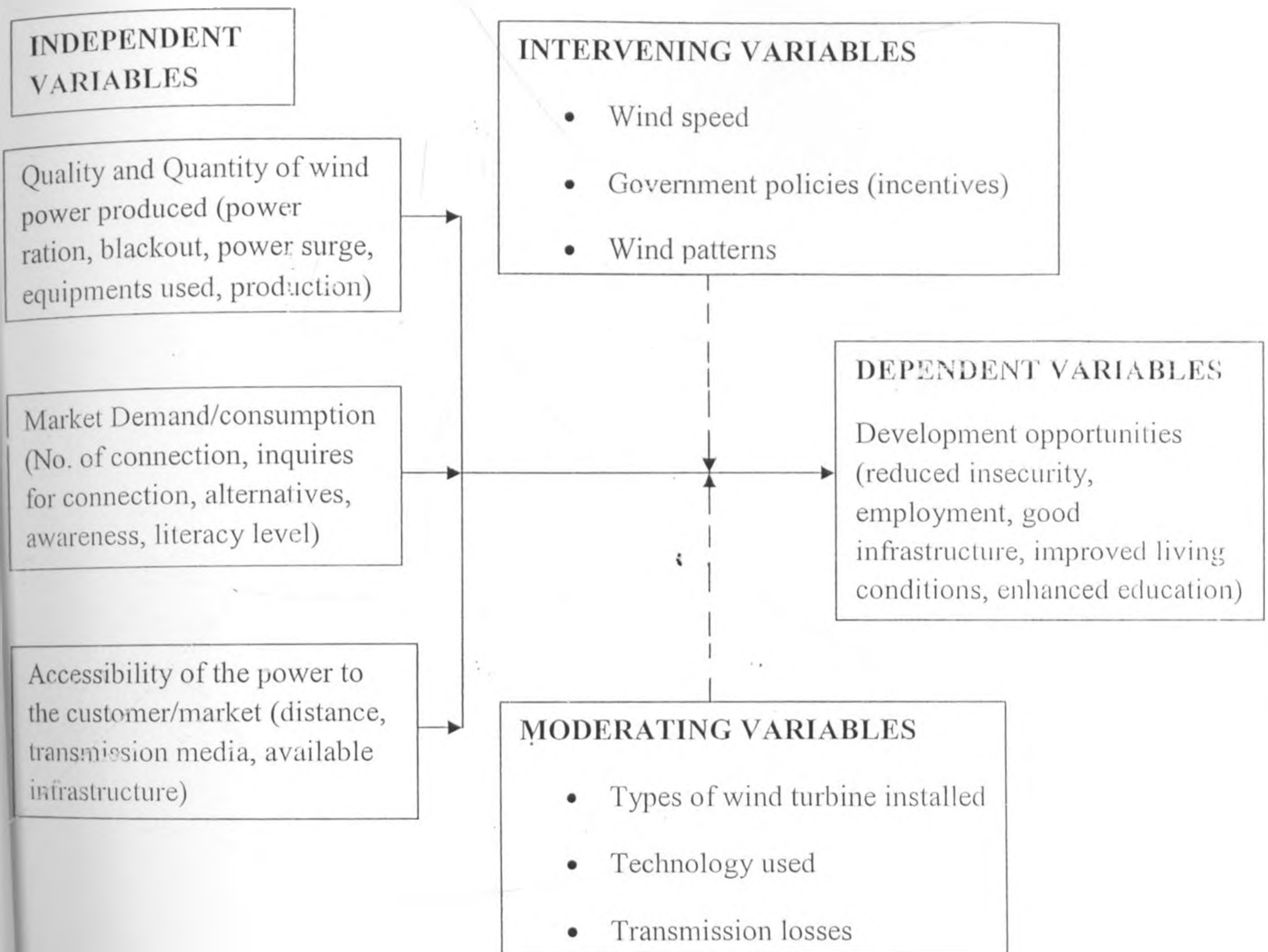
Intervening Variables

Wind patterns

Wind speed

Government policies (incentives)

Fig 2.6: Conceptual Framework



2.10. Summary

In this chapter various literatures related to wind power (energy) was looked at and thus various studies on the same were looked at. The major areas of concern in the chapter were the introductory part, non-renewable source of energy, renewable source of energy. Kenya's natural resources, (hydro resources, major hydro potential, geothermal resources, coal reserves resources, biomass resources, solar resources, wind resources and potential wind firms) history of wind energy (power) in the world, (a short history of wind power in Africa, wind production in some selected African states, wind power history in Kenya) major trends in wind turbines technology, sample 2.5MW direct drive magnet (DDPM) wind turbine, top ten wind turbines manufactures with current and future technological trends in the market and last but not least was the theoretical and conceptual framework.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter discusses the research methodology applied in the study. The following are discussed at length: the research design, the target population, the sampling procedure, methods (procedure) of data collection, reliability and validity, instruments of data collection and there reliability and validity, operational definitions of variables, methods of data analysis and finally the summary of the chapter.

3.2. The research design

Owing to the nature of the conceptual framework, both causal and descriptive research designs were used in this project (here, use of regression analytical technique qualifies the causal design while use of descriptive frequencies confirms a descriptive design). A survey was conducted using structured questionnaires comprising multiple closed and open-ended questions. The stages involved in this research model include; stage one determining whether this design was appropriate, at stage two determining the rationale for using the design, stage three was selecting the research design, stage four was collecting the data, stage five analyzing the data using quantitauve and qualitative techniques, stage six was validation of data, stage seven interpreting the data, and finally stage eight was writing a research report. This design enabled answering a range of research questions and thus produced more complete knowledge necessary to inform theory and practice.

3.3. The target population

The target population for the study was occupants of households (98,120) of Ngong Division in Kajiado County and 21,700 households of Marsabit district in Marsabit County and the implementers of the project through ministry of energy (Kenya Power and KENGEN). Up to date population data as per last census for Ngong and Marsabit regions was requested from the Kenya National Bureau of Statistics (KNBS) and geography department of the University of Nairobi.

3.4. The Sample and Sampling Procedure

3.4.1 The Sample Size

Using a confidence level of 95% and confidence interval of 7%, a sample size of 275 households was got (www.researchinfo.com/docs/calculators/samplesize.cfm). This consisted of 179 respondents from Ngong region and 96 respondents from Marsabit region.

3.4.2 The Sampling Procedure

Maps of Ngong and Marsabit Division were obtained from the Google Earth to demarcate the locations to be the sampling frame where the sample units were got. In order to select respondent households, every 10th household for the survey were picked and skipped the rest along demarcated mapped out path routes. Due the heterogeneity of the population under the research study, proportional random sampling technique was applied to enable getting a stratum of homogeneous characteristics. These characteristics included: size of household, location and gender of the house hold head.

Then the homogenous sub group of the population gave simple random samples independent of ach other. Hence, this stratified random sampling technique increased efficiency during the rvey process. Purposive sampling was used to identify the departments that deal with nplementation of wind energy in Kengen and we selected the head engineer of wind to respond. he same approach was followed to pick the head of Off-Grid stations at Kenya Power and ivate operators.

5. Methods of collecting data

s earlier stated the study was carried out in form of a survey of varied respondents whose servations were obtained by use of questionnaires, picture taking and interviews. The survey thod proved important for collecting primary data since it enabled gathering of abstract rmation of all type. Observation involved listening and reading, or rather, a full range of nitoring behavioral and non-behavioral activities and conditions.

Data collection and the instrument

elopment of correct instruments or data collection is one of the greatest achievements a rcher strives to achieve. The use of wrong instrument results into collecting false data and esults into wrong findings and conclusion. Therefore it can be said the development of the right instruments is critical to reliability and validity of any research project. The questionnaire had six section asking questions that could answer the research questions. The first section had demographic data with information on the respondent background (gender, age, education level and other relevant questions regarding the respondent).

The second section stressed on quality and quantity of wind power produced and thus measured indicators such as the rate of power ration, rate of power surge. The third section was on market demand where indicators such as the number of consumers, the usage of the wind power (application of wind power). The fourth section measured on awareness of the public on matters concerning wind energy; here indicators such as knowledge on wind resources, adverts on the same, what government and other stakeholders are doing towards the same. The fifth section addressed the question on accessibility of the power to the market; here indicators such as the distance of travel, infrastructure (good roads, good communication) and the last section addressed the question on the literacy level of the community, indicators such as the education level, education facilities available, and knowledge on matters concerning wind energy. Furthermore interviews were scheduled for some respondent from the management team on the implementation team of the said wind farm.

3.7 Reliability and Validity

As mentioned earlier, that conclusions made by any researcher are based on the information obtained from the instruments and thus the quality of instruments used in research is very important, and this is achieved by ensuring that the instruments used are reliable and valid. Validity refers to the appropriateness, meaningfulness and usefulness of the inferences that are made. On the other hand, reliability refers to the consistency of scores and answers from one administration of an instrument to another and from one set of items to another that is carried in the entire study.

3.7.1. Reliability

Reliability is the consistency of the data or scores that obtained throughout the project research. It is how consistent the scores are for each administration of an instrument to another and from one item to another in the study. This aspect was achieved by getting consistent results repeatedly after the measurements of the same object by the same instrument, the results of the repeated measurements was compared to help in the identification of the degree of stability.

Table 3.2: Operational meaning of variables

objectives	Variables	Indicator	Measurement Scale	Type of Data as used in Analysis	Tool of Measurement (technique)
1. To establish whether the quality of wind power generation influence development opportunities	Quality & quantity of wind power generated	Power surge/ power ration	Interval ordinal	Qualitative and quantitative analysis	Means, % frequencies
2.To determine how development opportunities are influenced (affected) by customers wind power consumption	-Customers consumption capability - Cost of electricity	-houses connected/ other use of electricity	Ratio interval	Qualitative and quantitative analysis	Regression and Analysis of variance (ANOVA)
3.To assess how customer accessibility to the wind power generated relate to development opportunities	Distance covered, infrastructure development	Availability of grid line/ good roads and communication facilities	Ratio ordinal	Qualitative and quantitative analysis	Regression, frequencies

3.9. Data analysis methods

Data analysis refers to the computation of certain measures along with searching for patterns of relationsnip that exist among data-groups. The relationships or differences supporting or conflicting with original or new research questions were analyzed and then subjected to statistical tests of significance to determine with what validity data can be said to indicate any conclusions. This analysis helped in interpreting data, drawing conclusions and making decisions. In the findings the result were provided in both concise manner and generalizations from the sample to the population were developed. Data was analyzed by use of SPSS computer package, version 17 which enabled the generation of descriptive frequencies, cross-tabulation and regression ($Y = \alpha_0 + \alpha_i X_i + \varepsilon_i$ for all $i = 1, 2, ..., n$) to show the relationship between independent, intervening, moderating and dependent variables.

CHAPTER FOUR

DATA ANALYSIS AND INTERPRETATION OF FINDINGS

4.1. Introduction

A total of 275 heads of households responded to this survey. The target number of households for the survey was 300 meaning that a high response rate of 92% was achieved and which was associated with 7% level measurement error. A hundred and seventy nine respondents (179) were selected from Ngong region while the remaining 96 (equal to 37%) were drawn from Marsabit region using stratified randomized technique. This chapter contains an interpretation of results from the field.

4.2. Results of reliability analysis

One of the tests which were important to conduct was a check for reliability of the data collection tool. The tool was tested for reliability using data from the pilot survey and the findings were presented in table 4.1 below.

Table 4.1: Reliability statistics

Cronbach's Alpha[b]	N of Items
.733	20

b. The items are: Age, Gender, HighestEducation, Occupation, EnergySource, AlternativeEnergy, EnergyService, ElectricityUse, MonthlyElectricityBill, TimeofHighestElectUse. ExperienceofPowerRationing, Frequency, ExperienceofPowerSurge, Frequency, ServiceValue, Satisfaction, EnergyEducation, Effect, Other benefits, Importance

Source: Author's Computation

It was established that the instrument was reliable because the Cronbach's statistic (alpha) was 0.733 against the minimum required threshold level of 0.3. This meant that the confident was high that the respondents would give consistent responses using the questionnaire for data collection. In the next section the results of some demographics about age, education gender and other selected characteristics of the respondents were given.

4.3. Demographic characteristics

Table 4.2: Demographic characteristics

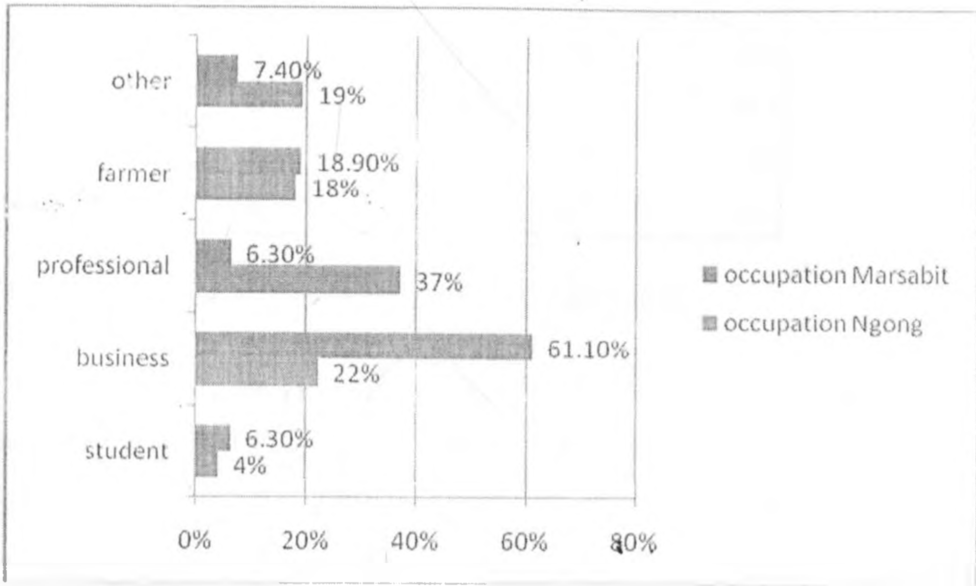
			Gender					
			Ngong			Marsabit		
			female	male	Total	female	male	Total
Age	below 20	Count	4	5	9	0	2	2
		% of Total	2.3%	2.8%	5.1%	.0%	2.1%	2.1%
	20-30	Count	37	47	84	22	18	40
		% of Total	20.9%	26.6%	47.5%	23.2%	18.9%	42.1%
	30-40	Count	26	31	57	26	14	40
		% of Total	14.7%	17.5%	32.2%	27.4%	14.7%	42.1%
	above 40	Count	9	18	27	4	9	13
		% of Total	5.1%	10.2%	15.3%	4.2%	9.5%	13.7%
Total		Count	76	101	177	52	43	95
		% of Total	42.9%	57.1%	100.0%	54.7%	45.3%	100.0%

Source: Author's Computation

The distribution of age was not significantly different between Ngong and Marsabit, composition of gender was. Most of the respondents (79.7% or 47.5 plus 32.2) in this study were aged between twenty and thirty years. Only a small fraction of them (5.1% and 15.3%) were under twenty and more than forty years respectively. More males than females (57.1% versus 42.9%) took part in the Ngong survey with the highest proportion of either gender being aged 20 to 30 years. On the contrary, more females than males (54.7% versus 42.9%) participated in the Marsabit survey.

From Ngong, over half of the heads of households had achieved (16% plus 41.9%) either primary or secondary level of education with 8.6% having vocational, 26.9% college and 5.7% bachelors level of education. The situation was reversed for Marsabit with the bulk 93.1% having only either primary or secondary level of education (that is 51.7% plus 41.4%). Only 6.8% had attained either vocational or college education.

Figure 4.1: Career disposition



Source: Author's Computation

Ngong had five times more professionals and technical career respondents than Marsabit sub-station. On the other hand, Marsabit had over two times (61.1% versus 22%) more business professionals responding to the survey than Ngong. the composition of student respondents was very minimal. This could be explained by the fact that, research assistants had been asked to ensure that only people with clear understanding of the issues covered by the survey would be selected for interview.

4.4. Sources of energy and supply constraints

Households were asked to indicate their current sources of energy. The table 4.3 below indicates the distribution of sources of energy for Nong and marsabit.

Table 4.3: Current energy source

		Ngong		Marsabit	
		Frequency	Percent	Frequency	Percent
Valid	thermal	24	13.4	3	3.1
	solar	6	3.4	12	12.5
	electricity	146	81.6	75	78.1
	other	3	1.7	5	5.2
	Total	179	100.0	95	99.0

Source: Author's Computation

More households use thermal in Ngong than Marsabit while more households use solar in Marsabit than Ngong. From Ngong, the highest proportion (81.6%) indicated that they used electricity, 13.4% used thermal – from burning diesel/petroleum products, 3% solar and almost none using other forms of energy. In Marsabit, 78.1% use electricity, 12.5% use solar and only 3.1% use thermal.

About two thirds or 66.5% of households in Ngong and 58.3% of households in Marsabit had alternative forms of energy. These various forms included kerosene lamps, candle and solar for lighting and charcoal, firewood and kerosene for cooking. Very few households (far less than 1%) indicated that they used renewable sources of energy (biogas, hydro, solar, wind) as alternatives for cooking, lighting or heating purposes.

Table 4.4: Energy service type

	Ngong		Marsabit	
	Frequency	%	Frequency	%
domestic	152	84.9	86	90.5
industrial	18	10.1	9	9.5
Total	170	95.0	170	95.0

Source: Author's Computation

Almost all the respondents (84.9% from Nong and 90.5% from Marsabit) were using their current energy source for domestic purposes with a very small segment using energy for industrial or commercial purposes (equal to 10.1% and 9.5% for Ngong and Marsabit, respectively).

As detailed in table 4.5, electricity was mainly used for lighting (by 86 percent of households). Perhaps the reason only 6% were found to use electricity for cooking was that it was way beyond their reach in terms of cost.

Table 4.5: Purpose for which households use electricity

Monthly Electricity Bill * Electricity Use Cross tabulation

			Electricity Use					
			Ngong			Marsabit		
			cooking	lighting	other	cooking	lighting	other
MonthlyElectricity Bill	below 500	% of Total	1.3%	27.8%	.0%	16.70%	33.10%	50.00%
	500-1000	% of Total	1.3%	49.4%	.0%	25.00%	31.70%	0.00%
	1000-2000	% of Total	5.1%	11.4%	2.5%	25.00%	24.50%	0.00%
	above 2000	% of Total	.0%	.0%	1.3%	33.30%	10.80%	50.00%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	8.816[a]	6	.084	42.059[a]	6	.000
Likelihood Ratio	8.094	6	.231	22.083	6	.001
Linear-by-Linear Association	1.479	1	.224	2.608	1	.106
N of Valid Cases	153			79		

Source: Author's Computation

We are able to affirm that, in both Ngong and Marsabit, those who use electricity for cooking are also the households with high monthly electricity bills. On the contrary, those who use electricity for lighting pay lighter electricity bills at the end of the utility period. This is confirmed by Pearson Chi-square (χ^2) of 8.816 and χ^2=42.059 that are significant at 10% and 1% in Ngong and Marsabit respectively. The statistical implication is that monthly bills differ depending on whether households cook or light with electricity.

Table 4.6: Time of highest electricity use

	Ngong		Marsabit	
	Frequency	Percent	Frequency	Percent
morning	1	.6	1	1.0
afternoon	5	2.8	5	5.2
evening	65	36.3	14	14.6
night	41	22.9	19	19.8
throughout	58	32.4	41	42.7
Total	170	95.0	80	83.3
Missing response	*9*	*5.0*	*16*	*16.7*

Source: Author's Computation

Evenings happen to be the time when households consume the most electric energy in Ngong but for Marsabit it is throughout the day as detailed by table 4.6. Mornings are the time of day households have least consumption across the wind intense regions. This can be connected to the fact that Ngong has higher proportion of professionals who are engaged during the day and wouldn't have much use of electricity at that time of day. The situation is reversed for Marsabit since even professionals of that town are working from distances nearer to their residential areas than Ngong.

We also asked the households if they used to undergo power rationing problems and results showed that, actually 77.9% of households experienced power rationing. These are also households that expressed interest in welcoming additional power generation capacity to boost current supply of lighting, cooking and heating energy.

Table 4.7: Experience of power rationing

			Experience of Power Rationing			
			Ngong		Marsabit	
			yes	no	yes	no
Frequency	Daily	Count	4	0	0	0
		% within ExperienceofPowerRationing	3.80%	0.00%	0.00%	0.00%
	Weekly	Count	64	1	42	0
		% within ExperienceofPowerRationing	60.40%	3.30%	58 3%	.0%
	Monthly	Count	26	11	27	0
		% within ExperienceofPowerRationing	24.50%	36.70%	37.5%	.0%
	Quarterly	Count	11	13	2	1
		% within ExperienceofPowerRationing	10.40%	43.30%	2.8%	1.4%
	Semi annually	Count	1	5	71	1
		% within ExperienceofPowerRationing	0.90%	16.70%	98.6%	1.4%
Total		Count	106	30	-46	-122
		% within ExperienceofPowerRationing	100.00%	100.00%	100.00%	100.00%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	45.812[a]	4	.000
Likelihood Ratio	49.644	4	.000
Linear-by-Linear Association	44.163	1	.000
N of Valid Cases	136		

a. 4 cells (40.0%) have expected count less than 5. The minimum expected count is .88.

Source: Author's Computation

Among those who had power rationing problems, 60.4% experienced it either weekly or monthly; among those who said they did not have power rationing issues, 43.3% experienced it quarterly in a year. As high as 60 percent of the respondents were experiencing power rationing weekly and power surge at least once monthly.

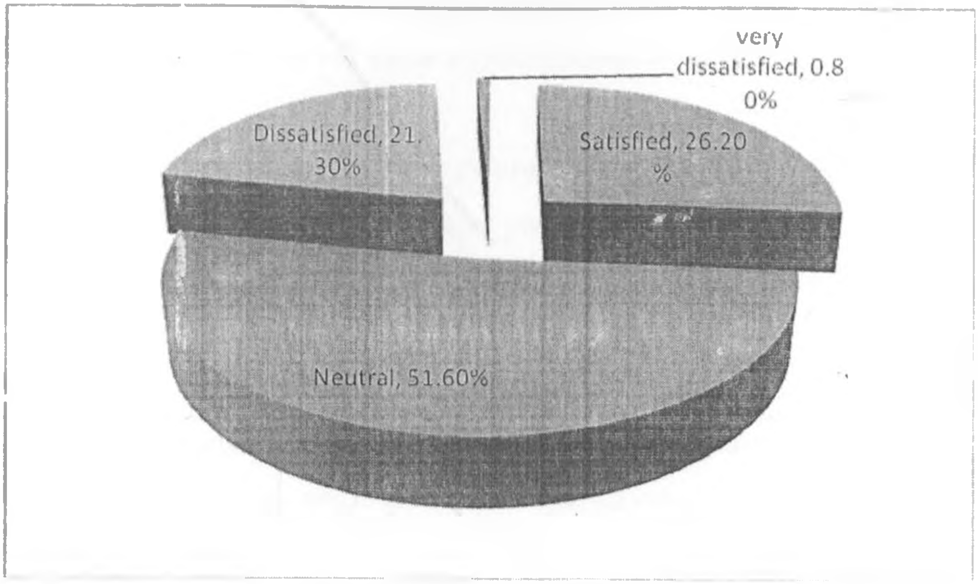
Table 4.8: Rating of value of service

		Ngong		Marsabit	
		Frequency	Percent	Frequency	Percent
Valid	excellent	3	1.7	22	22.9
	good	23	12.8	33	34.4
	fair	80	44.7	13	13.5
	poor	39	21.8	10	10.4
	terrible	13	7.3	22	22.9
	Total	158	88.3	78	81.3
Missing	*System*	*21*	*11.7*	*18*	*18.8*
Total		*179*	*100.0*	*96*	*100*

Source: Author's Computation

In terms of customer satisfaction with supply of energy, 56.2% were dissatisfied. Service value for money was rated generally fair by Ngong households (by the highest proportion 50.6% of respondents) excellent by 1.9%, good by 14.6% and poor by about a quarter. The largest proportion of Marsabit respondents rated service good (34%).

Figure 4.2: Satisfaction with current supply of energy



Source: Author's Computation

Twenty six percent of respondents in both regions were satisfied with current supply of energy, 21% and 36% from Ngong and Marsabit, respectively, were dissatisfied with the supply while more than half (51%) were neutral.

4.5. Wind and Other renewable energy sources

Knowledge of other renewable sources of energy was wide. Some respondents indicated that renewable energy was the most stable source of future energy. Therefore they showed knowledge of the potential of solar, wind, hydro, thermal, geothermal, biogas, and bio-fuels some of which the government of the republic of Kenya is currently promoting to beef up the national grid.

In terms of knowledge of wind energy, respondent felt that wind energy is a cheap and reliable source a natural source of energy and so it is cheap alternative to hydro power. Wind is readily available in Kenya, cheap to harvest and efficient to process. Besides it is clean and environmental friendly. Since the energy is produced when the turbines rotate, the efficiency depends on the speed of the wind, yet wind is available in strong currents around the hilly and arid regions of the country. Thus the country is naturally positioned to invest in large scale wind production. Finally respondents also felt that the propellers and masts at wind harvesting points had aesthetic value since they add to the resource sites tourists can visit to see in a region. Only very few in the sampled group did not know anything about wind energy.

The recommendations to increase wind energy production were also broad. They included that the country can add more propellers, build more projects, communicate the benefits of wind and install more in the country (especially in the remote rural areas); licensing other firms besides KenGen and KPLC who would be interested to venture into it, the government should study case studies of developed countries that use wind energy; a pilot project should be carried out to see whether it would work; construct more mills in other hilly areas other than Ngong and Marsabit. These included turbi, Laisamis and especially Loiyangayani. They felt the state corporation responsible for wind (Kengen) can install more propellers at hills in North Eastern Kenya, create awareness about wind energy, abolish the monopoly of KenGen and Kenya Power, government to invest in more energy production in the North and Upper Eastern and projects once started should be completed, enact more appropriate policies to encourage private sector.

It is worth noting that the government has played a good role by formulating feed in tariffs that will encourage participation of the private sector in generation of wind, solar, biomass and bio-fuels for sale to Kenya Power for distribution.

4.5.1. Results of regression analysis

To observe cause and effect, we conducted linear regression analysis to establish how development opportunities (here measured by number of development projects as a result of investment in wind energy) can be influenced by the type of energy currently being used by residents of an area, whether the power supply is erratic or stable, customer satisfaction with current power supply, effect of distances from power projects, and monthly electricity bill[1]. We

[1] This variable was used because once wind energy is generated it feeds into the national grid which supplies the households. As a result of this, the tarrifs (bills) contribute the budget that finances new wind projects (implemented

controlled for demographic characteristics such as age, gender and education levels of respondents.

Table 4.9: OLS Model summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.358[a]	.128	.275	1.27883
2	.383[b]	.146	.260	1.28914

a. Predictors: (Constant), EnergySource, ExperienceofPowerRationing, EnergyService, Effect of distance, MonthlyElectricityBill

b. Predictors: (Constant), EnergySource, ExperienceofPowerRationing, EnergyService, Effect of distance, MonthlyElectricityBill, Age, Gender, HighestEducation

c. Dependent Variable: noofdevprojects

The R-squared above measures the strength of determination. Results show that independent variables can explain more than a third (38.3%) percent of variation in the number of development projects connected to investments in wind energy generation. The next table (4.xx) presents F-statistic output, a ratio that measures joint significance of variables in explaining the dependent variables.

Table 4.10: Analysis of Variance (ANOVA)

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	19.714	5	3.943	2.411	.043[a]
	Residual	134.104	82	1.635		
	Total	153.818	87			
2	Regression	22.529	8	2.816	1.695	.113[b]
	Residual	131.289	79	1.662		
	Total	153.818	87			

a. Predictors: (Constant), EnergySource, ExperienceofPowerRationing, EnergyService, Effect of distance, MonthlyElectricityBill

by public agencies). At the same time private firms may also be attracted to invest when tarrifs are high because they are assured they can sell their megawatts are higher rates b Predictors: (Constant), EnergySource, ExperienceofPowerRationing, EnergyService, Effect of distance, MonthlyElectricityBill, Age, Gender, HighestEducation

c Dependent Variable: number of development projects

Source: Author's Computation

F-statistic is calculated by dividing the mean square of the regression model to the mean square of the residual (errors). A large F-statistic which is significant indicates presence of joint significance and that the model so constructed is applicable to the phenomenon being studied. Results of table 4.10 illustrates that at 5 degrees of freedom, the F=2.411 is significant at 5% level meaning that we are at least 95% confident that an F value this large enough did not happen by chance alone.

The next output presents a table of estimated parameters or coefficients that enabled the measuring of marginal effects; that is to say how much unit changes in an explanatory variable causes the dependent variable to change. The table also shows the direction of the relationship between the dependent and the independent variables (meaning whether such relationship is positive or negative/inverse) and also whether or not there is statistical significance in the causal relation (otherwise the relationship may not be consistent in different circumstances).

Table 4.11: Estimated parameters

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	7.209	1.674		4.307	.000
	Age	-.097	.184	-.059	-.530	.597
	Gender	-.068	.307	-.025	-.220	.826
	HighestEducation	.134	.123	.122	1.086	.281
2	(Constant)	7.710	1.833		4.206	.000
	MonthlyElectricityBill	.134	.148	-.105	-.906	.368
	ExperienceofPowerRationing	.605	.312	-.206	-1.940	.056
	Effect of distance	-1.087	.768	-.171	-1.417	.161
	EnergyService	-.074	.448	-.019	-.166	.868
	EnergySource	-.509	.260	-.214	-1.962	.053

a. Dependent Variable: no of dev projects

Source: Author's Computation

The constant represents the rate at which number of development projects (7) in an area remains even when the effect of all explanatory variables is nill. Controlling for age, gender and level of education of household heads, the number of development projects attributable to wind energy generation increases by 13% if the monthly bill rises by a shilling. Where there is erratic power rationing, the number of development projects to generate power increases by 60% as long as the area provides good environment for wind harvesting. The number of development projects attributable to a wind firm in an area becomes fewer by one for every kilometer away from the wind firm.

This implies that residents who are further away from wind firms benefit from fewer development projects implemented by the wind firm for surrounding communities. A unit rise in satisfaction on a likert scale causes the number of development projects to shrink by 7 percent.

Obviously satisfaction with current supply of energy will be a disincentive for new supply of energy. Finally when the energy source is different from electricity (if residents use charcoal, solar, kerosene, et cetera) the number of development projects related to wind declines because wind energy is a complement to electricity and new firms will want to ride on electricity infrastructure to implement wind energy generation.

4.6. Benefits of wind energy to the Person, Household and Society

The benefits of wind energy to the individual or household was felt to be creation of employment, provision of entertainment for children, generation of new business opportunities, improved security, less shortage of energy and power rationing, recreational site, among others

The advantages of wind energy at the society level are that it leads to welfare for example the project at Ngong has led to improvement of roads and construction of schools and chief's office. Beautification of Ngong, increased tourism and popularity of Ngong, has added power to national grid, improved infrastructure and security, increased power supply, by adding value to the land, no power rationing and increases business. It produces more energy using less resources than hydro, provides employment, acts as a land mark for giving direction and purifies the air; it provides tourism and recreation facility; still others felt that wind energy development leads to community development and awareness, educating students and recreation, educating young people on how wind energy works and improves the economy. Some respondents anticipated that wind will bring forth cheaper energy in the long run. Majority (95% felt that the distance from wind firm doesn't matter significantly when it comes to the benefits derived from wind energy generation. Almost all households sampled were within 10 kilometers of the Ngong wind propellers.

Future of Wind Energy

Table 4.12: Importance attached to wind energy

		Ngong		Marsabit	
		Frequency	%	Frequency	%
Valid	extremely important	13	7.3	14	14.6
	very important	82	45.8	68	70.8
	somewhat important	80	44.7	12	12.5
	Total	175	97.8	94	97.9
Missing	System	4	2.2	2	2.1
Total		179	100.0		179

Source: Author's Computation

As evidenced by the above table, using a Likert scale of "extremely unimportant" towards "extremely important", the survey respondents rated the energy sector as at least "important". The future of wind energy was anticipated to be bright and promising but public and private partnership would be necessary. Respondents indicated that the future can improve if more funds are directed into the sector, if more keen is given to it and when more people are educated, if awareness is created. The future of the wind energy sector also depends on whether the government plans to develop renewable energy source, if more wind energy is developed, the country will benefit from cheaper energy source. Some saw good prospects because wind is available. Lots of development will take place as a result but it might take long for any effect to be felt because such projects are long-term. But of more importance is that, people should be educated on how the sector works, uncertain because of political instability. Wind sector will be very useful especially when water levels are low and that was likely because hydroelectricity may decline given the climate change patterns. However it may slacken growth and lag behind if the government keeps focusing on hydro energy.

4.7. Other general comments regarding wind energy

Respondents suggested that they should be exempt from power rationing given that they lived around the wind power generation area. Others called for breaking up of the monopoly of Kenya

Power and provide financial support to wind firms. Wind energy was seen as clean (no pollution) but the government should create awareness about the available sources of energy and use the cheapest. The public should be educated about such cheaper means to generate power (including biogas and solar), get more financial help to install more masts. Eventually reliance on wind energy will help the country and community as the momentum to achieve vision 2030 takes shape.

Other comments were that we need people to be focused on improving the wind energy; there is need to embrace other cheap energy sources given the high costs of living in the economy. Wind energy is a good idea to increase megawatts going to the national grid and spread out to the rural areas; wind energy is more important than hydroelectricity due to outages; wind energy is important because it is cheap and environmental friendly.

The most available source is hydro-electricity which is expensive hence the need to switch to wind energy which is cheaper; they should improve infrastructure of the area to realize benefits. The energy generated should first help the community before others. Wind propellers should be put in many parts of the country, equipment import tariffs should be adjusted to reduce charges of installing energy in homes. Such projects should be promoted in the society through corporate social responsibility. The government should develop policies on such areas which will help us achieve vision 2030.

4.1. Focus group discussion (FGD) with Senior Managers of Kengen and Kenya Power

In order to get complete image of the issues surrounding development opportunities and investment in wind energy, it was also found to be imperative to also engage the opinions of generators and regulators of the energy sector. These were Kenya Electricity Generating firm (KENGEN) and Kenya Power which is the authorized state distribution company. The two firms were represented in the survey by senior manager wind division (Kengen) and manager of off-grid stations. Both of the mangers were experienced with at least seven years in their current employer and work designation hence had in-depth understanding of issues surrounding wind energy generation and impacts associated with the same.

Information provided by the two sectional heads indicated that the approximate proportion of Kenya's energy sources were as follows:

Table 4.13: Kenya's energy sources

Energy source	Proportion% of total	Recent change
Geothermal	12.9%	Increase
Thermal	34.3%	Increase*
Wind	0.3%	Increase
Solar	Not Known (insufficient data)	Increase
Hydro	48.5%	Decrease*

Note: * represents undesired direction of movement

Source: Author's Computation

Information gathered revealed geothermal, thermal, wind and solar are on the increase while hydro is declining. Thermal constitutes the largest source while wind is still small with a share of 0.3%. It was worrying to note that thermal energy (a non-renewable source) is on the increase and hydro (a renewable source) on the decrease. Most of the resources are currently directed to tapping geothermal. The senior managers felt that Kenya should put more emphasis on renewable energy especially geothermal, wind and solar. The biggest advantage with geothermal and wind is reliability except that wind fluctuates. Reasons for investing in wind sector ranged from the fact that wind is sustainable, cost effective and has pollution control. North Eastern part of Kenya provided the best location for wind harvesting due to fast velocity currents in the region.

The two firms acknowledged that they anticipated development opportunities (whether directly or indirectly) for communities as a result of wind energy generation at Ngong and Marsabit. These were mainly Corporate Social Responsibility (CSR) initiatives: employment creation during construction, improved business (tourism), repair of roads, and regional export revenues for county governments after implementation of the constitution in future. Another contemporary benefit that regions could negotiate is the Clean Development Mechanism (CDM) proposed under the Kyoto Protocol in 2008.

Given the energy implications of programs outlined in the vision 2030, Kenya was visualized to be in need of intense renewable energy. There was capacity to produce 1600MW but the current demand and system capacity is 1200MW. The call was for heavy capital and infrastructure investment (like extending power lines and power systems) all over the country but also interconnect with neighbors Uganda, Tanzania, Zambia, Rwanda and Burundi. Stretched out the system this way would increase the inertia and promote rapid investment in wind, solar and geothermal.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATION

5.1. Summary

This project aimed at establishing effect of wind power generation on development opportunities based on a case of Ngong and Marsabit wind firms in Kenya. Literature revealed that there is a shift toward renewable energy in both developed and developing worlds. In particular wind sector in Kenya is experiencing tremendous growth and contributing to welfare and community development. The effects of development are felt in terms of increased business, renovations and construction of schools roads and hospitals or even increased security among others. There was a gap of lack of knowledge with respect to if at all and how much development was happening at communities around Ngong and Marsabit arising from the wind firms that have been set up.

A field study was conducted in which 189 sample households and three implementing agencies of the wind power project in Ngong, Kajiado County and 94 households in Marsabit County from whom primary data was gathered by questionnaire method. Analysis was by descriptive frequencies and ordinary least squares. Findings reveal that actually the wind firms have contributed to development in Ngong and Marsabit areas. This chapter presents conclusion and suggests policy and general recommendations.

5.2. Conclusion

Ngong and Marsabit have strong wind currents and being near Nairobi, has both domestic and industrial consumers of electric energy. Thus the regions provide excellent case studies to provide lessons where implementers and stakeholders in wind energy sub-sector can learn from. Here we discuss and infer on some key findings from the study.

The first Objective ; was to establish whether the quality and quantity of wind power generation actually influence development opportunities. Indeed we noticed that the speed of wind determines the speed of propellers which connects to how fast turbines can rotate[23]. This nexus of relation eventually gets to amount of energy (mega-wattage or MW) that each section generates. The total MW for all sections is channeled together to the national grid (which happens to be Karen for the wind firm at Ngong and a. Marsabit thermal facility). Thus the speed of wind directly affects the potential quantity of energy generated. But since investment in wind is based on potential of energy produced and investment determines number of development opportunities (say infrastructure) in the region, then it is right to say that the quantity of wind directly determines the development attributable to wind energy investment in a locality.

The implication is that government needs to facilitate access to wind intense areas of the country such as northern and eastern regions (Nandi, Loiyangayani, Garissa and Mandera). Information dissemination needs to be improved so that data on location, facilities and potential of wind in this region is accessible to local and international investors.

The second Objective; was to determine how development opportunities are affected by customers wind power consumption/demand (awareness & knowledge level). Consumption here means the level of wattage a household utilizes per month. Because this is proxied by amount of monthly bills then even the tariffs and numbers of clients connected become important. Results showed that when tariffs and consumption are high, more investment in wind energy is experienced. Thus to encourage more development from wind energy requires additional demand. Policies that increase power demand (such as income earning opportunities) and power connectivity (such rural electrification) need to be sustained or enhanced.

The third objective; aimed at investigating how customer accessibility to the wind power generated relates to development opportunities. Distance from the wind firm was inversely

---

Speed of wind and availability are the most crucial determinants of choice of location by investors

Notably, the other very important determinant, alongside the speed of wind, is model/type of the turbine being used by the implementer (Albert, 2006).

related to the development due to wind energy. Indeed distance matters, access to society welfare resources such as schools and roads built as a result of developing wind resources.

Type of energy used by a household determines whether or not new energy is developed in a region. Specifically more wind energy projects will be attracted to areas where communities have intense electricity infrastructure such as power lines. Government needs to develop such infrastructure which will mitigate against higher expenses by investors.

5.3. Policy and General Recommendations

Wind energy generation has a direct impact on the challenge of energy security and climate change mitigation which are critical to social, economic and environmental sustainability. However, low information/education on the benefits, inadequate infrastructure and poor financing opportunities for investors can constrain rapid investment at a time the country is trying to switch to renewable energy. High priority should be given to reducing the heavy import taxes imposed on renewable energy equipment that are often higher than those imposed on competing energy systems.

In terms of policy and legal frameworks, pro-active and long-term policy-oriented renewable energy programs aimed at senior decision-makers in both government and the private sector should be initiated. Priority should be given to highlighting the real and tangible economic benefits (such as job creation and income generation) that renewable energy programs can deliver to the region at both the micro and macroeconomic levels.

The country needs better skills development in academic institutions. Long-term renewable energy training programs should be designed to develop a critical mass of locally-trained manpower with the requisite technical skills in the area of renewable energy production. The skills will permeate to community level to motivate switch to green energy for firms and households. Many of the engineering and technical courses that are currently taught at universities and colleges in Africa provide little exposure to energy technologies. Modest changes in the curricula of existing colleges and universities could significantly increase the supply of skilled renewable energy engineers, policy analysts and technicians.

Access to finance for investors needs to be enhanced. Banking institutions have unfavorable requirements for renewable energy financing. Conditions required included a feasibility study conducted at the applicant's expense, due to the limited knowledge on renewable energy by banks. In addition, the banks required land titles as collateral, portfolios of project sponsors and managers, data on past and current operations, approximate value of existing investment, a valuation report, raw material procurement plans, and the marketing strategy for the finished product (Turyareeba, 1993b).

Provision of Subsidies and concessions is also important. Experience has shown that most renewable energy technologies (especially those that can be locally manufactured) require subsidies only in the initial stages, and can become financially sustainable in the short to medium term after a certain level of technology dissemination has been attained. The government can even extend concessions and tax rebates to firms which are willing to operate in remote or rural areas as appreciation to employment creation and growth impetus such investments bring along.

Finally, it is important to study other non-renewable sources of energy. These include bio-fuels that requires planting greens that yield oil, geo-thermal, which is energy from hot water thrusting though earth's crust, solar and biogas. In March 2011, a national bio-fuel policy strategy that promotes and harmonizes development of sustainable bio-fuels in Kenya was presented to the country's national government. The draft strategy aims at increasing accessibility to energy (through bio-fuel production) and reducing dependence on imported petroleum products by 25 percent by 2030. The project is also expected to mitigate against environmental degradation and support rural development, economically, in pastoral and agro-pastoral areas. Further studies need to investigate how well individuals, households and firms can invest in such projects through which development opportunities will arise.

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Vestas wind company, Goldwind Wind Company, RE wind company, Vergent Wind Company, Gamesa Wind Company

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APPENDICES

LETTERS OF REQUEST FOR RESEARCH

FROM:

Wilberforce Imbiru Ndula
Box 103111-00101 Jamia
Tel: 0720299245
Nairobi-Kenya
17th January 2011

TO:

The Chief Engineer
Kenya Electricity Generating Company
Department Of Wind Energy Generation
Box
Nairobi-Kenya
ATTENTION: Christopher Maende, Head of Department

Dear Sir,

REF: REQUEST FOR WIND DATA INFORMATION UNDER YOUR CUSTODY

I do kindly submit my request for the above mentioned case. Currently I am a scholar at the University of Nairobi taking a master's degree course in Project planning and management. One of the requirements for the completion of the course is a research project in your area of interest as a student. This is a mandatory requirement as per the university academic regulation. My project topic is renewable energy and narrowing down to wind energy, thus the TITLE: THE INFLUENCE OF WIND POWER/ENERGY GENERATION ON DEVELOPMENT OPPORTUNITIES: A CASE OF NGONG AND MARSABIT WIND FIRMS IN KENYA

Having the same in mind I would kindly request any relevant information towards wind energy development as it is a fairly new discipline in the energy market in Kenya under commercial exploitation. Any information given for the same will be highly appreciated. I am looking forward to hear from you Many thanks in advance

Yours faithfully,

Wilberforce Ndula

Registration No: L50/76002/2009

FROM:

Wilberforce Imbiru Ndula,
Box 103111-00101 Jamia,
Tel: 0720299245
Nairobi-Kenya
8th February 2011.

TO:

The Head of Geography Department,
University of Nairobi,
Box 30266, Nairobi.

Dear Sir/Madam,

REF: REQUEST FOR A MAP OF NGONG REGION, KAJIADO COUNTY.

Currently I am a postgraduate student at the University of Nairobi taking a masters course in project planning and management. As a university policy approved by the senate one has to undertake a project research as part of fulfillment of the degree requirement. In line with this I am currently working on my project titled **TITLE: THE INFLUENCE OF WIND POWER/ENERGY GENERATION ON DEVELOPMENT OPPORTUNITIES: A CASE OF NGONG AND MARSABIT WIND FIRMS IN KENYA**

I therefore kindly request for the following information from your department; a digital map of Ngong region (area) indicating the following details: **-administrative regions/units, development infrastructure, the region up to date population, number of households using electricity, number of household not using electricity and any other information for this study.** Any assistance for the same will be highly appreciated. Many thanks

Yours faithfully,

Wilberforce Ndula

Registration No: L50/76002/2009

FROM:

Wilberforce Imbiru Ndula,

Registration No: L50/76002/2009

Box 103111-00101 Jamia,

Tel: 0720299245

Nairobi-Kenya

8th February 2011.

TO:

The Director General,

Kenya National Bureau of Statistics

Box 30266, Nairobi.

Dear Sir/Madam,

REF: REQUEST FOR A MAP OF NGONG REGION, KAJIADO COUNTY.

Currently I am a postgraduate student at the University of Nairobi taking a masters course in project planning and management. As a university policy approved by the senate one has to undertake a project research as part of fulfillment of the degree requirement. In line with this I am currently working on my project titled **TITLE: THE INFLUENCE OF WIND POWER/ENERGY GENERATION ON DEVELOPMENT OPPORTUNITIES: A CASE OF NGONG AND MARSABIT WIND FIRMS IN KENYA**

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Yours faithfully,

Wilberforce Ndula

Registration No: L50/76002/2009

RESEARCH QUESTIONNAIRE

I Wilberforce Imbiru Ndula, am a postgraduate scholar pursuing a Master's degree in Project Planning and Management from the University of Nairobi; I am carrying out a project research study on "**TITLE: THE INFLUENCE OF WIND POWER/ENERGY GENERATION ON DEVELOPMENT OPPORTUNITIES: A CASE OF NGONG AND MARSABIT WIND FIRMS IN KENYA**". I am seeking for vital information from you to enable me to carry out the study. Please complete this questionnaire in good faith and honestly answer all the questions. You are not required to state your name in the questionnaire and all the information you provide will be kept confidential to be used only for this academic purpose.

Q 1. User Demographic Information *(Please tick the appropriate box)*

a) Kindly state your age (Years): ☐ Below 20 ☐ 20-30 ☐ 30-40 ☐ Above 40

b) Kindly state your gender: ☐ Female ☐ Male

c) Kindly state the highest level of education you have achieved/Attained?

☐ Primary School ☐ High School or equivalent ☐ Vocational/technical school

☐ College ☐ Bachelor's degree ☐ Master's degree ☐ Doctoral degree

d) Kindly state your occupation?

☐ Student ☐ Business ☐ Professional ☐ Farmer ☐ Other (specify) --------------

Q2. Quality and Quantity of (wind) power produced *(Please tick the appropriate box)*

a) What source of energy do you use?

☐ Geothermal ☐ Thermal ☐ Wind ☐ Solar ☐ Electricity ☐ Other (specify)

b) Do you have other alternative sources of energy? ☐ Yes ☐ No
If yes, name them:____

c) What kind of service do you use the energy (electricity) for? ☐ Domestic use ☐ Industrial/commercial

d) Specifically, what do you use electricity for? ☐ Cooking ☐ Lighting ☐ Heating

☐ Others: ______________________________

e) How much do you spend on your electricity bills per month? (KSH):________________

☐ Below 500 ☐ 500-1000 ☐ 1000-2000 ☐ 2000 and above

f) At what time do you consume a lot of electricity?

☐ Morning ☐ Afternoon ☐ Evening ☐ At night ☐ All through out

g) Do you experience power rationing (shortage)? ☐ Yes ☐ No

If yes, how often is the rationing (shortage)?

☐ Daily ☐ Weekly ☐ Monthly ☐ Quarterly (3 mths) ☐ Semi -annually

h) Do you ever experience power surge? ☐ Yes ☐ No

If yes, how frequently?

☐ Daily ☐ Weekly ☐ Monthly ☐ Quarterly ☐ Semi -annually

i) How would you rate the service's value for money?

☐ Excellent ☐ Good ☐ Fair ☐ Poor ☐ Not Sure

j) How satisfied are you with the process of getting your queries on power surge resolved?

☐ Very Satisfied ☐ Satisfied ☐ Neutral ☐ Dissatisfied ☐ Very Dissatisfied

Q3. Public/customer awareness on (wind) energy/power *(Please tick the appropriate box)*

a) What sources of energy/power do you know?

____

____

b) How did you come to know of the various sources you have mention above?

____

____

c) Enough has been done on educating and informing people on various available cheap sources of energy/power

☐ Strongly Disagree ☐ Somewhat Disagree ☐ Neutral ☐ Somewhat Agree ☐ Strongly Agree

What makes you feel so?

d) What do you know about wind energy?

____

____

e) In your opinion what should be done to increase wind energy production in the country?

____

____

Q4. Accessibility and usefulness of wind power generation *((Please tick the appropriate box)*

a) How does wind energy generation at Ngong benefit you?

Personal/household level: ______________________________

Society level: ______________________________

b) How far is the wind firm from your home?______________________________

c) Does this affect you in any way? ☐ Yes ☐ No

If yes, how does it affect you? ______________________________

____

d) Does the wind firm help you in any other way apart from power generation? ☐ Yes ☐ No

If yes, specify in which way?

____

____

Q5. Literacy level of the community/customer *((Please tick the appropriate box)*

a) Where do you see the wind energy sector in the next few years?

____

____

b) How important is the wind energy sector to you?

☐ Extremely important ☐ Very important ☐ somewhat important

c) Any other comments?

____

____

THANK YOU FOR YOUR PARTICIPATION

RESEARCH QUESTIONNAIRE FOR IMPLEMENTERS

I, Wilberforce Ndula, am a postgraduate scholar pursuing a Master's degree in Project Planning and Management from the University of Nairobi; I am carrying out a project research study on "TITLE: **THE INFLUENCE OF WIND POWER/ENERGY GENERATION ON DEVELOPMENT OPPORTUNITIES: A CASE OF NGONG AND MARSABIT WIND FIRMS IN KENYA**". I am seeking for vital information from you to enable me to carry out the study. Please complete this questionnaire in good faith and honestly answer all the questions. You are not required to state your name in the questionnaire and all the information you provide will be kept confidential to be used only for this academic purpose.

A - COMPANY/ORGANIZATION ID

□ Kenya Power

□ KenGen

□ Other:______________________

B - DEMOGRAPHIC INFORMATION (PLEASE TICK APPROPRIATE BOX)

a) Kindly state your age (Years): □ Below 20 □ 20-30 □ 30-40 □ Above 40

b) Kindly state your gender: □ Female □ Male

c) Kindly state the highest level of education you have achieved/Attained?

□ Vocational/technical/ College □ Bachelor's degree □ Master's degree □ Doctoral degree

d) Designation at work:____

C - IMPLEMENTER OBJECTIVES OF (WIND) POWER GENERAZTION

k) What is your approximation of the relative proportion of Kenya's energy sources by type?

Energy source	Proportion (%) of total
Geothermal	
Thermal	
Wind	
Solar	
Hydro electric	
Other:___________	

a) What source of energy do you think Kenya should focus on most?

□ Geothermal □ Thermal □ Wind □ Solar □ Electricity □ Other (specify) -------------------

a) Compared to other renewable sources of energy, how important is the wind energy sector to you?

□ Extremely important □ Very important □ somewhat important

a) What motivated Kenya Power/KENGEN to invest in the Wind energy sector?

____

____

____

b) Which (wind energy) generation sites are best producers for Kenya by priority?

____

c) As an implementer, did you anticipate any community development benefits as a result of wind energy generation for Ngong and Marsabit? □ Yes □ No

d) Which ones?

____

____

____

How else do host communities stand to gain from investment in wind energy?

____

____

b) Where do you visualize Kenya in terms of renewable energy?

____

____

____

c) Where do you see the wind energy sector in the next few years?

____

____

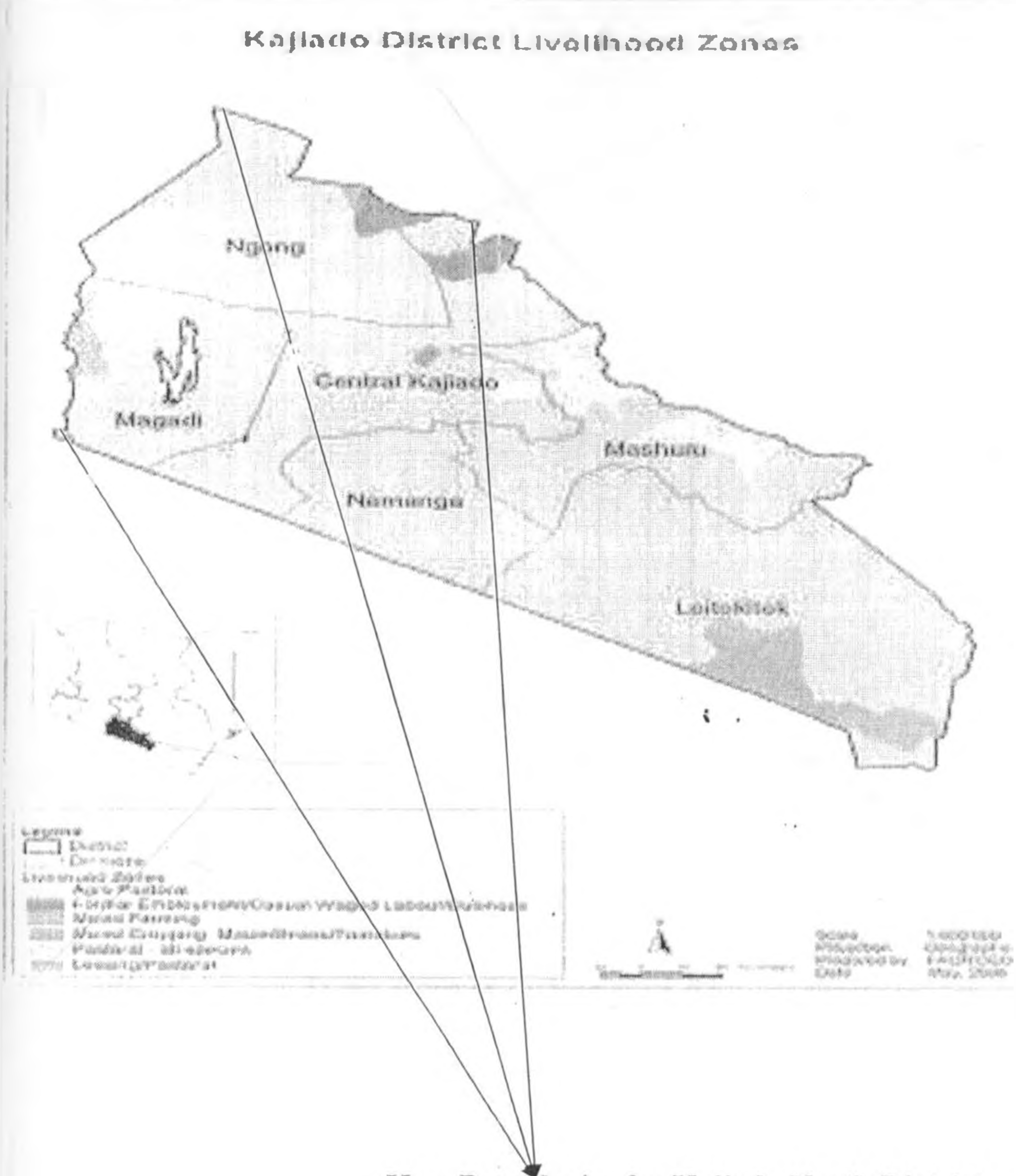
d) Any other comments?

____

____

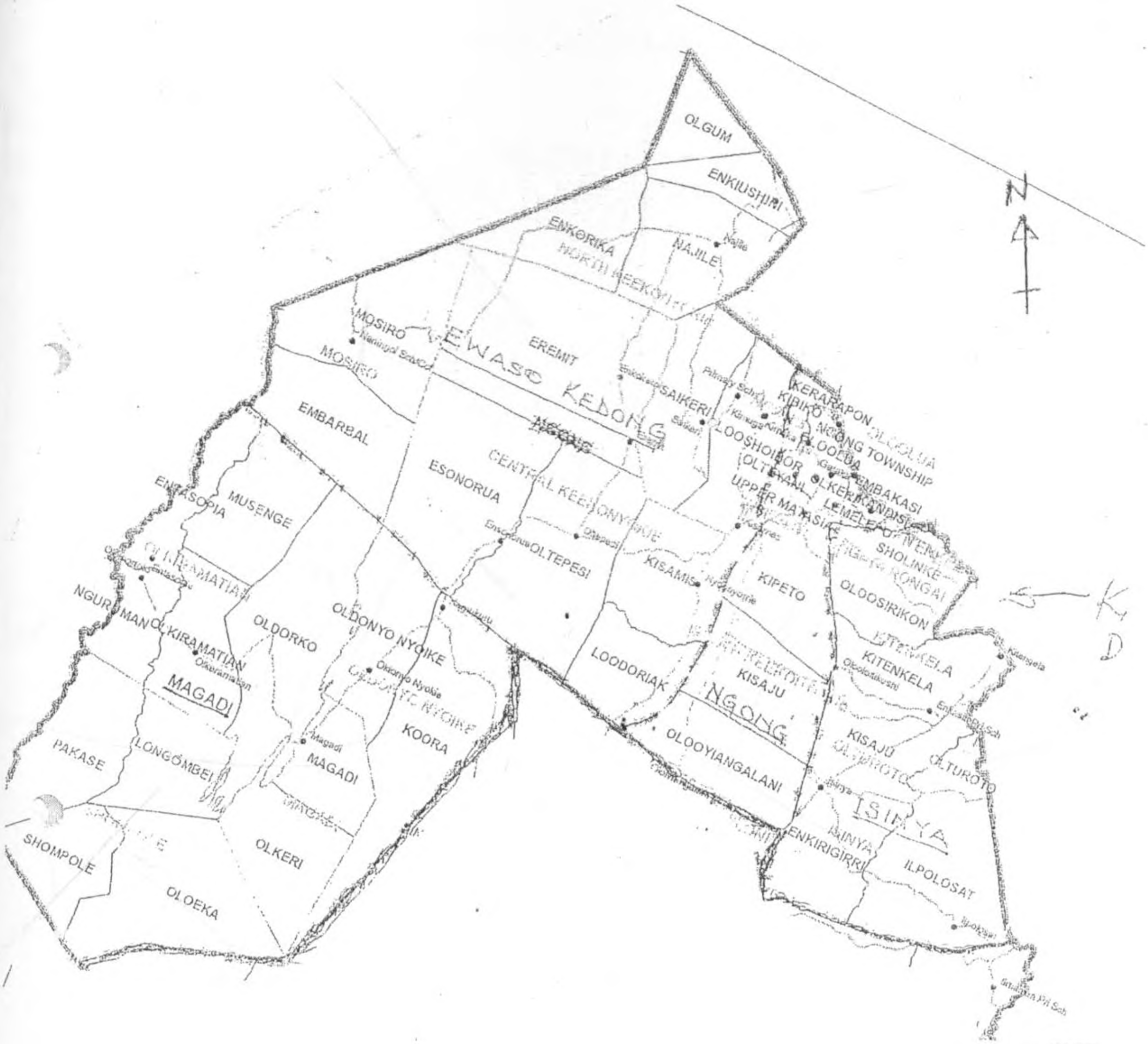
THANK YOU FOR YOUR PARTICIPATION

MAPS



Key: Boundaries for Kajiado North District

N/B: See the scanned Map for the District in the following page


OLGUM
ENKIUSHIRI
NAJILE
ENKORIKA
NORTH KEEKONYOKIE
MOSIRO
EREMIT
EWASO KEDONG
SAIKERI
EMBARBAL
ESONORUA
CENTRAL KEEKONYOKIE
KERARAPON
KIBIKO
NGONG TOWNSHIP
OLOOLUA
LOOSHOIBOR
OLTEYANI
EMBAKASI
OLKERI
UPPER MATASIA
LEMELEPO
SHOLINKE
OLOOSIRIKON
KIPETO
KISAMIS
OLTEPESI
MUSENGE
OLDORKO
OLDONYO NYOKIE
LOODORIAK
KISAJU
NGONG
OLOOYIANGALANI
KITENKELA
OLTUROTO
ISINYA
ENKIRIGIRRI
ILPOLOSAT
KOORA
MAGADI
NGURUMAN
OLKIRAMATIAN
PAKASE
LONGOMBEI
OLKERI
SHOMPOLE
OLOEKA
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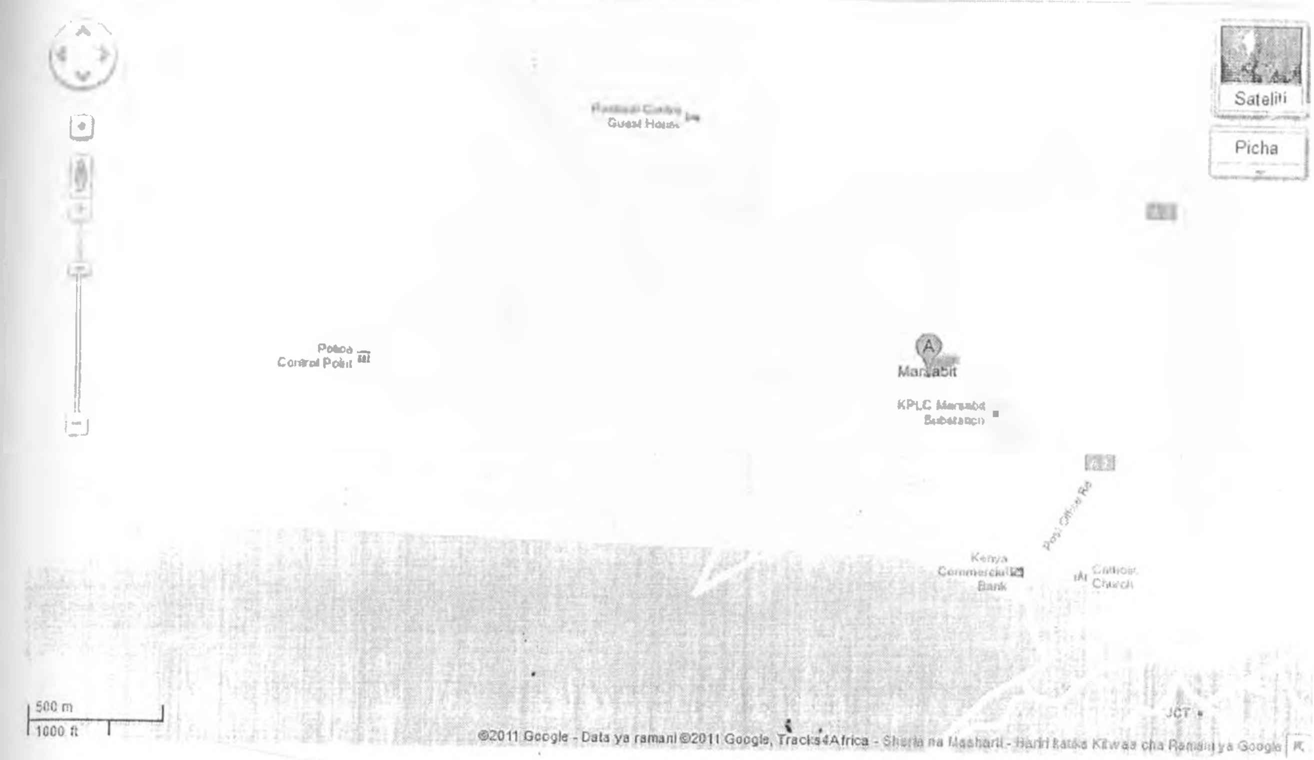
K
D

MARSABIT


Sateliti
Picha
Guest House
Police Control Point
Marsabit
KPLC Marsabit Substation
Post Office Rd
Kenya Commercial Bank
Catholic Church
JCT
500 m
1000 ft
©2011 Google - Data ya ramani ©2011 Google, Tracks4Africa

Preparing for Erection - Marsabit

"Students of Wind" Preparing to put their hard training to the test by raising the mast

HUMAN POPULATION DISTRIBUTION, NUMBER OF HOUSEHOLDS, AREA IN SQUARE KILOMETRES AND ADMINISTRATIVE UNITS IN KAJIADO NORTH DISTRICT, 2009 (Source: Kenya National Bureau of Statistics, 2010)

Table 1.6

Administrative Unit (Division)	Number of Male	Number of Female	Number of Household	Area in Sq. Km
Ewaso Kedong	18,208	19,065	7,501	2,934.3
Isinya	45,780	41,229	27,127	1,056.0
Magadi	13,039	12,412	5,610	2,694.0
Ngong	118,928	118,877	68,120	716.7
Total	**195,955**	**191,583**	**108,358**	**7,401.0**
	387,538			

Source: Kenya National Bureau of Statistics, 2010.

RAW ANALYSIS OUTPUTS

Experience of Power Surge

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	yes	85	47.5	54.8	54.8
	no	69	38.5	44.5	99.4
	4	1	.6	.6	100.0
	Total	155	86.6	100.0	
Missing	System	24	13.4		
Total		179	100.0		

Frequency

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	weekly	18	10.1	20.9	20.9
	monthly	47	26.3	54.7	75.6
	quarterly	16	8.9	18.6	94.2
	semi-annually	5	2.8	5.8	100.0
	Total	86	48.0	100.0	
Missing	System	93	52.0		
Total		179	100.0		

Distance

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid		6	3.4	3.4	3.4
	< 1 km	4	2.2	2.2	10.1
	1 km	7	3.9	3.9	9.5
	1.5 km	1	.6	.6	10.1
	10 - 12 km	2	1.1	1.1	11.2
	10 km	20	11.2	11.2	22.3
	10-12 km	2	1.1	1.1	23.5
	11 - 12 km	1	.6	.6	24.0
	11 km	2	1.1	1.1	25.1
	12 km	6	3.4	3.4	28.5
	1km	2	1.1	1.1	29.6
	2 km	14	7.8	7.8	37.4
	200 m	2	1.1	1.1	38.5
	3 km	14	7.9	7.9	46.4
	4 km	21	11.8	11.8	58.1
	5 km	27	15.1	15.1	73.2
	6 km	11	6.1	6.1	79.3
	600 m	1	.6	.6	79.9
	7 - 8 km	2	1.1	1.1	81.0
	7 km	9	5.0	5.0	86.0
	8 - 9 km	20	10.7	10.7	96.6
	9 - 10 km	5	2.8	2.8	99.4
	not sure	1	.6	.6	100.0
	Total	179	100.0	100.0	

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	.9417	3.7279	1.9545	.50887	88
Residual	-2.64078	3.18511	.00000	1.22844	88
Std. Predicted Value	-1.990	3.485	.000	1.000	88
Std. Residual	-2.048	2.471	.000	.953	88

a. Dependent Variable: noofdevprojects