DETERMINANTS OF ENERGY PRODUCTION ON SUSTAINABLE ENERGY IN OLKARIA GEOTHERMAL AND KENYA POWER STATIONS, NAKURU COUNTY, KENYA

BY

GIDEON KIPSIELEI

THIS DISSERTATION IS SUBMITTED TO THE FACULTY OF SOCIAL SCIENCES IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF A MASTER OF DEVELOPMENT STUDIES DEGREE FROM ST. PAUL'S UNIVERSITY

AUGUST 2020

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SUPERVISORS: DR. PAUL GESIMBA

DR. DAVID GICHUHI

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DECLARATION

This dissertation is a product of my own work and is not the result of anything done in collaboration. It has not been previously presented to any other institution. I agree that this dissertation may be available for reference and photocopying, at the discretion of the University.

Gideon Kipsielei. Signature: …… Date: 20/08/2020

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This research project has been submitted for examination with our approval as university student's supervisors.

Dr. Paul Gesimba Signature:…… Date: 20/08/2020

Senior Lecturer,

Department of Development Studies

St. Paul's University, Kenya

Dr. David Gichuhi Signature:…….. Date: 20/08/2020

School of Business,

Karatina University

DEDICATION

This dissertation is dedicated to my dear wife Zahra M. and my beloved children Kimoi M. Kigen M, Lulu M. for the support and prayers throughout this period. May God bless you and grant you your heart's desire.

ACKNOWLEDGEMENT

I humbly take this opportunity to thank God for the good health and for bringing me this far. I also want to extend special gratitude to my supervisors, Dr. Paul Gesimba and Dr. David Gichuhi, for the great partnership we made. Their continuous guidance, encouragement and patience in reading, correcting, re-reading and refining this dissertation were highly commendable. I also want to greatly thank my wife for cheering me on when I almost gave up. A special thanks also to St. Paul's University, all lecturers and staff for their contribution all through my education.

ABSTRACT

The purpose of this study was to evaluate energy production determinants on sustainable energy management in Olkaria Geothermal and Kenya Power stations in Nakuru County, Kenya. Energy is one of the most important resources in the growth of an economy. The generation of power is key to the effectiveness of sustainable energy management. Energy production warrants production hence connected to economic development. The specific objectives were: To assess the influences of sources of power on sustainable energy management, to examine the effects of technology and innovation on sustainable energy management, to assess the influence of operational costs on sustainable energy management, and the last objective was to analyze the effects of environment change on sustainable energy management in Olkaria Geothermal and Kenya Power Station, Nakuru County, Kenya. The study was informed by two theories namely; Socio-technical Transitions Approach Theory and Co-evolutionary Approach to Transitions. The study adopted a mixed research design which involved descriptive research design and cross-sectional design. The target population was 359 employees with a stratified sample design. The sample frame was 108 employees being 30% of the total population. The preliminary data was analysed using descriptive statistics and presented in the form of tables and graphs. Inferential statistics were employed through Pearson's Correlation analysis and regression analysis was used to test the study hypotheses at a 5% significance level. The findings indicated no statistically significant relationship between sources of power and sustainable energy ($r=0.186$; $p=0.071$). There was however a positive correlation between technology and innovation and sustainable innovation ($r=0.219$; $p=0.033$). Similarly, environmental change had a statistically significant relationship with sustainable energy ($r=0.286$; $p=0.005$). However, there was a negative correlation between the costs of operation and sustainable energy but a statistically significant relationship between the variables ($r=-0.376$; $p=0.000$). Further, the study revealed that cost of operations, technology and innovation, and environmental change have a statistically significant effect on sustainable energy in Olkaria Geothermal and Kenya Power Station, Nakuru County, Kenya ($p<0.05$). The study recommended that a similar study be conducted to investigate other determinants of energy production and their influence on sustainable energy.

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LIST OF ABBREVIATIONS/ ACRONYMS

CDM: Clean Development Mechanisms

KenGen Kenya Electricity Generating Company

KPLC Kenya Power and Lighting Company

MWe MegaWatts

SEM Sustainable Energy Management

CHAPTER ONE

INTRODUCTION

1.1 Chapter Overview

This chapter focuses on the background of the study and related issues from the global perspective to the region. The chapter discusses the effectiveness of energy management and its role in sustainable development, it also presents the statement of the problem, research questions, objectives of the study, significance of the study, limitations of the study, the hypothesis of the study and the scope of the study.

1.1.1 Background of the Study

Geothermal power is spread across the world and is tapped in various countries which include: Italy, New Zealand, Japan, Mexico, USA, El Salvador, Iceland, the Phillippines and Turkey (Tubei, 2019). It forms one of the best forms of clean energy in the world if properly harnessed and gives a substantial amount of energy. Geothermal power currently meets over 5.5% of Kenyans electricity consumption (Omenda, 2001). Geothermal energy set up is highly capital intensive and requires technology that can tap the thermal energy into electricity generation with a minimal environmental impact associated with its exploitation. A whole geothermal plant project takes from 5 to 10 years to complete (Dolor, 2005; ESMAP, 2012; Steingrimsson, 2014; Gudmundsson, 2016).

The Kenyan government embarked in the use of other energy sources to fill the gaps of relying on one source of power. According to RoK (2011) "if geothermal power is developed it would aid in meeting the current electric power demand of about 1191MWe". Thus, additional expansion is envisaged. The Clean Development Mechanism (CDM) creates a more powerful incentive for geothermal projects. Energy management is one of the main key driving factors that help in achieving the economic growth of any country. In Kenya, the country needs to have well-manageable energy which is geared towards the actualization of vision 2030 (Dalla Longa, & van der Zwaan, 2017). Among many other renewable energy sources, geothermal energy is ranked third in the category of MWe produced. Kenya is among the forefront African nations to explore geothermal energy from the crust of the earth in a more efficient and significant

approach (Eberhard, Gratwick, & Kariuki, 2018). Geothermal energy is a natural renewable source of energy which is natural heat that comes from the earth inner core and is stored in rocks and in water that is within the earth crust. In Kenya, the geothermal energy is extracted through the drilling of wells to tapping of the steam from the underground which is at high pressure. It is then led through pipes to drive electricity-generating turbines.

Matthíasdóttir (2010) states that "CDM has the potential to produce incentives for promoting and accelerating the development of geothermal energy utilization in developing countries." Currently, the alternate sources of energy are the great contributors of pollution in experienced in industrial areas. Hence there is the need for the Kenyan government to advocate and ensure that energy produced is not hazardous to its citizens. Sustainable energy development has become the goal of every nation across the globe and hence measures need to be put to achieve sustainable energy which is in line with the set climatic standards which helps in conserving the environment. If environmental conservation can be done, then this will ensure future sustainable energy.

Hák, Janoušková, and Moldan (2016) show that global coordination, monitoring, and modelling of socio-economic and environmental factors can effectively address climatic changes. The future clean atmosphere relies on the present mitigating factors that are put in place to ensure carbon dioxide reduction in the atmosphere. The renewable energy sources such as geothermal power help in eliminating many atmosphere problems offering sustainable energy sources.

Due to the high capital intensity required to develop a geothermal power station, geothermal projects have to go through a feasibility study in both economic and financial perspectives before their execution to identify the project's viability in the long run. In Kenya, the government has fully embarked on geothermal power by lately setting up another geothermal station at Menengai still in Nakuru county thus making the geothermal power tapped in this power stations in the year 2006 more than 301MWe (Kiruja, 2017).

1.2 Statement of the problem

Effective energy management helps in ensuring continuous use of energy in a well manageable manner that helps in protecting the environment that is sustaining the source of energy. Over the

years misuse of power sources has led to the severe negative impact on the environment which include: pollution, emission of greenhouse gases and land biodegradation among others. The main source of energy in Kenya is the use of Hydro Electricity which is harnessed through the use of water. Overexploitation of water resources has led to a power shortage in the country. Most of the river crosses in semi-arid areas of the country where they can be effectively used for irrigation farming but due to low water supply, there has been low food production to overexploitation of water resources.

The need for stable energy supply is vital in ensuring a continuous stable economic growth, hence the need for the government to tap other sources of energy to fill in the gap left by over-reliance of one source of energy. Tapping on other energy sources helps in the elimination of the high cost of power in Kenya. In the recent past, the government has embarked on the use of alternative sources of energy which include: solar energy, wind and geothermal energy. For example, the street lighting which is currently being installed especially in hot areas such as in Machakos County relies purely on solar energy.

Gehringer and Loksha (2012) confirm that geothermal power needs not to be a short-term measure of solving a country's power supply but a long-term measure for electricity generation that will enhance energy sustainability.

Kenyan companies and industries have been supplementing hydroelectricity by using standby generators due to the many instances of power loss; this has led to an increase in production cost as the use of diesel generators for production is expensive compared to the use of hydroelectricity. Therefore, this research focused on the determinants of energy production on sustainable energy management in Olkaria Geothermal and Kenya Power stations, Nakuru Kenya.

1.3 Objective of the Study

1.3.1 General objective

The purpose of this study was to focus on the determinants of energy production on sustainable energy in Olkaria Geothermal and Kenya Power stations, Nakuru County, Kenya.

1.3.2 Specific Objectives

i. To assess the influences of sources of power on sustainable energy in Olkaria Geothermal and Kenya Power Station, Nakuru County, Kenya.
ii. To examine the influences of technology and innovation on sustainable energy in Olkaria Geothermal and Kenya Power Station, Nakuru County, Kenya.
iii. To assess the influences of costs of operation on sustainable energy in Olkaria Geothermal and Kenya Power Station, Nakuru County, Kenya.
iv. To analyze the effects of environmental change on sustainable energy in Olkaria Geothermal and Kenya Power Station, Nakuru County, Kenya.

1.5 Research Hypotheses

H_{O1}. Sources of Power do not have a statistically significant effect on sustainable energy in Olkaria Geothermal and Kenya Power Station, Nakuru County, Kenya.

H_{O2}. Technology and Innovation do not have a statistically significant effect on sustainable energy in Olkaria Geothermal and Kenya Power Station, Nakuru County, Kenya.

H_{O3}. Costs of Operation do not have a statistically significant relationship on sustainable energy t in Olkaria Geothermal and Kenya Power Station, Nakuru County, Kenya.

H_{04}: Environment Change does not have a statistically significant relationship on sustainable energy in Olkaria Geothermal and Kenya Power Station, Nakuru County, Kenya.

1.6 Scope of the Study

The scope of the study was on determinants of energy production on sustainable energy. The study's main focus was to determine the contributing factors on enhancing sustainability hence sustainable development by the use of alternative sources of power. The study was conducted at Olkaria geothermal and Kenya Power stations, Nakuru County, Kenya. The target population was 359 employees working in these firms. The duration of the research was from October 2019 to June 2020.

1.7 Justification of the study

This study shall be important to the energy sector where the policy makers will be able factor in the realization of vision 2030. Over the years, the government has been at the forefront in

ensuring proper energy management and sustainable development. This will be achieved by having efficient resource utilization. Companies that entirely depend on electricity shall have an assurance of lower costs of production. This will ultimately contribute to the economies of scale. Since the local consumers pay the escalating prices, the locals will be the beneficiaries if the energy produced will have better economic value. The regulatory bodies will peg some of their decisions on the report presented to them. Most of the governing structure may need to be revised based on the recommendations made. This will give a chance for the new beginning of reduced prices of energy.

1.8 Limitations of the Study

Data collection proved to be challenge since most of the employees worked in shifts due to COVID-19. The researcher therefore liaised with the human resource manager and the questionnaires were administered via email. However, some were filled by hand and picked from designated spots in the company but in strict adherence to their work schedule. This prolonged the data collection period.

Olkaria Power station management had a lot of bureaucracy but the researcher managed to get approval to collect data.

1.9 Assumptions of the Study

The study presumed that government intervention in enhancing energy management in Kenya has a great impact on achieving sustainable development. The study also assumed that all the data collected through the administration of the questionnaire would be accurate and relevant to the questions asked. The other assumption was that different departmental heads would give the authorization to collect data.

1.10 Definition of Key Operational Terms

Renewable energy- This is the use of energy sources that cannot be depleted, for example, the use of solar energy, wind energy and geothermal energy.

Sustainable Development-sustainable development refers to any development that has continuous life despite the changes in the environment, that is, its continuity can be sustained for a long period.

Energy management- this may involve setting policies and procedures that are aimed at governing and regulating use of energy sources to ensure they are not misused or overexploited.

Clean energy- this refers to the various energy sources which are environmentally friendly, that is, they do not pollute the environment, for example, solar energy and wind energy.

1.11 Chapter Summary

This chapter introduces the study background and research problem statement. The study focus is on determinants of energy production on sustainable energy in Olkaria Geothermal and Kenya Power Stations in Nakuru County, Kenya. The chapter addresses specific research objectives and research hypotheses that defines the scope and significance of this study.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter presents a review of the empirical literature on effective energy management and its role in sustainable development a case of Olkaria Power station in Nakuru County, Nakuru Kenya. Sustainable energy is enhanced by various factors that are discussed in this chapter in the aim of filling the gaps that are as a result of poor energy management. This chapter also gives a critical review, conceptual framework and analytic literature with a summary of research gaps that need to be filled to achieve sustainable energy management.

2.2 Theoretical Literature Review

This study was anchored by two theories; Socio-technical transitions approach and co-evolutionary approach to transitions. These theories were used to justify how sustainable energy management can be realized.

2.2.1 Co-evolutionary Approach to Transitions

Foxon's (2011) developed a co-evolutionary approach to transition theory which is aimed at solving the challenges of high carbon energy systems into transitioning them into a low carbon system. Unlike Social technological theory, Foxon energy change management relies on the ecosystems, technologies, property rights, institutions regulatory framework and standards of organizations. Organization activities and strategies define the means of energy it uses and its capability to co-evolve into new energy innovations in society. These systems relate to each other and help in co-evolving with each social-technical system which helps in developing energy demand through technology influence, business and institutional practices.

The theory also helps in capturing the complexity, interaction, dynamic and mutual stability that can exist between different elements and players in the energy management systems. This theory focuses on putting across the agency of influencing different innovations and technological changes in the energy management sector by showing the importance of adoption of new energy management techniques which will help in sustainable energy management at any nation's economy as well as in the global economy sustainability.

This theory is hence relevant to the study as it relies on the need-based agency of adopting sustainable energy management techniques and formulation of low carbon energy use in the environment. In this study, the focus is on the need to transition which is manageable as compared to the previous energy changes in the nation. Fouquet (2010) suggests that large scale energy transition is vital in enhancing sustainable energy management globally. This theory acts as a driving vehicle which can be used to transition the county's present energy technique to more advanced energy technology which is sustainable and manageable in the long run.

2.2.2 Socio-technical Transitions Approach Theory

Shove and Walker in 2007 developed a social-technical transition approach theory which is aimed at sustainable energy development. The theory has over the years been developed under different scholars who have tried to show on the various approaches that can be used to enhance sustainable energy development. Geels (2010) states that the theory is presented as a change mechanism from one relatively stable state of the social-technical system to another. Transition entails invention of new technologies and various ways of achieving the usual results only in this case in a sustainable manner that will ensure continuity of such systems. In this case, this theory can be used to capture

different ways of energy development that can be developed to enhance more sustainable power management in the long run which protects and cares for the environment. According to Geels (2010), transition is a complex structure that entails different areas which include: technology, politics, industry and society.

Verbong and Loorbach (2012) describe the transition as a mega-scale transformation that makes use of high carbon transition to energy practices that emit low carbon through innovation technologies of different energy sources such as solar, wind and geothermal nationally and globally. Any transitions involve detailed research which is aimed at the construction and adoption of the set new changes which can be used to replace fully or partially the existing technology which helps in achieving sustainability and effective management. In most cases, radical changes have challenges in sailing through the existing practices due to regulations, user practices, infrastructure and maintenance networks which are all aligned to existing technology.

This theory was relevant to this study as it helps in explaining various ways that can be adopted in the society to enhance effective energy management starting at the community level as the society is able to embrace other sources of energy that are readily available and those that can be used to supplement the usual energy sources at the societal level. The theory also helped in explaining the various practices that can be adopted to enhance a smooth transition in the society which is nationally accepted. New technologies and innovations are easily developed using this theory as it focuses on the society level.

2.3. Empirical Literature Review

2.3.1 Sustainable Energy Management

The current demand for energy and its related services to satisfy human social and economic development, health and welfare are increasing. Individuals in the society now need energy services to meet basic human needs such as health, lighting, cooking, space comfort, mobility and communication and serve as generative processes (Edenhofer et al., 2011). Securing energy supply and curbing energy contribution to climate change are the two overriding challenges of the energy sector on the road to a sustainable future (Abbasi & Abbasi, 2010; Kaygusuz, 2012). Global statistics indicate that 1.4 billion people lack access to electricity, while 85% of them live in rural areas. As a result of this, the number of rural communities relying on the traditional use of biomass is projected to rise from 2.7 billion today to 2.8 billion in 2030 (Kaygusuz, 2012).

A significant climate change has become one of the greatest challenges of the twenty-first century. Its grave impacts may still be avoided if efforts are made to transform current energy systems. Renewable energy sources hold the key potential to displace greenhouse gas emissions from fossil fuel-based power generating and thereby mitigating climate change (Edenhofer et al., 2011). Sustainable development has become the centre of recent national policies, strategies and development plans of many countries. The United Nations General Assembly proposed a set of global Sustainable Development Goals (SDGs) which included 17 goals and 169 targets at the UN in New York by the Open Working Group. In addition, a preliminary set of 330 indicators was introduced in March 2015 (Lu, Nakicenovic, Visbeck, & Stevance, 2015). The SDGs place greater value and demands on the scientific community than did the Millennium Development Goals. In addressing climate change, renewable energy, food, health and water provision requires coordinated global monitoring and modelling of many factors which are socially, economically

and environmentally oriented (Hák, Janoušková, & Moldan, 2016; Owusu, Asumadu-Sarkodie & Ameyo, 2016).

Research into alternate sources of energy dated back in the late 90s when the world started receiving a shock from oil producers in terms of price hiking (Abbasi et al., 2011). It is evidential in the literature that replacing fossil fuel-based energy sources with renewable energy sources, which include: bioenergy, direct solar energy, geothermal energy, hydropower, wind and ocean energy (tide and wave), would gradually help the world achieve the idea of sustainability. Governments, intergovernmental agencies, interested parties and individuals in the world today look forward to achieving a sustainable future due to the opportunities created in recent decades to replace petroleum-derived materials from fossil fuel-based energy sources with alternatives in renewable energy sources. The recent launch of a set of global SDGs is helping to make sure that climate change for the twenty-first century and its impacts are combated, and a sustainable future is ensured and made as a bequest for future generations (Edenhofer et al., 2011; Lu et al., 2015).

Renewable energy sources replenish themselves naturally without being depleted in the earth; they include bioenergy, hydropower, geothermal energy, solar energy, wind energy and ocean (tide and wave) energy (Panwar et al., 2011). Tester (2005) defines sustainable energy as, "a dynamic harmony between the equitable availability of energy-intensive goods and services to all people and preservation of the earth for future generations". The world's growing energy need, alongside the increasing population led to the continual use of fossil fuel-based energy sources (coal, oil and gas) which became problematic by creating several challenges such as the depletion of fossil fuel reserves, greenhouse gas emissions and other environmental concerns, geopolitical and military conflicts, and the continual fuel price fluctuations. These problems will create unsustainable situations which will eventually result in a potentially irreversible threat to human societies (UNFCC, 2015). Notwithstanding, renewable energy sources are the most outstanding alternative and the only solution to the growing challenges (Tiwari & Mishra, 2011). In 2012, renewable energy sources supplied 22% of the total world energy generation (U.S. Energy Information Administration, 2012) which was not possible a decade ago. Reliable energy supply is essential in all economies for heating, lighting, industrial equipment and transport (International Energy Agency, 2014). Renewable energy supplies reduce the emission of

greenhouse gases significantly if replaced with fossil fuels. Since renewable energy supplies are obtained naturally from ongoing flows of energy in our surroundings, it should be sustainable. Despite the outstanding advantages of renewable energy sources, certain shortcomings exist such as the discontinuity of generation due to seasonal variations as most renewable energy resources are climate-dependent, that is why its exploitation requires complex design, planning and control optimization methods. Fortunately, the continuous technological advances in computer hardware and software are permitting scientific researchers to handle these optimization difficulties using computational resources applicable to the renewable and sustainable energy field (Baños et al., 2011).

Renewable technologies are considered as clean sources of energy and optimal use of these resources decreases environmental impacts, produces minimum secondary waste and are sustainable based on the current and future economic and social needs. Renewable energy technologies provide an exceptional opportunity for mitigation of greenhouse gas emission and reducing global warming through substituting conventional energy sources (fossil fuel-based) (Panwar, Kaushik, & Kothari, 2011).

2.3.2 Sources of Energy

International Renewable Energy Agency (IRENA) (2018) states that the increased pollution in the environment has raised concerns on the type and mode of energy used. The high cost of power has also led nations to embark on renewable energy sources in Kenya. IRENA (2018) defines renewable energy as energy produced from sources that are replenished constantly in its different forms where it directly or indirectly derives the sun or wind from heat generated from the core of the earth. International Energy Agency (IEA) (2005) refers to renewable energy as energy that comes from processes which are natural and they are replenished faster than their consumption. Renewable energy includes: geothermal, ocean resources, biomass, wind and solar energy. In Kenya, there are various large resources. Tester et al. (2012) refer to sustainable energy as harmony between availability and equitability of energy-intensive goods and services that are provided to people as well as ensuring that the earth is preserved for future generations.

Tiwari & Mishra (2011) show that renewable energy sources are the most efficient and effective alternative sources of energy that help solve the growing energy management challenges across

the globe. U.S Information Administration (2012) shows that by the end of the year 2012 the use of renewable energy sources in the world had increased to 22% of the total world's energy generation. This was characterized by the embracing of various countries towards adopting sustainable sources that would ensure energy continuity in the long run. The use of renewable energy sources reduces the risk of emission of harmful gases in the atmosphere that leads to global warming. Twidell & Weir (2015) states that consideration of sustainable biofuel should not increase carbon dioxide emissions because it can negatively affect as well threaten food security and biodiversity. The renewable energy source is then perceived as the solution that the nation should desperately need and invest heavily to renewable energy projects to achieve vision 2030 as well as sustainable energy for all by the end of the same year.

Sarkodie (2018) states that the growth of carbon dioxide in the atmosphere has increased over the past years. This has been greatly characterized by among many others, the use of petroleum energy in running the various industries as well the different modes of transport. The use of renewable energy is aimed at bridging the long-existing gap of the use of clean energy in running the various industries. To achieve sustainable energy management in the country, the use of clean energy acts as the driving factor that aids in ensuring environment conservation as well as the fight for scarce resources between human being and energy generation. A good example is derived from the 2013 power rationing program in Kenya which was a result of reduction of water levels in various dams. This did not only affect hydropower generation but also lack of water for both human consumption, animals and irrigation water. Over-reliance of the same natural resource may also lead to over-exploitation and climatic changes. This then fits the great use of renewable energy sources to substitute a significant percentage of the use of hydropower energy and petroleum products.

Førsund (2015) states that although hydropower does not emit greenhouse gasses it is hence a green source of energy which relies on water and may affect the socio-economic development of a country as water from various large sources are channeled to hydro dams hence creating conflict between the social development of communities and the production of hydroelectricity. Bioenergy being a renewable energy source which is derived from biological sources is effective renewable energy which can be used to replace the use of significant petroleum products for

transport and biodiesel. Bioenergy can also be used for electricity generation, cooking and heating. Urban and Mitchell (2011) highlight that the use of bioenergy does not create any conflict or competition between land for food use and land for energy use.

Many countries have embarked on the use of biofuels. In the U.S the use of biofuel has over the years increased significantly at a rate of 30-50% per year with at least 15 billion litres consumption in the year 2006 which was expected to grow to 30 billion litres by the end of the year 2012 (Ayoub & Abdullah, 2012). Bioenergy has a great potential to meet the goal of clean energy management and the reduction of emission of greenhouse gases and also in ensuring energy supply in the future. This makes it one the most reliable and sustainable fuel energy sources which is easily managed and creates a good relationship with the environment.

Geothermal energy is one of the renewable energy sources which can be used towards sustainable energy development. Geothermal energy is obtained from the earth's core as a heat energy source. The heat is as the result of the interior structure of the earth and the continuous magma movement which creates heat which is then released from the earth crust to the atmosphere. The geothermal energy is not always evenly distributed or even accessible mechanically or even possible to drill. Barbier (2002) states that heat from the earth crust can be mined through the sinking of wells to tap the heat to the earth surface and is used to drive turbines which produce electric energy. There are two geothermal energy stations in Kenya, that is, Menengai and Olkaria power stations which are harnessed and used to generate electricity. Geothermal energy is one of the most sustainable energy sources as it does not pollute the atmosphere or cause a reduction of the natural resources on the earth surface.

Manwell, McGowan and Rogers (2010) define wind energy as a process of harnessing kinetic energy from moving air in the atmosphere. Wind energy falls as one of the renewable energy sources which can be used in achieving sustainable energy management. Presence of wind is available in all parts of the world although wind energy is best harnessed in specific areas where wind movement has a strong speed especially in high raised areas such as mountains and hills. According to Edenhofer et al. (2011), the application of wind energy is important as it is used to drive large turbines which convert wind energy to electric energy. Ocean energy which includes

tides and waves also works similarly as wind energy only that this type of energy is harnessed offshore. Jacobson and Delucchi (2011) state that, "the faster the wind speed in the ocean, the longer the wind can be sustained and the greater the wind travels, the greater the wave height and the greater the wave energy produced."

Sarkodie and Owusu (2016) state that, "Renewable energy has a direct relationship with sustainable development through its impact on human development and economic productivity." Renewable energy sources provide effective energy security, energy access, social and economic development, reduction of environmental and health impacts as well as climatic change mitigation. Energy security can also be defined as energy sustainability as both have the idea of a continuous supply of energy relevant in the development and driving of an economy. Edenhofer et al. (2011) show that the relationship between energy consumption and economic growth relies on the access to quality, stable supply of energy. Also, in both developing and developed countries, energy is considered as important in different aspects such as political, technical and even the monetary aspect. Energy sustainability can hence be easily achieved as renewable energy sources are evenly distributed across the globe as opposed to fossils fuels which are only available to certain countries. The aspect of renewable energy resources being traded in the market reduces energy import and encourages diversification on the source of supply hence reducing an economy's vulnerability to price fluctuations in the energy market. Sources of energy create diverse portfolios which can be effective in the management of energy and the design of systems to make a country more energy secure and sustainable (Edenhofer et al., 2011).

2.3.3 ICT Integration

Information and communication technologies (ICT) is a term that is used to define all forms of technologies that are used in handling information that gives its communication in digital format. It also helps in the acquisition, processing, storage, creation, retrieval, exchange, transmission and dissemination of information. Chu, Cui, & Liu, (2017) suggests sustainable energy technology as the design that is aimed at eliminating negative impacts on the environment before the usage of any energy source. Sustainable energy development relies on ICT in developing and designing energy systems that not only protect the environment but also help in ensuring continuous energy production in the same system. Sustainable ICT energy helps in developing

energy with technology that helps in decarburization in both energy production and usage hence conserving the environment.

Pesch et al. (2017) state that the use of ICT integrated energy also helps in the minimal consumption of energy due to the development and innovation of low consumer machinery and effective ways of energy conservation. Madden & Weibrod (2008), state that, "industries should promote a shift not only from products and services but also to services that are increasingly environmentally sound." When ICT energy is managed, it adds sustainable energy design that promotes renewability of wasted energy to fully utilize the available energy resources and also promoting the use of sustainably-manageable energy sources.

Costanza (2016) shows sustainable energy in an economic view, and ICT sustainable energy management as the amount of energy that consumed is indefinitely without degrading energy and material sources. This is enhanced by linking technology and energy sources to avoid environmental damage and resource depletion. ICT can be integrated with renewable energy processes for the purpose of gaining sources of energy that are clean and to reduce environmental impacts which are negative to achieving sustainability in the achievement of social and economic needs. Panwar, Kaushik and Kothari (2011) describe renewable energy technologies as those that help in proving an alternative opportunity that can be used in mitigating greenhouse gas emission which greatly helps in the reduction of global warming by substituting the use of fossil fuels.

ICT integration has in the recent past proven to be the strongest change management in energy waste disposal. ICT is the main player that has recently been used in a low carbon economy by substituting the use of high carbon energy with an environmental-friendly energy source and also technology which helps in de-carbonizing waste products. ICT has a great impact on innovation influence on both renewable energy and also developing existing energy sources into clean energy. Reisch (2001) states that the use of ICT has positive potential in delivering clean energy that benefits the environment. The global conservation organization (2008) suggested ten ways ICT can be used in other economic sectors in helping them in energy efficiency and mitigating carbon dioxide emissions globally. Some of the ICT uses in achieving sustainable energy

management include: setting up of smart grid energy systems which include the innovation of the smart meters and communication technologies in the electricity network which has led to the effective energy management in the power usage sector. In Kenya, the use of prepaid electricity meters has not only helped to curb electricity theft but also effective electricity usage by the end consumer. Since the introduction of prepaid meters, consumers have been able to account for their power usage and to pay for the exact number of electricity units unlike before when electricity consumers used to suffer wrong and overstated meter readings and electricity bills.

According to Arcanjo (2018), the integration of ICT in energy management not only helps the country to effectively manage and document the power usage but also to account for every produced power. Integrated renewable energy solutions are best developed by simulating and analyzing the feasibility study on management tools which enable renewable energy deployment across the country. ICT also helps in developing smart city planning and lighting through technology simulation software that helps to improve urban designs which conserve energy. Sustainable energy which is ICT managed helps in software development with technology that helps in providing with tools that allow for monitoring, measuring and assessing the renewable energy sources and how they can be harnessed to effectively substitute the use of the existing fossil fuel energy. Technology awareness has proven to be the solution that helps in the mitigation of environmental pollution due to energy use or production and also in eliminating overuses of natural resources that are used for human consumption and energy production.

SE4All (2012) states that the use of ICT in energy management will go a long way in innovating new ways that can be used by the country to harness new renewable energy sources. The detailed feasibility study helps in determining the approach to be used in harnessing the energy and whether or not to invest in the project. Most of the renewable energy requires high technological machines to harness and to tap the energy and this is best achieved by the use of ICT in both the production process and distribution process. Technology in energy management helps in monitoring and evaluation of energy usage.

2.3.4 Costs of Operation

Vera and Langlois (2007) state that “access to clean, affordable, reliable and sustainable energy is key in achieving sustainable development.” This has formed the basis of any nation making energy affordable and available to ensure economic development. Puenyo (2018) suggests that

the lack of adequate stable energy has been the leading factor and hindrance to development majorly in developing countries such as Kenya. Also, this is a major contributor to water scarcity, food insecurity and climatic changes which all affect the health and wellbeing of the people. This is attributed to the high cost of energy connection and usage in the country. In Kenya, the high cost of energy has led to low energy connectivity and use as many people fear the high cost of energy consumption. UN (2015) shows that sustainable affordable energy has been the focus of worldwide debate on development, disaster risk reduction, environment and climatic change.

Cassidy (2014) states that the provision of stable and affordable energy to all people without harming the environment is a great challenge facing humanity today. This has been attributed to the use of fossil energy which has many negative impacts on the environment. This has then called for a debate on how to provide affordable stable energy which is accessible to all and doesn't pollute the environment. The future of developing countries like Kenya depends on the high use of energy towards economic development.

Kenya's Vision 2030 has industrialization as one of its main pillars which leads to economic development. This relates to a high-energy future which is mandated to protecting the natural resources to achieve high energy production which is environmentally friendly and leads to high economic growth. In Kenya, sustainable energy development has taken a new direction by focusing on renewable energy production which will lead to low production costs which will in turn translate to low distribution and usage costs. According to Wang (2013), financing of an efficient clean energy project development and its use is vital in ensuring energy stability as well as cost reduction which translates to energy connectivity to all. This is in line with the Kenya's Vision 2030 which aims at ensuring the availability of stable energy connectivity to all citizens. Gillingham et al. (2009) states that, "Energy solution that overlooks economic aspect and cost is not realistic, especially in developing countries where billions of people currently can't afford and access basic energy services."

According to Jairaj (2013), it is the mandate of the local civil society, government and other stakeholders to formulate and implement efficient energy policies that ensure equitability and availability of energy to all citizens. In Kenya, efforts towards energy cost efficiency measures have not been fully implemented despite the continuous focus on the country's electricity leading

provider, Kenya Power on power connectivity. The government through the ministry of energy has over the past years come up with ways that are aimed at ensuring cheap affordable energy rates that encourage economic development, especially in the small-scale businesses. It is also important for the government to involve the public in energy formulation and create awareness to the public on the various ways that can be adopted to reduce energy consumption. Reduced energy operation cost is a joint effort between both the citizen and the government through its energy suppliers Kenya Power.

According to Gillingham et al. (2009), "Energy markets and market prices influence consumer decision on energy consumption and investments in more energy-efficient products and equipment." For consumers to make well-informed decisions, they need to be aware of the efficient energy solutions and options that are available to them and on how they effectively use them as a measure aimed to reduce the cost of energy consumption. Hence, this calls for the government through its energy-producing agency, Kengen to continually tap all available renewable energy sources in the country. In the recent past, the country has increasingly embarked on harnessing renewable energy, for example at geothermal in Olkaria and Menengai, wind energy and solar energy. Kengen has continually developed the Olkaria power plant together with other renewable energy sources such as the wind energy project in Ngong hills. Setting up a geothermal power station is highly expensive but offers a cheap energy source in the long run as opposed to the use of hydroelectricity.

The government has in the recent past been at the forefront of adopting new energy strategies which have helped in reducing energy consumption cost to both individuals, organization and to the government itself. Solar energy has been the cheapest and easily harnessed form of energy even at the home level. The government has been sensitizing the use of solar panels to tap solar energy. This has been evident by replacing electricity lit street lights with solar street lights in areas which have high solar energy, for example, Machakos County solar street lights. The government has also introduced different home appliances which use low electricity through the adoption of Low Emitting Diodes (LEDs). The use of LEDs helps in saving energy up to 80% energy used on lighting and they have a high long life as opposed to the normal lighting bulbs. The use of electronic ballasts for fluorescent tube lighting saves energy as it uses up to 40% less energy, and is flicker-free. In 2010, the government through Kenya Power rolled out the

distribution of 1.25 million fluorescent tubes and 3.3 million energy-saving bulbs in 2013 in their phase I and II campaign on energy-efficient lighting program respectively, targeting the middle- and low-income households. In this exercise, Kenya Power was able to save an estimate of up to 60MW of energy in phase one and 150MW in phase two.

IRENA (2018) has been in the forefront in formulating cost analysis programs that are aimed at collecting the current high cost of energy operation and use. This has changed focus to the use of renewable energy technologies which not only offer cheap but also clean energy which conserves the environment and is stable in the long run. Since the start of the campaign on energy conservation and efficient energy production and use the government has recorded an increase in stable power production by 7%. In the recent past, the country used to suffer high rates of power shortages due to over-reliance of a single source of power which is hydropower. In 2010, the country suffered a power rationing program due to water reduction levels in the hydroelectric dams.

The government has since then heavily invested in other forms of energy especially stable renewable energy. The Olkaria power plant has then been ranked second largest power generating option after hydropower. This helps in ensuring power stability in the long run and hence the need for the government to continually invest on renewable energy sources in the country. Kenya has been making significant efforts in ensuring energy efficiency initiatives and programs. The country has formulated policies and regulatory frameworks which are aimed at protecting energy consumers and ensuring stable energy supply as well as environmental conservation. This has been achieved through efficient energy practices and awareness creation for both the consumers and suppliers in the country to maximize the cost-efficient benefits of efficient energy practices and inventions.

2.3.5 Environmental Change

Sarkodie and Owusu (2016) state that an increase in climatic change in the world has increased over the years causing the amount of carbon dioxide emission in the atmosphere to increase at an alarming rate. This rate has raised concerns not only with the scientists but also within political discussions that have been formed to look for solutions that can be used to solve climatic changes. Climatic changes in the atmosphere can be defined as the changes in the weather patterns that affect the seasons negatively and have adverse effects on the atmosphere mostly

associated with global warming. UN framework convention on climatic change points directly and indirectly to human activities which have over the years altered the composition of the atmosphere globally. This has eventually created a variance in the natural environment compared with earlier years.

Sarkodie, Owusu, and Jayaweera (2015) state that over the years, the world's climatic debate has been focusing on keeping global warming below 2°C. Climatic changes have highly been attributed to the use of fossil fuels which have increased and dominated as the main energy source and has led to high carbon emission in the atmosphere. Edenhofer et al. (2011) state that 2010 data on fossil fuel consumption accounted for the highest emission of greenhouse gases leading the concentration to increase to 390 ppm which is 39% above the preindustrial levels. This has then called for the country to resort to renewable energy sources which are clean energy sources and their uses decrease negative impacts in the environment. This is due to the production of less secondary waste which is sustainable based on the current and future social and economic needs. Renewable energy technologies offer a great opportunity that can be used to curb climatic changes by mitigating greenhouse gasses emission, global warming, reduction of environmental and health complications associated with pollutants found in fossil fuels energy sources.

Johansson et al. (2012) states that biomass energy has the greatest potential in reducing the greenhouse gases and enhance fuel supply. Biomass energy varies in different countries and this calls for a lot of research in focusing on the environmentally acceptable and sustainable sources to mitigate climatic changes (Demirbas, Balat & Ballat 2009). High climatic changes lead to a reduction of natural resources and these create conflict and over-exploitation of natural resources. Overexploitation of biomass energy can also lead to adverse effects on land and soil which will, in turn, affect the soil fertility leading to low food production. Biomass energy also faces a lack of adequate land for biomass energy production. Ajonivic (2011) states that, "most of the suitable land for biomass production is already in use. This calls for the proper operational management of biomass energy production to create positive results in mitigating climatic change.

Sustainable energy development has become the goal of every nation across the globe and hence measures need to be put to achieve sustainable energy which is in line with the set climatic

standards which helps in conserving the environment. In the recent past, environment conservation has been the backbone that ensures future sustainable energy. Global warming has increased, leading to land degradation which has over the years led to food shortages, and loss of both marine and wildlife.

The great contributor of pollution being carbon dioxide and is emitted in the atmosphere during energy production and usage of fossil fuels. In many industrial areas, climatic changes have been experienced over the years. This is because they are the main areas which emit a lot of carbon dioxide in the atmosphere. This has been proven by the availability of acid rains in industrial areas which leads to less vegetation as well as reduced soil productivity. Hák et al. (2016) show that global coordination, monitoring, and modelling of socio-economic and environmental factors can effectively address climatic changes. The future clean atmosphere relies on the present mitigating factors that are put in place to ensure carbon dioxide reduction in the atmosphere.

2.3.6 Government Policy

Kenyan energy management program is an act of parliament passed under the energy bill of 2017 which consists of laws that mandate both the National and County government in energy management functions which include: new energy sources exploration, promotion of renewable energy, geothermal energy utilization in large scale, regulation of petroleum and coal and regulation, production and supply of electric power in the country. According to Pesch et al. (2017), to achieve sustainable energy management in Kenya, the country needs to embrace other sources of energy to eliminate the over-reliance of the normally used sources.

Vision 2030, sustainable energy management is a key factor in realizing the vision as energy is the driving factor of all manufacturing industries, transport sector and security implementation. The vision projects that the growth of energy demand in all public and private sectors will heavily rely on electricity. In line with this vision, the government needs to work towards ensuring 100% access to affordable, efficient electricity to all Kenyans. The revised mission and vision in the national energy draft policy of 2015 envisions that access of quality, affordable electricity to all Kenyans can only be achieved by first increasing the production of electricity to ensure all-time electricity availability. This vision has led to the incorporation of other sources of

energy that can be used in electricity generation with the most efficient electricity generation source besides hydropower being geothermal power sources.

The Kenyan Constitution (2010) led to the devolution of governance in Kenya, allowing the National government and the 47 counties to work together in achieving sustainable energy management in Kenya. In the recent past, Turkana County with collaboration with the national government has successfully led in the exploration and drilling of petroleum energy in the county. Availability of petroleum in the country will go a long way towards the achievement of sustainable energy in the country as the country has its petroleum supply. For the country to achieve sustainable energy management, it has to continue with different energy explorations, innovation and expansion of the existing energy sources to ensure lifelong stable energy supply for the country.

United Nations Secretary-General Ban Ki-moon's dream was to save our planet, lift people out of poverty, advance economic growth and these are one and the same fight. Therefore he launched the Sustainable Energy for all Initiative (SE4All) (SE4ALL, 2013). This was followed by the declaration of the year 2012 as a sustainable energy year to sensitize nations in embracing different methods which could be used in achieving sustainable energy management. The main aim of the initiative was to work towards new investments which would accelerate the transformation of the world's energy systems, and work in the eradication of energy poverty and promote prosperity. This would be achieved by mobilizing all stakeholders to take firm action towards ensuring universal access to modern energy and to increase the global rate of energy efficiency. The initiative would also help in the increased focus on renewable energy development (SE4ALL, 2013).

The Kenyan government embraced the SE4All initiative as its timeline was in line with Kenya's Vision (2030). This was efficient to implement as the country had already developed an energy framework in the energy policy (2004) and the energy act (2006). The two documents have over the years helped the country to achieve significant development in energy management. President Kibaki's (2007), administration embraced this initiative by launching *"Umeme Mashinani"* and electricity connection loans to private individuals. The move led to high electricity connections in rural areas and accessibility of electricity to all was now beginning to be realized in the country. According to KPLC (2008) report, electricity connection in Kenya had

increased by 40%. The move has over the years led to an electrical connection across the country. The Ngamia one petroleum exploration in Turkana county, Olkaria geothermal station and Menengai Geothermal station projects were later initiated and developed with the main aim of ensuring available, clean energy in the country, which would be accessible and distributed across the country. The recent energy report, July (2018) states that the country through Kenya Power has connected over 70% of the country's homes with electricity and the country intends 100% power connectivity by the year 2030.

In 2013, Faith Odongo and Isaac Kiva who were working with the directorate of renewable energy sources in East Africa were tasked with rolling out the projects that would help governments in East Africa to effectively manage the energy sources towards sustainable development of the economy. Their report was in line with the Energy Regulatory commission (ERC) which was established under energy Act, 2006. The task acts as the management body of the country to regulate the power usage in the country sustainably. In 2012, Eng. Joseph Njoroge, Principal Secretary, Ministry of Energy and Petroleum Kenya said that through the help of ERC, the country had been able to manage its energy sources in a sustainable manner which also led to the expansion of the existing hydropower sources as well as the development of new projects like Menengai power station, Ngong wind power project and the Ngamia one oil project which were aimed at increasing energy sources in the country.

The ERC has driven the country towards achieving sustainable energy management through regulating economic and technical aspects of electric power, renewable energy sources and petroleum sectors. Keter (2017) states that the commission has not only been able to innovate new energy sources but also to implement regulations that will help the country in ensuring effective energy management through the protection of energy consumers, investors and other stakeholders, preparing strategic energy plans. The commission also maintains the nation's energy database and helps in monitoring and ensuring the implementation principle that protects all the players in the country.

Keter (2017) states that by 2014, there were nine power generation substations which transform 1846 MVA and 45 transmission substations with a capacity of 3181 MVA. The Kenyan government intends to grow this MVA output by increasing the capacity of the two geothermal

stations and tapping wind energy with a pilot project in Ngong hills which will add on the existing energy output. The country through achieving energy management and energy supply for all embarked on solar energy in 2014 through a project that would equip Kenyans in areas that lack electricity connectivity by having the capacity of tapping solar energy. It hence rolled out the M-kopa solar and intermedia solar panel which has covered 14% of Kenya's population who use solar energy for lighting and charging purposes. In 2013, the country had to implement a power rationing plan so as to meet the demand for electricity in the country in that year. This was characterized by a prolonged dry season which had led to the reduction of water levels in dams used in power generation. This then called for the government to come up with other energy sources which would be used to supplement the use of hydropower and hence the implementation of geothermal, wind and solar energy as sources of power which, if well managed and implemented, would supplement the sources of power.

2.4 Conceptual Framework

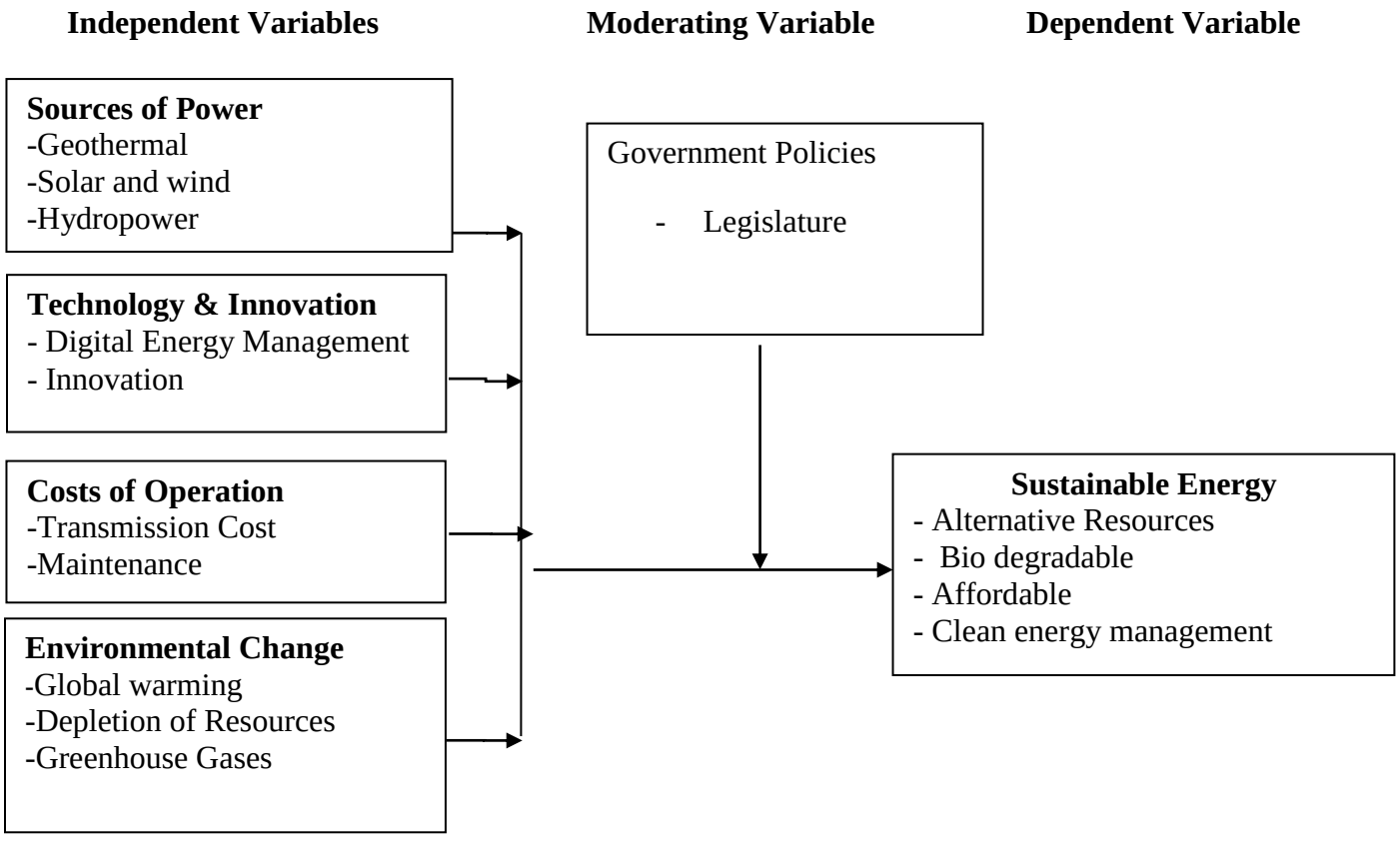


Figure 2.1: Determinants of Energy Production on Sustainable energy.

Source: Author (2020)

2.5 Summary and Gaps

Sustainable energy management is a critical aspect in achieving economic growth of any country and hence measures and innovation techniques need to be put in place to achieve effective energy management across the country. Energy is a driving factor for both the economic growth of any country as well as everyday human use as it helps in improving living standards. Embracing sustainable energy sources will help in realizing the country's continuous availability of energy. The main of the aim is to show the effectiveness of various energy management techniques in achieving sustainable energy management. The use of renewable energy sources has been proven to be sustainable and a shift from the use of fossil fuel energy to renewable energy would help in reducing climatic changes and its negative impact in the atmosphere.

The study has shown that the need for sustainable energy sources is not only a problem for developing countries but for the whole world where the United Nations has been in the forefront of ensuring sustainable energy for all programs. The Olkaria geothermal power station has shown the capability to significantly supplement a great percentage of the electricity and would be among the leading sources of clean sustainable energy. This has then shown the need for the government to develop and expand the various energy sources in the country to ensure the country realizes vision 2030 of 100% affordable, quality, sustainable energy to all homes. Renewable energy has also been shown not only to be sustainable but also produces clean energy which protects the environment as it does not emit greenhouse gases. This helps in reducing climatic changes and global warming in the world. The renewable source also helps in reducing resource conflicts between human beings, animals, plants and energy production. All renewable sources do not affect food production or affect water sources and they promote a clean environment which promotes good health.

ICT integration in sustainable energy management has shown to be among the leading factors that can help in ensuring effective energy management through the use of technology to connect electricity and to manage its usage. Technology has also been shown as one of the ways that can be used to innovate new ways of tapping to the new energy source and also to expand the existing energy sources to meet the country's energy demand. This study has shown the need for

the government to invest heavily in exploiting renewable energy sources and also to put up measures that will ensure 100% energy connectivity and effective energy management.

CHAPTER THREE
RESEARCH METHODOLOGY

3.1 Introduction

This chapter presents the methodology to be used for conducting the study. This involves the target population, sample size and sampling procedure, the research tools, pilot testing, data collection, data analysis techniques and research ethics.

3.2 Research Design

The research study adopted a descriptive survey design. Descriptive survey designs are used in studies to allow researchers to collect information, summarize the information, present and interpret the information. Kothari (2017) defines research design as a master plan which specifies data collection methods and procedures, and analysis of data which provides relevant information for a study. Cohen et al. (2003) state that descriptive survey research is meant to produce statistical information about aspects of education that interest policymakers and other users. In this case, the researcher intended to use the data to see the existing relationships hence descriptive survey design was appropriate.

3.3 Target Population

The target population was 359 employees from three companies namely: Geothermal Development Cooperation, Kenya Power and Olkaria Geothermal, Nakuru County. The total population comprised of 114 Kenya power employees and 245 employees from GDC and Olkaria Geothermal.

3.4 Sample Size and Sampling Procedure

The researcher used a proportionate stratified sampling method. A sample frame of 30 % was drawn from the total population. This allowed the researcher to draw a sample which was representative of each stratum. Any sample greater than 30 elements were considered large (Mugenda & Mugenda, 1999). Larger samples allowed for greater insight about the population characteristic and provided for more generalizations of the findings. Selecting a sample size was however done with respect to the size of the population as well as the resources and the time consideration. The division of employees in the facilities allowed the researcher to draw a

stratified sample that is homogenous within a sector (stratum and heterogeneous across the sectors (strata).

According to Cooper & Schindler (2014) sampling is done to lower costs, increase the speed of data collection, greater accuracy of results and availability of population elements.

Table 3.1: Sample Size of Employees Working in Energy Sector Companies Nakuru

Company	Strata	Number of Employees	Total Staff	30% Sample Size
Kenya Power	Engineer	8		
Staff	Management	12		
	Electrician	10		
	Support Staff	84	114	34
GDC & Olkaria Power				
Stations staff	Engineer	10		
	Management	16		
	Electrician	18	245	
	Support Staff	201		74
Total		**359**		**108**

Source: Human Resource Departments of each Firm

Respondents of the study were selected through systematic random sampling design. Before conducting the research, the researcher requested the Human Resource Managers of each company to provide the staff records. The sampling was then done by picking every *n*th employee until the sample size is filled the 108 item.

3.5 Data Collection Instrument

Primary data was collected using a self-administered questionnaire which entailed a combination of open and closed-ended questions. This enabled easier analysis as they were in a directly usable form while the unstructured questions were used to encourage the respondent to give an

in-depth and felt response without holding back in revealing any information. Kumar (2019) states that questionnaires are easy to administer to respondents who occupy a large scattered area. This type of data helped in providing the accurate status of the problem under study.

3.6 Validity and Reliability of the Instruments

The study used content validity and criterion-related validity. Content validity focused on the extent to which a data collection instrument provides enough coverage of the topic being studied. This was achieved by cross-checking that all items reflected on the instrument. The set of items accurately represented the variables under study. Criterion validity related to the ability of an individual to predict or estimate the existence of a current condition. This was achieved through pilot testing which was carried out to test the accuracy of language and comprehension of meanings and to test whether the pilot respondents understood the instruments. The pilot study was carried out at Kenya Power, Nairobi with about 20 employees. Baker (2002) established that a sample size of 10 to 20 per cent of the sample size for the actual study is a reasonable number of respondents to consider for participation in a pilot study.

Kimberlin and Winerstein (2008) define validity as the extent to which results are interpreted and warranted to achieve the results so that they can serve the intended purpose. Validity can also be defined as the degree to which results obtained from the analysis of the data represent the phenomenon under study (Mugenda & Mugenda, 2003). It is the accuracy and meaningfulness of inferences, which are based on research results. It means the agreement between the value of measurements and its true value. Validity is quantified by comparing measurements with values that are as close to the true values as possible. When validity is poor, the precision of the study is undermined because it becomes difficult to establish the relationship between the variables.

Reliability is the degree to which results obtained from the analysis of the data represent the phenomenon under study (Hair et al., 2017). Poor reliability degrades the precision of a single measurement and reduces the ability to track changes in measurements in a study (Mugenda & Mugenda, 2003). This was tested using Cronbach Alpha coefficient which was computed using Statistical Packages for Social Science (SPSS) to determine internal consistency. A pilot study was conducted in Nakuru Geothermal Development Company (GDC) and the data was used to determine the reliability of the study instrument. Studies have shown that Cronbach reliability

alpha coefficient value of 0.7 and above is judged as being reliable (Saunders, Lewis & Thornhill, 2009).

3.7 Data Analysis and Presentation

The questionnaire was first edited and coded to ensure completeness and accuracy. The data were analysed using SPSS. The data were analysed through the use of descriptive statistics and inferential statistics. The preliminary data was analysed using descriptive statistics and presented in the form of tables and graphs.

Inferential statistics were employed through Pearson's Correlation analysis and regression analysis was used to test the study hypotheses at a 5% significance level. The combined effect of sources of power, technology and innovation, costs of operation and environmental changes were tested using the Multiple Regression Model below.

$$y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \varepsilon$$

Where;

Y= Sustainable Energy Management

α =constant

$\beta_1 \ldots\ldots \beta_{4d}$= parameter estimates

X_1 = Sources of Power
X_2 = Technology and Innovation
X_3 = Operation Cost
X_4 = Environment change effects
ε = the error of prediction.

3.8 Research Ethics

The researcher first sought necessary authoritative letters and also considered to have an introductory letter from the university which were presented to relevant authorities. All information gathered was handled with confidence. The information collected was presented to the research subject organisation for adoption. The research process was adhered to without manipulation of data and was purely used for academic purposes.

CHAPTER FOUR

DATA ANALYSIS, PRESENTATION AND DISCUSSION OF FINDINGS

4.1 Introduction

This chapter presents the results of the study. The data were analysed through descriptive and inferential statistics. The chapter presents the response rate, respondents' personal information, sources of power, technology and innovation, costs of operation, environmental change, government policy, and sustainable energy. These results are presented in form of tables and graphs.

4.2 Response Rate

A total of 108 questionnaires were issued and 97 questionnaires were returned. out of which 97 questionnaires, 95 of them were properly filled. This gave a response rate of 87.9%. According to Mugenda and Mugenda (1999, 2003), a response rate of 50% is considered as adequate while 60% is perceived as good but a response rate of 70% and above is considered as excellent or very good. This research posits a response rate of 87.9% which is adequate for justifying and generalizing the study's findings.

4.3 Background Information of Respondents

The information presented in this subsection is on gender, age, duration of service, the highest level of education and position in management.

4.3.1 Gender of Respondents

The findings on the gender of the respondents are presented in Table 4.1.

Table 4.1: Gender of Respondents

Gender	**Frequency**	**Percent (%)**
Male	53	55.8
Female	42	44.2
Total	**95**	**100.0**

The results in Table 4.1 show that there were 55.8% male respondents and 44.2% female respondents who participated in the study. This is an indication that gender parity exists among the employees of Olkaria Geothermal, GDC and Kenya Power Stations in Nakuru County, Kenya.

4.3.2 Age of Respondents

The findings on the age of the respondents are presented in Table 4.2.

Table 4.2: Age of Respondents

Age Category (years)	Frequency	Percent (%)
25-34	41	43.2
35-44	32	33.7
45-54	19	20.0
>55	3	3.2
Total	**95**	**100.0**

The results in Table 4.2 show that 43.2% of the respondents were aged between 25-34 years, 33.7% of the respondents were aged between 35-44 years, 20.0% of the respondents were aged between 45-54 years, and 3.2% of the respondents were aged more than 55 years. These results are an indication that the majority of the respondents were aged between 25 and 34 years implying that they were energetic. In the energy sector, this group is considered vital in carrying out day to day operations as well as field supervision of energy production activity.

4.3.3 Duration of Service

The findings on the respondents' duration of service in the organization are presented in Table 4.3.

Table 4.3: Duration of Service

Duration of Service	Frequency	Percent (%)
Below 5 years	26	27.4
5-10 Years	35	36.8
11-15 Years	21	22.1
16 years and above	13	13.7
Total	**95**	**100.0**

As indicated in Table 4.3, 27.4% of the respondents had worked in their respective organizations for below 5 years, 36.8% had served for 5-10 years, 22.1% had worked for 11-15 years, and 13.7% had worked for 16 years and above. Most of the respondents had worked in their respective organizations for 5-10 years or more which is an implication that the respondents properly understood the operations of their organization and would provide the needed information based on the knowledge they had acquired over the years.

4.3.4 Level of Education

The findings on the level of education of the respondents are presented in Table 4.4.

Table 4.4: Highest Level of Education

Highest Level of Education	Frequency	Percent (%)
Secondary School	1	1.1
College Certificate	6	6.3
Diploma	27	28.4
Bachelor's Degree	43	45.3
Post-Graduate Degree	18	18.9
Total	**95**	**100.0**

The study sought to understand the highest level of education of the respondents and as shown in Table 4.4, over 90% of the respondents had acquired post-secondary education. This is an indication that the majority of the respondents were able to understand the questionnaire and the questions posed therein.

4.3.5 Position in Organization

The positions that the respondents held in the organization were studied and the results indicated in Figure 4.1.

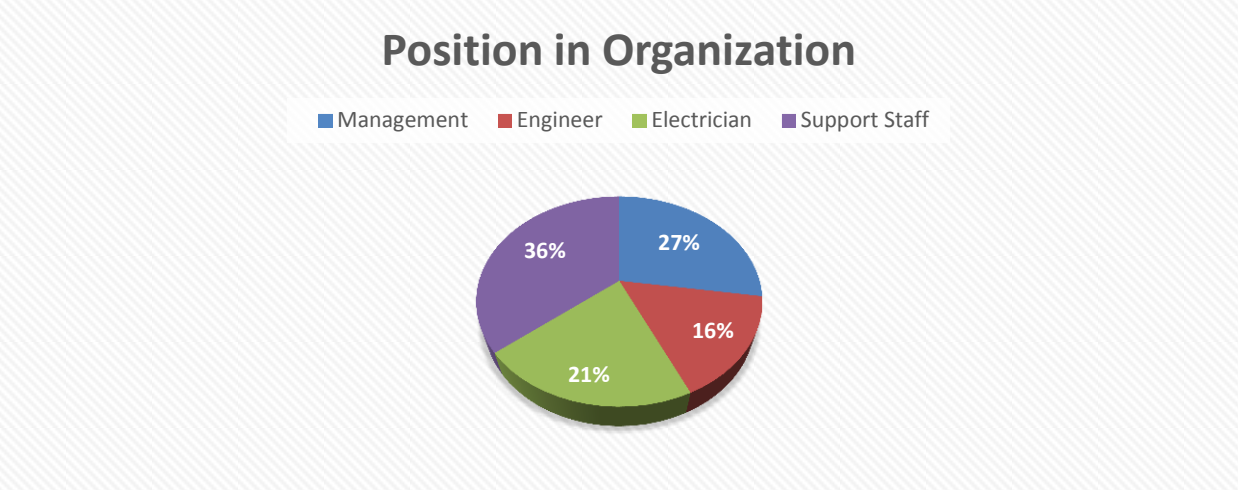


Figure 4.1: Position in Organization

As indicated in Figure 4.1, respondents who were at the management level were 27%, engineers were 16%, electricians were 21%, while the support staff were 36%. This implies that majority of the respondents were support staff which is at the operations levels. This was of value in this study as they understood how the operations of the organization take place.

4.4 Sources of Power

The first objective of the study was to assess the influence of sources of power on sustainable energy in Olkaria Geothermal and Kenya Power Station, Nakuru County, Kenya. The study sought to understand the sources of power in the organizations and the results are shown in Figure 4.2.

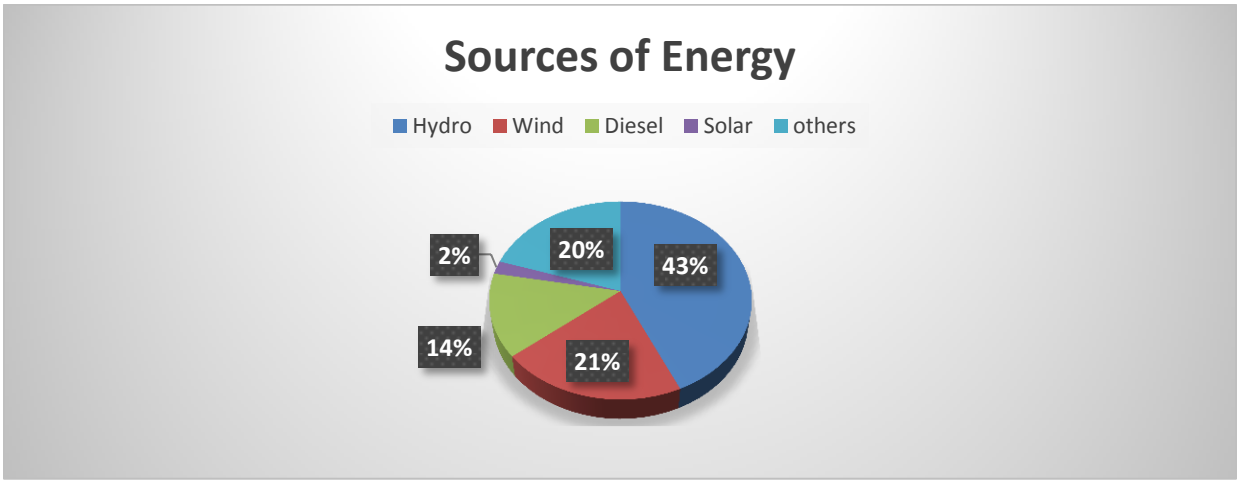


Figure 4.2: Sources of Energy

As indicated on Figure 4.2, 43% of the respondents indicated that their organization used hydro energy, 21% used wind energy, 14% used diesel, 2% used solar energy and 20% used other sources of energy such as thermal energy. There are diverse renewable sources of energy that are used on the organizations. These results agree with the results of Tiwari and Mishra (2011) who found out that across the globe, alternative sources of energy are being used. Adopting sustainable sources is important in ensuring that there is continuity of the energy in the long run.

This study also sought to find out the different aspects of the sources of power and the results are indicated in Table 4.5.

Table 4.5: Sources of Energy

	Item	Yes (%)	No (%)
1.	The use of renewable energy sources helps in realizing sustainable energy.	97.7	2.1
2.	Geothermal power heavily relies on other substitutes to generate power.	85.3	14.7
3.	Geothermal power is one of the leading renewable sources of energy that will help in sustainable energy.	97.9	2.1
4.	Geothermal has helped to bridge the gap of energy shortage in Kenya	98.9	1.1
5.	Geothermal exploitation should be continually developed in Kenya	97.9	2.1

6. Other sources of renewable energy sources should be developed towards achieving sustainable energy management	88.4	11.6

As indicated in Table 4.6, 97.7% of the respondents indicated that the use of renewable energy sources helps in realizing sustainable energy. Also, 85.3% of the respondents agreed that geothermal power heavily relies on other substitutes to generate power. The results also show that 97.9% of the respondents agreed that geothermal power is one of the leading renewable sources of energy that will help in sustainable energy. Additionally, 98.9% of the respondents were in agreement that geothermal has helped to bridge the gap of energy shortage in Kenya. Moreover, 97.9% of the respondents agreed that geothermal exploitation should be continually developed in Kenya. The results also show that 88.4% of the respondents believed that other sources of renewable energy sources should be developed towards achieving sustainable energy management.

Agreeing with these results, Twidell and Weir (2015) found out that renewable energy sources are important and countries such as Kenya should invest in projects that support renewable energy as they help to achieve sustainable energy. This not only contributes to ensuring that over-reliance on the same natural resources is reduced, but the country can achieve its Vision 2030. Substituting the renewable energy sources helps to blanket the natural resources especially in times of unpredictable climatic changes.

4.5 Technology and Innovation

The second objective of this study was to examine the influences of technology and innovation on sustainable energy in Olkaria Geothermal and Kenya Power Station, Nakuru County, Kenya. The findings were recorded in Table 4.6.

Table 4.6: Technology and Innovation

	TECHNOLOGY AND INNOVATION	SD (%)	D (%)	U (%)	A (%)	SA (%)
1	The plant and machinery system has been incorporated with high level of technology.	2.1	16.8	9.5	55.8	15.8
2	There is a strong link between technology and innovation.	0	9.5	4.2	53.7	32.6
3	Research and development have contributed to innovation.	1.1	8.4	7.4	54.7	28.4
4	Office automation has been incorporated in energy management skills.	1.1	37.9	6.3	36.8	17.9
5	Geothermal power production highly relies on available technology.	1.1	8.4	7.4	68.4	14.7
6	Technology and innovation are key in tapping renewable energy sources in Kenya.	1.1	5.3	6.3	61.1	26.3
7	Technology and innovation has been adopted by majority of the staff.	1.1	41.1	11.6	32.6	13.7
8	The company has adopted digital energy management technology.	4.2	31.6	5.3	44.2	14.7

SA= Strongly agree A= Agree U= Uncertain D= Disagree SD= Strongly Disagree

The findings in Table 4.6 show that 55.8% of respondents agreed that the plant and machinery system has been incorporated with a high level of technology. There was an indication that over 80% of the respondents believed that there is a strong link between technology and innovation. Among the respondents, 54.7% agreed that research and development have contributed to innovation. Also, the results show that majority of the respondents (37.9%) disagreed that office automation has been incorporated in energy management skills in the organizations. There was an over 80% agreement among the respondents that geothermal power production highly relies on available technology. Additionally, 61.1% of the respondents agreed that technology and innovation are key to tapping renewable energy sources in Kenya. The findings also show that

41.1% of the respondents disagreed that technology and innovation have been adopted by majority of the staff. Interestingly, 44.2% of the respondents agreed that their company has adopted digital energy management technology.

According to Ockwell and Byrne (2016), in renewable energy technology, there is a challenge on whether the technologies used can produce enough power which can be maintained as required. The cost of power generation from specific technology should be affordable enough to ensure that when compared to other available options, productive activities are viable economically. On the hand, when it comes to the provision of sustainable energy organizations, Gollwitzer et al. (2018) focus on methods of selecting appropriate technology, adoption of the technology and also an improvement to technology efficiency. In Kenya, there has been a focus on ensuring that the right technology is adopted for sustainable energy access to be attained. However, when the organization adopts technological innovations but does not involve the staff and consumers in understanding the technologies, there is a likelihood that sustainable energy management will fail.

4.6 Costs of Operation

The third objective of this study was to assess the influences of costs of operation on sustainable energy in Olkaria Geothermal and Kenya Power Station, Nakuru County, Kenya. The findings were recorded in Table 4.7

Table 4.7: Costs of Operation

	Item	Yes (%)	No (%)
1.	The expenses incurred at the time of production greatly determine the end product value	94.7	5.3
2.	Geothermal power has the least maintenance costs	52.6	47.4
3.	The energy costs vary depending with the sources of energy.	86.3	13.7
4.	The vision of the organization is to take lead in offering reliable and efficient power.	95.8	4.2
5.	The Kenyan government is working towards making geothermal power sustainable.	87.4	12.6
6.	Are there any government offered subsidies to help in cutting cost on	57.9	42.1

consumers?		
7. The costs of operation have been manipulated by the management in the supply chain towards the consumption	45.3	54.7

As indicated in Table 4.7, 94.7% of the respondents agreed that the expenses incurred at the time of production greatly determine the end product value. There was a 52.6% agreement that Geothermal power has the least maintenance costs. It was also indicated by 86.3% of the respondents that the energy costs vary depending on the sources of energy. Majority of the respondents (95.8%) indicated that the vision of their organization was focused on taking the lead to offer reliable and efficient power. Likewise, majority of the respondents (87.4%) agreed that the Kenyan government is working towards making geothermal power sustainable. Also, 57.9% of the respondents agreed that the government provides subsidies to help in cutting cost on consumers. Majority of the respondents (54.7%) also disagreed that the costs of operation have been manipulated by the management in the supply chain towards the consumption.

In agreement with these findings, Puenyo (2018) states that in developing countries, such as Kenya, there are still hurdles in accessing sustainable affordable energy. This is due to the lack of adequate stable energy. The result is that there are high costs of energy at the production stage which are passed on to the connection and usage phases. The energy consumption incurs high costs. Moreover, Merem et al. (2019) found out that the source of energy determines the costs of energy. However, when it comes to geothermal power, there are electricity power tariff reductions for the consumers. Additionally, with geothermal power, there is reduced operational costs for the firms. While geothermal power is capital intensive, its low maintenance costs have the potential for achieving overall economic prosperity for Kenya.

This study also sought to investigate the reliability and efficiency of geothermal power and the results were recorded in Figure 4.3.

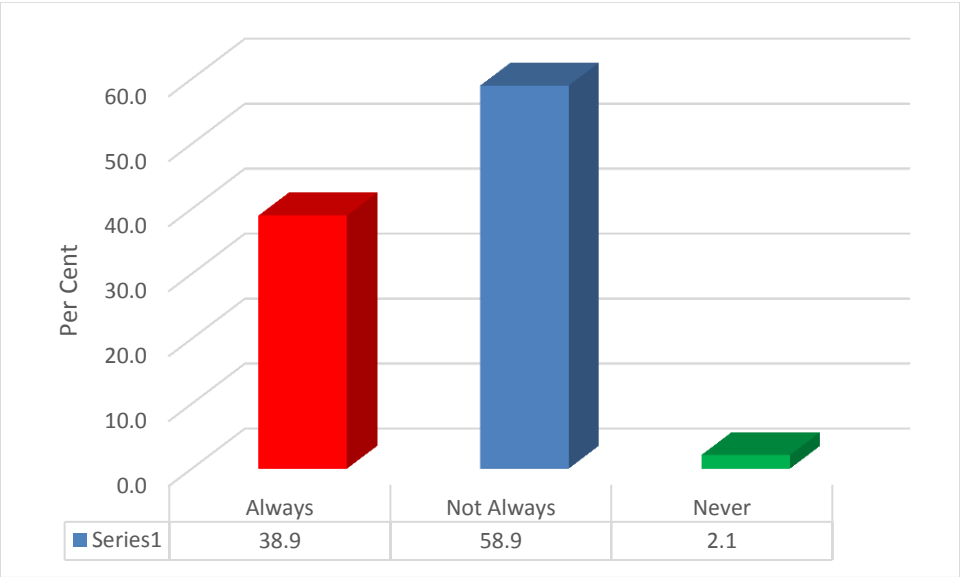


Figure 4.3: Reliability and Efficiency of Geothermal Power

As shown in Figure 4.3, 38.9% of the respondents indicated that geothermal power is always reliable and efficient as compared to the use of fossil fuels and hydropower. Also, 58.9% of the respondents indicated that geothermal power is not always reliable and efficient as compared to the use of fossil fuels and hydropower. Finally, 2.1% of the respondents indicated that geothermal power is never reliable and efficient as compared to the use of fossil fuels and hydropower. According to Lu et al. (2015), the achievement of sustainable energy calls for the reduction of fossil fuel-based energy sources which emit carbon dioxide into the air and cause pollution. The use of renewable energy sources such as geothermal energy is established as an alternative to reduce this kind of air pollution. The renewable energy sources, if well maintained, can be more reliable and efficient than fossil fuels.

In this study, there was a need to establish the factors that contribute to the increased cost of production and the results are shown in Figure 4.4.

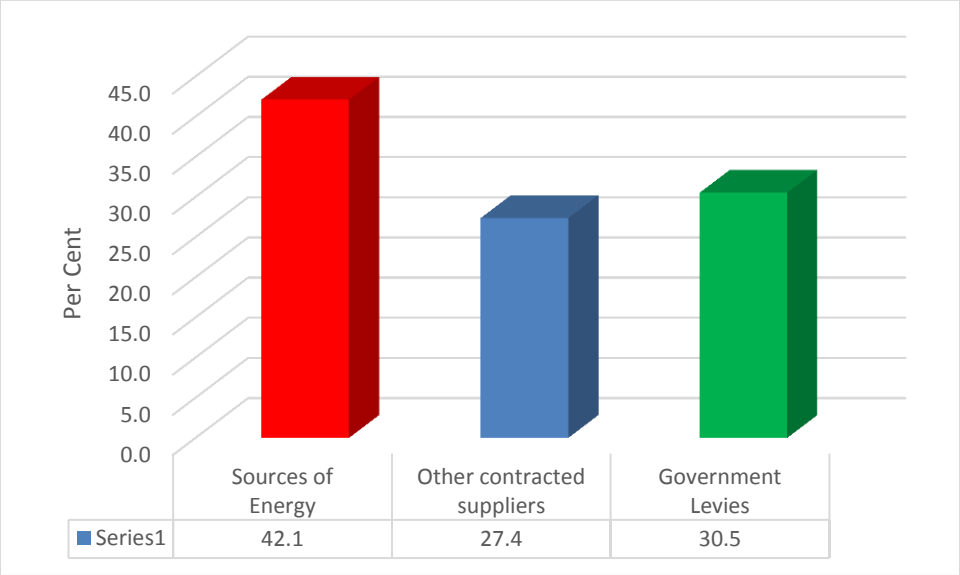


Figure 4.4: Factors Contributing to Increased Production Costs

Figure 4.4 shows that 42.1% of the respondents indicated that the sources of energy led to increased costs of production of energy while 27.4% indicated other contracted suppliers, and 30.5% indicated government levies as the cause of increased energy production costs. According to Merem et al. (2019), the sources of energy predict the production costs of energy. For instance, geothermal power is considered as a low-cost energy source as compared to thermal sources when aspects of climatic changes are considered. Thermal sources depend on hydropower generation and aridity pressures that occur when there are drastic climatic changes can lead to the thermal sources being expensive. Furthermore, the least-cost development plan in Kenya indicates that sources of power determine the cost of production. Geothermal power is seen as a cost-effective source of energy and as such, the use of geothermal power would reduce the cost of production.

This study also sought to establish whether the production costs are dependent on the number of Megawatts produced. The findings are indicated in Figure 4.5.

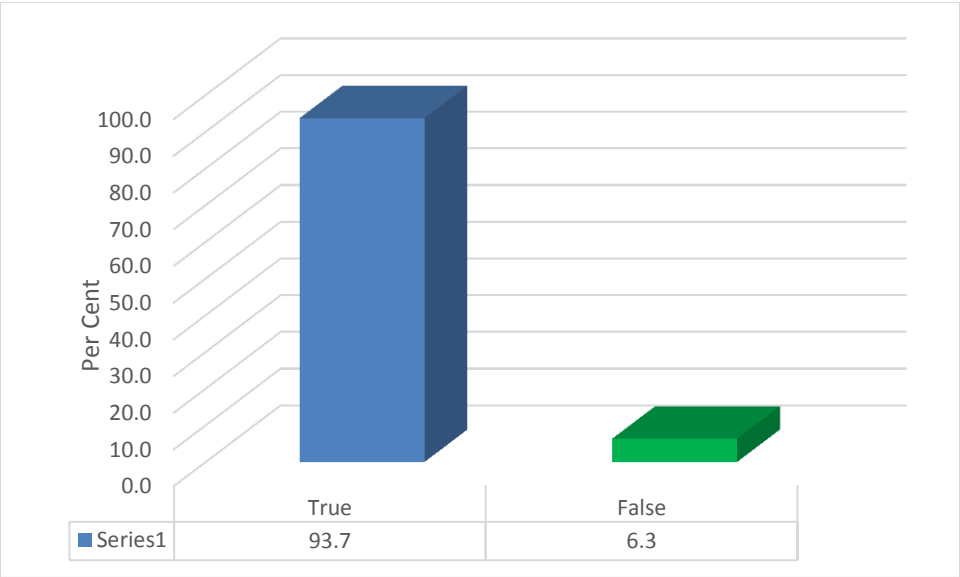


Figure 4.5: Cost of production of power and Megawatts produced

Figure 4.5 shows that 93.7% of the respondents believed that the costs of power production depend on the number of megawatts produced. This is in agreement with the views of Mutei (2015) who found out that in 2014, the Kenyan government sought to increase the geothermal power generation capacity which led to reduced costs of production of energy and a further reduction of power costs to both domestic and industrial consumers. The power generation capacity was increased from about 1700 MW to 2000 MW which reduced the production costs of energy.

4.7 Environmental Change

The fourth objective of this study was to analyze the effects of environmental change on sustainable energy in Olkaria Geothermal and Kenya Power Station, Nakuru County, Kenya. The data were analyzed and the findings were recorded in Table 4.8.

Table 4.8: Environmental Change

Environmental Change	SD (%)	D (%)	U (%)	A (%)	SA (%)
1. Environment change has a very little negative impact on the sustainability of renewable energy	15.8	45.3	0	37.9	1.1
2. Pollution of the environment has nothing to do with sustainable energy management.	14.7	42.1	11.6	27.4	4.2
3. Fossils fuel have been the main cause of unsustainable energy management.	16.8	23.2	24.2	31.6	4.2
4. Geothermal and other renewable sources offer clean energy in the environment	2.1	23.2	5.3	51.6	17.9
5. Renewable energy sources help in eliminating the competition of energy sources.	7.4	28.2	7.4	46.3	10.5
6. The use of renewable energy sources contributes to energy conservation and protection of the environment.	4.2	21.1	3.2	49.5	22.1
7. The future of the safe environment depends on the effectiveness of migrating from fossil fuels and embracing renewable energy.	5.3	14.7	12.6	51.6	15.8
8. Exploration of geothermal power has an effect on sustainable energy management.	6.3	13.7	11.6	51.6	16.8

SA= Strongly agree A= Agree U= Uncertain D= Disagree SD= Strongly Disagree

As indicated in Table 4.8, 45.3% of the respondents disagreed that environmental change has very little negative impact on the sustainability of renewable energy. There was also an indication that 42.1% of the respondents disagreed that pollution of the environment has nothing to do with sustainable energy management. Among the respondents, 31.6% agreed that fossils fuel has been the main cause of unsustainable energy management. Majority of the respondents (51.6%) agreed that geothermal and other renewable sources offer clean energy in the

environment. There was also a 46.3% agreement that renewable energy sources help in eliminating the competition of energy sources. Over 60% of the respondents believed that the future of a safe environment depends on the effectiveness of migrating from fossil fuels and embracing renewable energy. The results also indicate that 51.6% of the respondents agreed that the exploration of geothermal power affects sustainable energy management.

Consistent with these results, Ockwell and Byrne (2016) indicate that environmental changes negatively impact renewable energy sustainability. The environmental changes are mainly climatic and in instances of aridity, production of hydropower becomes difficult. Renewable energy sustainability is highly dependent on climatic changes. Renewable energy sources eliminate carbon pathways transmissions brought about by fossil fuels which pollute the air and bring about rapid and unpredictable climatic changes. Similarly, Gollwitzer et al. (2018) found out that environmental changes bring about seasonality which affects the supply side of renewable energy. For instance, in Kenya, the provision of solar energy is dependent on sunshine variations while wind energy is dependent on wind speed, and hydropower is dependent on rainy seasons. These variations determine the sustainability of renewable energy.

4.8 Government Policy

In this study, government policy was used as a moderating variable between the independent variables (sources of power, technology and innovation, cost of operation, and environmental changes) and the dependent variable (sustainable energy). The data was analyzed and the findings were recorded in Table 4.9.

Table 4.9: Government Policy

	Government Policy	SD (%)	D (%)	U (%)	A (%)	SA (%)
1.	The government is highly involved in regulating sustainable energy management.	9.5	44.2	10.5	29.5	6.3
2.	Government regulations on power exploration are adhered to.	4.2	47.4	20.0	25.3	3.2
3.	Operations are regulated and monitored by the government.	6.3	36.8	16.8	29.5	10.5
4.	The government has led to power management policies.	7.4	28.4	14.7	38.9	10.5
5.	All operations are government-financed.	18.9	15.8	13.7	36.8	14.7
6.	Clean energy management has been as a result of government policies	8.4	44.2	13.7	27.4	6.3
7.	The government makes regular changes to ensure effectiveness in energy management.	7.4	41.1	13.7	31.6	6.3
8.	The government gives grants and subsidies to help in energy efficiency	20.0	43.2	13.7	14.7	8.4
9.	All energy programs are licenced and controlled by the government	9.5	16.8	16.8	47.4	9.5
10.	The government advocates the use of renewable energy.	12.6	52.6	2.1	25.3	7.4

SA= Strongly agree A= Agree U= Uncertain D= Disagree SD= Strongly Disagree

The results in Table 4.9 show that 44.2% of the respondents disagreed that the government is highly involved in regulating sustainable energy management. Also, 47.4% of the respondents disagreed that government regulations on power exploration are adhered to. Majority of the respondents (36.8%) disagreed that operations are regulated and monitored by the government.

There was however a 38.9% agreement that the government has led to power management policies. The findings show that 36.8% of the respondents agreed that all energy operations are government-financed. There was a 41.1% disagreement that the government makes regular changes to ensure effectiveness in energy management. There is also an indication that 43.2% disagreed that the government gives grants and subsidies to help in energy efficiency. Majority of the respondents (47.4%) agreed that all energy programs are licenced and controlled by the government. There was a 52.6% disagreement that the government advocates the use of renewable energy.

There is incongruent with the findings of this study and those of Merem et al. (2019) who found out that the Kenyan government is highly involved in sustainable energy management. This is evidenced by its involvement in coming up with energy frameworks and policies. The efforts of the government have driven the emergence of renewable sources of energy. For instance, the government has enacted the National Policy on energy which has created an enabling environment for the exploration of geothermal power in Kenya. The government has also come up with power development plans such as the least cost plan aimed at providing cost-effective power to Kenyans. The government has invested heavily in boosting the production of renewable energy sources to provide clean energy to the public.

Supporting the findings by Merem et al., Mori and Le (2017) found out that the energy policies by the Kenyan government have immensely contributed to the emergence and sustenance of renewable energy in the country. The energy policies are continually reformed to deal with different implementation challenges that occur. For instance, the FiT (Feed-in-Tariff) policy was adopted in 2008 to cover renewable energy sources such as hydro and wind energy however, the lack of investors and poor technologies led to the failure of the policy. Policy reforms led to the enactment of the 2015 Energy Bill. The results by Mori and Le, however, support the findings of this current study by indicating that the government has spearheaded power management policies in the country. Additionally, government licenses and controls all energy programs. This is indicated in policies such as the National Energy Policy and the Energy Bill.

4.9 Sustainable Energy

The dependent variable of this study was sustainable energy. Data on this variable were captured and analysed and the results are indicated in Table 4.10.

Table 4.10: Sustainable Energy

SUSTAINABLE ENERGY	SD (%)	D (%)	U (%)	A (%)	SA (%)
Sources of power have proved to have an influence on sustainable energy.	3.2	3.2	4.2	69.5	20
Technology and innovation if well utilized have an influence on sustainable energy.	3.2	4.2	3.2	48.4	41.1
The costs of operation such as levies, taxes greatly contribute to sustainable energy.	3.2	11.6	17.9	49.5	19.9
Environment change is a natural regulator on sustainable energy.	3.2	16.8	17.9	45.3	16.8
Government policies have to some extent influenced sustainable energy.	3.2	20.2	4.2	60.0	12.6
Clean energy management technique can be realised if bills can be kept minimum.	3.2	14.7	16.8	38.9	26.3
The use of clean energy helps in moderating the effects of relying on fossil fuels	6.3	4.2	13.7	52.6	23.2

SA= Strongly agree A= Agree U= Uncertain D= Disagree SD= Strongly Disagree

The findings of Table 4.10 show that majority of the respondents (69.5%) agreed that sources of power have proved to influence sustainable energy. The findings also showed that 48.4% of the respondents agreed that technology and innovation if well-utilized influences sustainable energy. Additionally, 49.5% agreed that the costs of operation such as levies and taxes greatly contribute to sustainable energy. Majority of the respondents (45.3%) also agreed that environment change is a natural regulator on sustainable energy. Further, 60.0% of the respondents agreed that government policies have to some extent influenced sustainable energy. There was also a 38.9% agreement that clean energy management technique can be realised if bills can be kept minimum. The findings indicate that 52.6% of the respondents agreed that the use of clean energy helps in moderating the effects of relying on fossil fuels.

Similarly, Eberhard et al. (2018) stated that sustainable energy management is important in ensuring the overall sustainability of resources for future generations. There have to be

alternative sources of power which limit over-exploitation of the present resources. This requires policies that ensure that the environment is conserved and that the levels of pollution are minimized. The use of technology is also deemed as important in enriching and ensuring that there is sustainable energy. Furthermore, Sarkodie (2018) presents that clean energy management is a global focus as it can help in reducing the growth of carbon dioxide in the atmosphere which is harmful to human beings. The use of renewable energy is therefore in demand and the use of renewable energy helps in the achievement of clean energy which can be used in different industries. The use of clean energy is therefore deemed important in the achievement of sustainable energy management.

4.9 Influence of Determinants of Energy Production on Sustainable Energy

In this study, the determinants of energy production are cited as sources of energy, technology and innovation, costs of operation, and environmental change. The study, therefore, sought to test the influence of the determinants of energy production on sustainable energy. The tests were conducted using Pearson correlation and multiple regression tests.

To carry out these tests, the researcher first computed new continuous dummy variables by adding the questionnaire items under each variable. The new dummy variables were sourcesofpower1, technology and innovation1, costsofoperation1, environmentalchange1, governmentpolicy1, and sustainableenergy1.

Thereafter, the researcher sought to identify whether the study variables had a strong correlation between them which would negatively affect the inferential statistics tests. A multicollinearity test was conducted using collinearity statistics and the results were recorded in Table 4.11.

Table 4.11: Multicollinearity Test

Model		Collinearity Statistics	
		Tolerance	VIF
1	(Constant)		
	SourcesofPower1	.917	1.091

TechnologyandInnovation1	.861	1.162
Cost of operations1	.945	1.058
Envrionmentalchange1	.925	1.081

a. Dependent Variable: Sustainable Energy 1

The results in Table 4.11 show that tolerance and Variance Inflation Factor (VIF) values were used to test multicollinearity. This study's variables do not suffer from multicollinearity. George and Mallery (2016) suggest that when the tolerance value is less than 1 and the VIF ranges between 1 and 10, then, the variables do not suffer the collinearity issues. Thereafter, a Pearson correlation test was conducted using the independent and dependent variables and the results are recorded in Table 4.12.

Table 4.12: Correlation Table

		Sustainable Energy1	Sources of Power1	Technology and innovation1	Cost of operations1	Envrionmentalchange1
Sustainable Energy1	Pearson Correlation	1				
	Sig. (2-tailed)					
	N	95				
Sources of Power1	Pearson Correlation	.186	1			
	Sig. (2-tailed)	.071				
	N	95	95			
Technology and innovation1	Pearson Correlation	.219*	.207*	1		
	Sig. (2-tailed)	.033	.044			
	N	95	95	95		
Cost of operations1	Pearson Correlation	-.376**	-.049	-.187	1	
	Sig. (2-tailed)	.000	.641	.069		
	N	95	95	95	95	
Envrionmentalchange1	Pearson Correlation	.286**	.153	-.170	-.026	1
	Sig. (2-tailed)	.005	.139	.099	.801	
	N	95	95	95	95	95

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

According to George and Mallery (2016), a correlation relationship can be positive or negative and the relationship is deemed to be present when the p-value is less than 0.05. The findings in Table 4.12 show that there is no correlation between sources of power and sustainable energy (r=0.186; p=0.071). There was however a positive correlation between technology and innovation and sustainable innovation (r=0.219; p=0.033). There was a negative correlation between the costs of operation and sustainable energy (r=-0.376; p=0.000). On the other hand, there was a positive correlation relationship between environmental change and sustainable energy (r=0.286; p=0.005). Correspondingly, findings by Merem et al. (2019) indicate that there is a positive relationship between environmental change and sustainable energy. This is due to the fact that in the Kenyan energy landscape, there has been a concentration on renewable energy which is highly dependent on climatic variation.

The correlation test in this study did not indicate causality between the dependent and independent variables. As such, a multiple regression analysis was conducted. The model summary, ANOVA and Coefficient results are presented in Tables 4.13, 4.14, and 4.15 respectively.

Table 4.13: Model Summary

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.363[a]	.132	.093	4.363

a. Predictors: (Constant), Envrionmentalchange1, Cost of operations1, Sources of Power1, Technology and Innovation1

Results in Table 4.13 shows that the R^2 value is 0.132 which means that the variance proportion in sustainable energy can be explained by 13.2% of the determinants of energy production in this study. This is an indication that there are other variables that should be indicated in the study and this presents a chance for further studies to be conducted including other predictable variables.

The Analysis of Variance (ANOVA) was conducted in this study to establish whether the predictors influence the dependent variable. Two models were used in the ANOVA Test. The first model included the predictors of this study (sources of power, technology and innovation, costs of operation and environmental change). In the second model, the moderator variable which is government policy is added to establish whether the moderator variable has a significant influence on the predictor and the dependent variables. The results were recorded in Table 4.14.

Table 4.14: ANOVA Test

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	266.633	4	66.658	3.515	.010[b]
	Residual	1706.904	90	18.966		
	Total	1973.537	94			
2	Regression	277.350	5	55.470	2.911	.018[c]
	Residual	1696.187	89	19.058		
	Total	1973.537	94			

a. Dependent Variable: Sustainable Energy

b. Predictors: (Constant), Envrionmentalchange1, Cost of operations1, Sources of Power1, Technology and innovation1

c. Predictors: (Constant), Envrionmentalchange1, Cost of operations1, Sources of Power1, Technology and innovation1, Government Policy1

According to Table 4.14, the first model shows an F-statistic is 3.515 and the significance is 0.010. This is an indication that the regression model is significant. In other words, the environmental change, cost of operations, and sources of power have a significant effect on sustainable energy. When the moderator variable is added, there is still a significant effect between the predictor and the dependent variables ($p<0.05$).

The ANOVA test does not, however, indicate the significance of individual predictors. As such, the coefficient test was conducted and the results are indicated in Table 4.15.

Table 4.15: Coefficients Table

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		

	(Constant)	15.670	4.192		3.738	.000
	Sources of Power1	1.042	1.025	.104	1.016	.312
1	Technology and Innovation1	1.582	.732	.219	2.163	.033
	Cost of operations1	-.017	.004	-.376	-3.909	.000
	Envrionmentalchange1	2.361	.813	.297	2.905	.005

a. Dependent Variable: Sustainable Energy

In this study, the multiple regression formula was;

$$y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \varepsilon$$

Where;

Y= Sustainable Energy Management

α =constant

$\beta_1 \ldots\ldots \beta_{4d}$= parameter estimates

X_1 = Sources of Power
X_2 = Technology and Innovation
X_3 = Operation Cost
X_4 = Environment change effects
ε = the error of prediction.

The findings in Table 4.15 show that regression equation can be estimated as:

Sustainable energy=15.670+1.042*sources of power+1.582*technology and innovation-0.017*cost of operations+2.361*environmental change+ε

The findings show that when all factors are held constant, there is a unit change of sources of power which increases sustainable energy (β= 1.042, p =0.312). Since p>0.05, the relationship between the source of power and sustainable energy is not significant. This leads to the acceptance of null hypothesis that sources of power do not have a statistically significant effect on sustainable energy in Olkaria Geothermal and Kenya Power Station, Nakuru County, Kenya. These findings are not similar to those of Kazimierczuk (2019) who found out that the sources of

energy determine the sustainability of the energy in Kenya. When the sources of power focus on renewable energy such as wind energy, then sustainability can be achieved. Similarly, Merem et al. (2019) found out that sustainable energy depends on the sources of energy. For instance, when the source of energy is renewable, there is a likelihood that sustainable energy will be achieved in comparison to when fossil fuels are used.

The findings of this study also revealed that when all factors are held constant, there is a unit change of technology and innovation which increases sustainable energy (β= 1.582, p =0.033). Since $p<0.05$, the relationship between technology and innovation and sustainable energy is significant. This leads to the rejection of the null hypothesis which states that technology and innovation do not have a statistically significant effect on sustainable energy in Olkaria Geothermal and Kenya Power Station, Nakuru County, Kenya. According to Mori and Le (2017), technology and innovation are important aspects of the energy industry in Kenya as they provide transformation pathways in the sector. Technology accumulation and transfer processes are vital in ensuring that energy is sustainable. Insistence is however placed on the use of renewable energy to achieve sustainable energy.

Moreover, the findings of this study indicate that when all factors are held constant, there is a unit change of cost of operations which decreases sustainable energy (β= -0.017, p =0.000). Since $p<0.05$, the relationship between the costs of operation and sustainable energy is significant. This leads to the rejection of the null hypothesis which states that the costs of operation do not have a statistically significant effect on sustainable energy in Olkaria Geothermal and Kenya Power Station, Nakuru County, Kenya. These findings, to some extent, disagree with those of Mori and Le (2017), who highlight that it is the cost of production rather than the cost of operations which lead to sustainable energy. The production of the energy, especially renewable energy, financially weighs heavily on the government of Kenya. The cost of energy production is expensive and that is why the government enters into partnerships to ensure financial aid in the production process. If the cost of production of energy is high, then the cost of operations is high and this makes it difficult for sustainable energy to be achieved. Nevertheless, if the costs of operation are reduced, sustainable energy is achieved.

Finally, the findings of this study show that when all factors are held constant, there is a unit change of environmental change which increases sustainable energy (β= 2.361, p =0.005). Since

$p<0.05$, the relationship between the costs of operation and sustainable energy is significant. This leads to the rejection of the null hypothesis which states that environmental change does not have a statistically significant effect on sustainable energy in Olkaria Geothermal and Kenya Power Station, Nakuru County, Kenya.

Compatibly, Ockwell and Byrne (2016) present that there is a nexus between environmental change and sustainable energy. In Olkaria Geothermal, the organization depends on renewable energy and when there are climatic changes, the sustainability of the energy is negatively affected. In support of these findings, Kazimierczuk (2019) asserts that perhaps environmental change factors affect sustainable energy the most. This is especially true in the case of renewable energy such as wind energy which highly depends on the environment and climatic variabilities.

4.10 Chapter Summary

This chapter has shown how the data collected for this study were analyzed. The findings have been presented in accordance with the study's objectives which focused on sources of power, technology and innovation, cost of operations, and environmental change. These findings were presented in the form of graphs and tables.

CHAPTER FIVE
SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This chapter provides a summary of the findings that were presented in the previous chapter. The summary is provided according to the objectives of the study. Additionally, conclusions based on the findings of this study are provided. There are recommendations that the study makes which are also discussed in this chapter.

5.2 Summary of Findings

The purpose of this study was to focus on the determinants of energy production on sustainable energy in Olkaria Geothermal and Kenya Power stations, Nakuru County, Kenya. The data was collected based on the study's variables which included sources of energy, technology and innovation, cost of operations, and environmental change. The data was analyzed and it was found that the response rate of the questionnaires was 87.9% which was deemed as adequate for the generalization of the findings.

Focusing on the background information of the respondents, this study found out that there were 55.8% male and 44.2% female respondents. This implied that gender parity exists among the employees of Olkaria Geothermal, GDC and Kenya Power Stations in Nakuru County, Kenya. On age, the study found out that majority of the respondents (43.2%) were aged between 25-34years. This implied that they are energetic to undertake energy demanding activities that are present in energy production processes. Also, majority of the respondents had worked in their respective organizations for 5-10 years or more which meant that they had a good understanding of the operations of the organizations. Over 90% of the respondents had acquired post-secondary education which meant that majority of the respondents were able to understand the questionnaire and the questions posed to them. Majority of the respondents (36%) were support staff who worked in the operations level of the organization and as such, they understand the operations of the organizations well.

5.2.1 Sources of Power

The study sought to assess the influence of sources of power on sustainable energy in Olkaria Geothermal and Kenya Power Station, Nakuru County, Kenya. It was found that majority of the respondents (43%) of the respondents indicated that their organization used hydro energy. Most of the respondents agreed that renewable energy sources help in realizing sustainable energy. There was also an indication that geothermal power heavily relies on other substitutes to generate power. Geothermal power is one of the leading renewable sources of energy that will help in sustainable energy. It was also indicated that geothermal energy has helped to bridge the gap of energy shortage in Kenya. In this regard, most of the respondents felt that geothermal exploitation should be continually developed in Kenya. However, other sources of renewable energy sources should be developed towards achieving sustainable energy management.

On the inferential statistics, the study found out that there is no correlation between sources of power and sustainable energy ($r=0.186$; $p=0.071$). Also, the regression analysis produced a p-value that was higher than 0.05 leading the study to accept the null hypothesis which states that sources of power do not have a statistically significant effect on sustainable energy in Olkaria Geothermal and Kenya Power Station, Nakuru County, Kenya.

5.2.2 Technology and Innovation

The study found out that most of the respondents agreed that plant and machinery system has been incorporated with a high level of technology in the organizations. Also, over 80% of the respondents believed that there is a strong link between technology and innovation. There was also an agreement that research and development have contributed to innovation. Moreover, the respondents agreed that geothermal power production highly relies on available technology. Most of the respondents agreed that technology and innovation are key in tapping renewable energy sources in Kenya. However, the respondents disagreed that office automation has been incorporated in energy management skills in organizations. Also, the respondents negated that technology and innovation have been adopted by the majority of the staff. Interestingly, most of the respondents agreed that their company has adopted digital energy management technology.

Technology and innovation were found to have a positive correlation between technology and innovation with sustainable innovation ($r=0.219$; $p=0.033$).The findings of the regression

analysis indicated a p-value lower than 0.05 which led to the rejection of null hypothesis which states that technology and innovation do not have a statistically significant effect on sustainable energy in Olkaria Geothermal and Kenya Power Station, Nakuru County, Kenya.

5.2.3 Cost of Operations

The study found out that majority of the respondents agreed that the expenses incurred at the time of production greatly determine the end product value. There was also an indication that geothermal power has the least maintenance costs and that the energy costs vary depending on the sources of energy. The vision of the organization was seen to focus on taking the lead to offer reliable and efficient power. It was also agreed that the Kenyan government is working towards making geothermal power sustainable and it provides subsidies to help in cutting cost on consumers. The respondents also indicated that geothermal power is not always reliable and efficient as compared to the use of fossil fuels and hydropower. It was indicated that the sources of energy led to increased costs of production of energy. Most of the respondents, however, disagreed that the costs of operation have been manipulated by the management in the supply chain towards consumption. Additionally, the respondents believed that the costs of power production depend on the number of megawatts produced.

The findings of the study showed that there was a negative correlation between the costs of operation and sustainable energy ($r=-0.376$; $p=0.000$). With a p-value that was lower than 0.05, the regression analysis led to the rejection of null hypothesis which states that cost of operations does not have a statistically significant effect on sustainable energy in Olkaria Geothermal and Kenya Power Station, Nakuru County, Kenya.

5.2.4 Environmental Change

This study found out that the respondents did not agree that environmental change has a very little negative impact on the sustainability of renewable energy. The respondents also disagreed that the pollution of the environment has nothing to do with sustainable energy management. It was however agreed that fossils fuel has been the main cause of unsustainable energy management. Geothermal and other renewable sources were believed to offer clean energy in the

environment. It was also agreed by the respondents that renewable energy sources help in eliminating the competition of energy sources. Over 60% of the respondents believed that the future of a safe environment depends on the effectiveness of migrating from fossil fuels and embracing renewable energy. It was agreed that the exploration of geothermal power affects sustainable energy management.

The study established that there was a positive correlation relationship between environmental change and sustainable energy ($r=0.286$; $p=0.005$). Likewise, the p-value of the regression analysis was lower than 0.05 which led to the rejection of the study's null hypothesis which states that environmental change does not have a statistically significant effect on sustainable energy in Olkaria Geothermal and Kenya Power Station, Nakuru County, Kenya.

5.2.5 Government Policy

The government policy was used as a moderating variable between the independent variables (sources of power, technology and innovation, cost of operation, and environmental changes) and the dependent variable (sustainable energy). The results indicate that the respondents disagreed that the government is highly involved in regulating sustainable energy management. The respondents did not also feel that the government regulations on power exploration are adhered to. The respondents indicated that the operations of the organizations are not regulated and monitored by the government.

The government was seen not to make regular changes to ensure effectiveness in energy management and also not to give grants and subsidies to help in energy efficiency. The government was also seen not to advocate for the use of renewable energy. There was however an agreement that the government has led to power management policies. Also, the respondents agreed that all energy operations are government-financed. Most of the respondents agreed that all energy programs are licenced and controlled by the government. The results show that as a moderating variable, government policy establishes a significant relationship between the independent and dependent variables ($p<0.05$).

5.2.5 Sustainable Energy

The study found out that majority of the respondents agreed that sources of power have proved to influence sustainable energy. It was also found that that technology and innovation if well-utilized influences sustainable energy. The costs of operation such as levies and taxes were seen to greatly contribute to sustainable energy. Environment change was seen as a natural regulator on sustainable energy. Government policies were agreed to influence sustainable energy. It was indicated that clean energy management technique can be realised if bills can be kept minimum. The respondents also agreed that the use of clean energy helps in moderating the effects of relying on fossil fuels.

5.3 Conclusions

This study focused on the determinants of energy production on sustainable energy in Olkaria Geothermal and Kenya Power stations, Nakuru County, Kenya. The study concludes that Kenya is focusing on renewable sources of energy which are deemed to be better than the use of fossil fuels. Geothermal energy is the leading renewable source of energy in the country and it has helped to bridge the gap of energy shortages in the country. The study concludes that sources of power have no statistically significant relationship with sustainable energy. There is however need for the sources of renewable energy to be developed to achieve sustainable energy in the country.

The study concludes that there is a high level of technology and innovation at Olkaria Geothermal and Kenya Power stations, Nakuru County, Kenya. However, the technology and innovation efforts focus generally on the organizations, but the staff are not involved in these efforts. Office automation has also not been incorporated in energy management skills in the organization. Nevertheless, there is a statistically significant relationship between technology and innovation and sustainable energy.

This study also deduces that different energy costs vary depending on the sources of energy. The costs of operation in the organizations have not been manipulated by the management in the supply chain towards consumption. The costs of energy production determine the costs of

operations in the organization. This study also infers that there is a statistically significant relationship between the costs of operation and sustainable energy.

Environmental change has an impact on the sustainability of renewable energy. Fossils fuels lead to the pollution which affects sustainable energy management. Renewable energy sources such as geothermal energy offer clean energy in the environment. The future of the safe environment depends on the effectiveness of migrating from fossil fuels and embracing renewable energy. The study concludes that there is a statistically significant relationship between environmental change and sustainable energy.

Further, this study concludes that the government is involved in the energy production processes in Kenya. The government is involved in the formulation and implementation of power management policies. The government also finances, licenses and controls the energy operations and programs. There is however lack of knowledge on the extent of the government involvement in the energy production processes among the employees of energy production companies in Kenya. It is deduced that government policies significantly moderate the relationship between determinants of energy production (sources of power, technology and innovation, cost of operations, and environmental change) and sustainable energy.

5.4 Recommendations

The conclusions made in this study lead to several recommendations:

First, this study recommends that more efforts be put in the development of renewable energy. This can be achieved by phasing out the use of fossil fuels which lead to the production of greenhouse gases. The high release of carbon dioxide in the environment results in negative climatic changes that affect the achievement of sustainable energy. The organizations should also consider the development of different sources of renewable energy.

Secondly, at Olkaria Geothermal and Kenya Power stations in Nakuru County, digital energy management is put in place. There is however need for office automation to be incorporated in energy management skills. Also, technology and innovation adoption among the staff should be encouraged. This will help with coming up with innovative ideas which will not only give the organizations a competitive advantage but also help in raising Kenya on a global platform in the energy sector. Exertions on technology and innovation can help in achieving sustainable energy.

Third, the organizations should develop ways of reducing the high costs of energy at the production stage. This would help to reduce the ripple effect of energy costs whereby high production costs lead to increased connection and usage costs. Further development of renewable sources of energy can reduce the costs of operation in the energy sector. Additionally, cost-effective sources of energy should be pursued for sustainable energy to be achieved.

Furthermore, environmental change influences the achievement of sustainable energy. The organizations should consider the effectiveness of migrating from fossil fuels to renewable energy production. The focus on renewable energy sources should ensure that renewable sources are not over-exploited in a bid to ensure energy production. As well, mechanisms should be put in place in mitigating drastic climatic changes which may affect different renewable energy sources.

Finally, more efforts should be made to provide information on government policies on energy production among the staff which can be in form of building capacity and training. This will help the staff understand the extent to which the government is involved in the energy production processes. As a result, organizational policies that are in line with the national energy policies may be developed and implemented to help in the achievement of sustainable energy management.

5.5 Suggestions for Further Research

For further research, this study makes the following suggestions:

i) A similar study can be conducted to investigate other determinants of energy production and their influence on sustainable energy.
ii) Institutional environmental changes should be examined and their influence on sustainable energy management.

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APPENDICES

APPENDIX I: LETTER OF INTRODUCTION

St. Paul's University
Faculty of Social Sciences
Private Bag 00217
Limuru

Dear Sir/Madam,

RE: PERMISSION TO CARRY OUT ACADEMIC RESEARCH

I am a Postgraduate student in Development Studies at St. Paul's University conducting a research study entitled "**Determinants of Energy Production on Sustainable Energy in Olkaria Geothermal and Kenya Power Stations, Nakuru County, Kenya"**.

The purpose of this letter is to inform you that you have been selected as a respondent for this study and you are therefore requested to kindly fill in the questionnaire with precision and accuracy. The information that you provide will assist in answering the specific objectives of the research which is being undertaken as part of the University requirement. This information will be strictly used for academic purposes and will be treated with the utmost confidentiality

Thank you.

Gideon Kipsielei M.
Reg. No. MDSLMR269319

APPENDIX II: QUESTIONNAIRE

Dear Respondent

I am a Postgraduate student in Development Studies at St. Paul's University conducting a research study entitled "**Determinants of Energy Production on Sustainable Energy in Olkaria Geothermal and Kenya Power Stations, Nakuru County, Kenya"**. The purpose of this letter is to inform you that you have been selected as a respondent for this study and you are therefore requested to kindly fill in the questionnaire with precision and accuracy. The information that you provide will assist in answering the specific objectives of the research which is being undertaken as part of the University requirement. This information will be strictly used for academic purposes and will be treated with the utmost confidentiality

SECTION A: PERSONAL INFORMATION

Kindly answer all the questions by MARKING the relevant boxes.

1. **Gender** *(Please tick)*: Male ☐ Female ☐

2. **Age:……**

3. **Duration of service**

Below 5 years ☐ 5 to 10 years ☐

11 to 15 years ☐ 16 years and above ☐

4. **Highest Level of Education:**

Secondary school level ☐ Certificate or equivalent ☐ Diploma level ☐

Bachelor's degree ☐ Postgraduate level ☐

5**. Position in the organization:**

Management ☐ Engineer ☐ Electrician ☐ Support staff ☐

SECTION B: SOURCES OF POWER

1. Please tick below sources of energy your company uses.
   Hydro ( ) Wind ( ) Dissel ( ) Solar ( ) Indicate if there is any other ( )
2. The use of renewable energy sources helps in realizing sustainable energy.
   Yes( ) No ( )
3. Geothermal heavily relies on other substitutes to generate power.
   Yes( ) No ( )
4. Geothermal power is one of the leading renewable sources of energy that will help in sustainable energy. Yes( ) No ( )
5. Geothermal has helped to bridge the gap of energy shortage in Kenya
   Yes( ) No ( )
6. Geothermal exploitation should be continually developed in Kenya.
   Yes( ) No ( )
7. Other sources of renewable energy sources should be developed towards achieving sustainable energy Management. Yes( ) No ( )

SECTION C: TECHNOLOGY AND INNOVATION

Please tick on the response scale based on the degree in which you agree or disagree with the statements about Technology and innovation as a determinant of sustainable energy.

Strongly Agree (5), Agree (5), Uncertain (3), Disagree (2), Strongly Disagree (1)

	TECHNOLOGY AND INNOVATION	**SD**	**D**	**U**	**A**	**SA**
1	The plant and machinery system has been in cooperated with high level of technology.					
2	There is a strong link between technology and innovation.					

3	Research and development has contributed to innovation.					
4	Office automation has been in cooperated in energy management skills.					
5	Geothermal power production highly rely on available technology.					
6	Technology and innovation is key in tapping renewable energy sources in Kenya.					
7	Technology and innovation has been adopted by majority of the staff.					
8	The company has adopted digital energy management technology.					

SECTION D: **COSTS OF OPERATION**

1. The expenses incurred at the time of production greatly determine the end product value.

Yes ( ) No ( )

2. Geothermal power has the least maintenance costs. Yes ( ) No ( )

3. The energy costs vary depending on the sources of energy. Yes ( ) No ( )

4. Geothermal power is reliable and efficient as compared to the use of fossil fuels and hydropower. Always ( ) Not Always ( ) Never ( )

5. The vision of the organization is to take lead in offering reliable and efficient power.

Yes ( ) No ( )

6. The Kenyan government is working towards making geothermal power sustainable.

Yes ( ) No ( )

7. Are there any government offered subsidies to help in cutting cost on consumers?

Yes ( ) No ( )

8. What factors below may contribute to the increased cost of production.?

Sources of energy ( ) other contracted suppliers ( ) Government levies ( )

9. The cost of power production depends on the number of Megawatts produced.

True ( ) False ( )

10. The costs of operation have been manipulated by the management in the supply chain towards the consumption. Yes ( ) No( )

SECTION E: ENVIRONMENTAL CHANGE

Please tick on the response scale based on the degree in which you agree or disagree with the statements about environmental change as a determinant of sustainable energy.

Strongly Agree (5), Agree (4), Uncertain (3), Disagree (2), Strongly Disagree (1)

	1. ENVIRONMENTAL CHANGE	**SD**	**D**	**U**	**A**	**SA**
1	Environment change has a very little negative impact on the sustainability of renewable energy					
2	Pollution of the environment has nothing to do with sustainable energy management.					
3	Fossils fuel have been the main cause of Unsustainable energy management.					
4	Geothermal and other renewable sources offer clean energy in the environment					
5	Renewable energy sources help in eliminating the competition of energy sources.					
6	The use of renewable energy sources contributes to energy conservation and protection of the environment.					
7	The future of the safe environment depends on the					

	effectiveness of migrating from fossil fuels and embracing renewable energy.					
8	Exploration of geothermal power has an effect on sustainable energy management.					

SECTION F: GOVERNMENT POLICY

Please tick on the response scale based on the degree in which you agree or disagree with the statements about government policy as a moderator of sustainable energy.

Strongly Agree (5), Agree (5), Uncertain (3), Disagree (2), Strongly Disagree (1)

	GOVERNMENT POLICY	**SD**	**D**	**U**	**A**	**SA**
1	The government is highly involved in regulating sustainable energy Management.					
2	Government regulations on power exploration are adhered to.					
3	Operations are regulated and monitored by the government.					
4	The government has led to power management policies.					
	All operations are government-financed.					
5	Clean energy management has been as a result of government policies					
6	The government makes regular changes to ensure effectiveness in energy management.					
7	The government gives grants and subsidies to help in energy efficiency					
8	All energy programs are licenced and controlled by the government					
9	The government advocates the use of renewable energy.					

SECTION G: SUSTAINABLE ENERGY

Please tick on the response scale based on the degree in which you agree or disagree with the statements about government policy as a moderator of sustainable energy.

Strongly Agree (5), Agree (5), Uncertain (3), Disagree (2), Strongly Disagree (1)

	SUSTAINABLE ENERGY	**SD**	**D**	**N**	**A**	**SA**
1	Sources of power have proved to have an influence on sustainable energy .					
2	Technology and innovation if well utilized has an influence on sustainable energy.					
3	The costs of operation such as levies, taxes greatly contributes to sustainable energy.					
4	Environment change is a natural regulator of sustainable energy.					
5	Government policies have to some extent influenced sustainable energy.					
6	Clean energy management technique can be realised if bills can be kept minimum.					
7	The use of clean energy helps in moderating the effects of relying on fossil fuels					

THANK YOU FOR TAKING YOUR TIME TO COMPLETE THIS QUESTIONNAIRE

APPENDIX III: UNIVERSITY RESEARCH AUTHORIZATION LETTER

ST. PAUL'S UNIVERSITY

Private Bag 00217 LIMURU, KENYA
Email: office@spu.ac.ke
Website: www.spu.ac.ke

Tel Office: +254 (0) 20 - 2020505/10
Mobile: +254 (0) 728 - 669000
(0) 736 - 424440

19th March 2020

National Commission for Science and Technology,
P.O. BOX 30623-00100,
Nairobi.

Dear Sir/Madam,

RE: RECOMMENDATION FOR GIDEON KIPSIELE- MDSLMR269319 TO CONDUCT RESEARCH

This letter confirms the above named person is a student of the Masters of Development Studies at St. Paul's University.

The second year consists of a major research work leading to a dissertation. The student's selected topic is *'Determinants of energy production on sustainable energy in Olkaria Geothermal and Kenya power stations, Naivasha Sub-County, Kenya'*

Kindly grant this student the required permit.

BOARD OF POSTGRADUATE STUDIES ST. PAUL'S UNIVERSITY 19 MAR 2020 KENYA TEL: 020 - 2020505 / 2020510 P.O. PRIVATE BAG - 00217, LIMURU.

Yours Faithfully,

Dr. Sammy Githuku
Director, Postgraduate Studies

APPENDIX IV: RESEARCH PERMIT

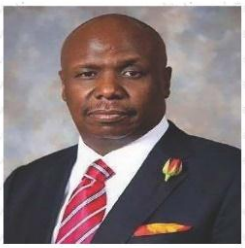
REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: **665514**

Date of Issue: **09/April/2020**

RESEARCH LICENSE



This is to Certify that Mr.. Gideon Kipsielei Moi of St. Paul's University, has been licensed to conduct research in Nakuru on the topic: Determinants Of Energy Production On Sustainable Energy In Olkaria Geothermal and Kenya Power Stations, Naivasha Sub-County, Kenya. for the period ending : 09/April/2021.

License No: **NACOSTI/P/20/4752**

665514

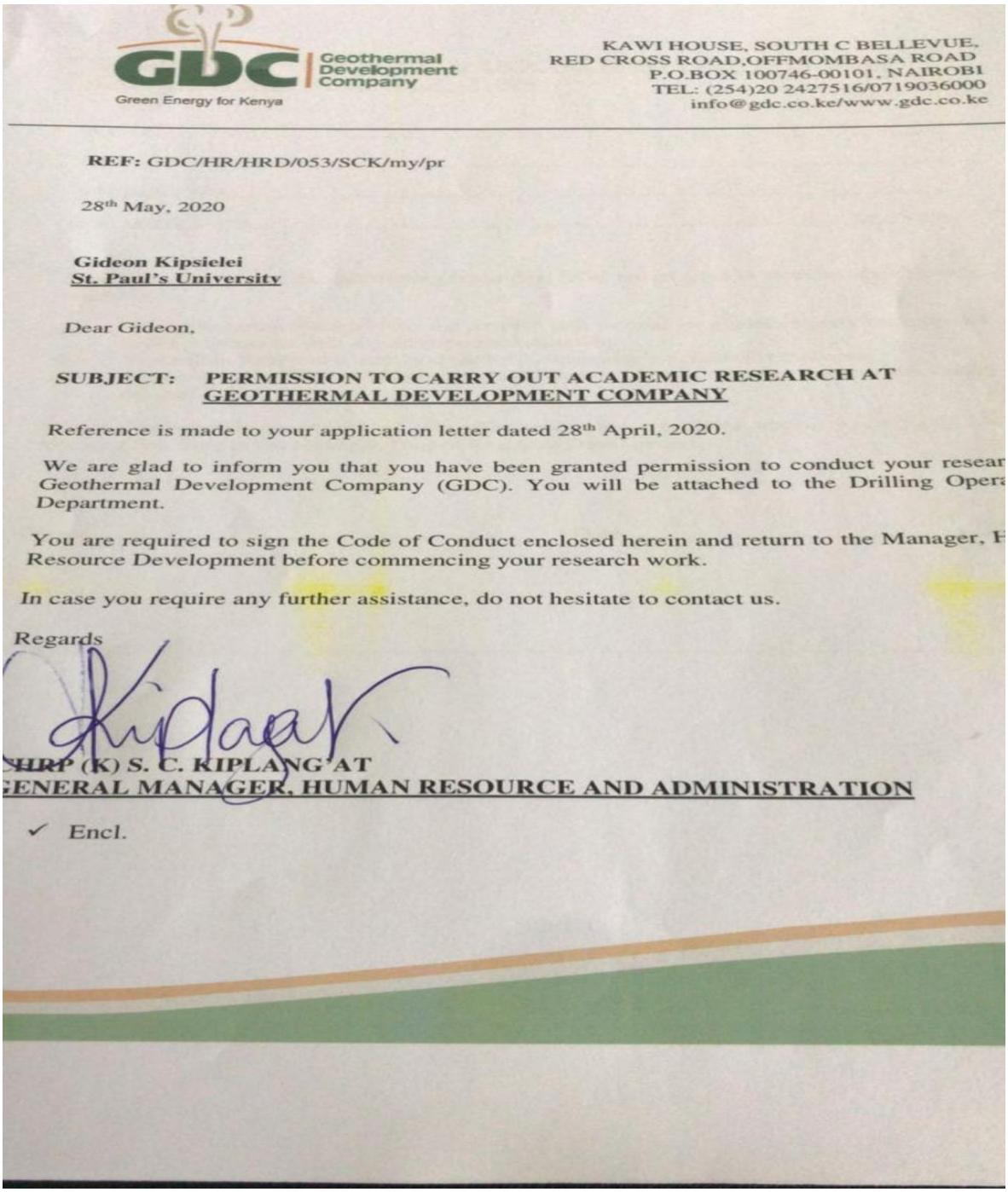
Applicant Identification Number

Director General
NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Verification QR Code

NOTE: This is a computer generated License. To verify the authenticity of this document, Scan the QR Code using QR scanner application.

APPENDIX V: ORGANIZATION RESEARCH AUTHORIZATION LETTER



GDC Geothermal Development Company
Green Energy for Kenya

KAWI HOUSE, SOUTH C BELLEVUE,
RED CROSS ROAD,OFFMOMBASA ROAD
P.O.BOX 100746-00101, NAIROBI
TEL: (254)20 2427516/0719036000
info@gdc.co.ke/www.gdc.co.ke

REF: GDC/HR/HRD/053/SCK/my/pr

28th May, 2020

Gideon Kipsielei
St. Paul's University

Dear Gideon,

SUBJECT: PERMISSION TO CARRY OUT ACADEMIC RESEARCH AT GEOTHERMAL DEVELOPMENT COMPANY

Reference is made to your application letter dated 28th April, 2020.

We are glad to inform you that you have been granted permission to conduct your resear
Geothermal Development Company (GDC). You will be attached to the Drilling Opera
Department.

You are required to sign the Code of Conduct enclosed herein and return to the Manager, H
Resource Development before commencing your research work.

In case you require any further assistance, do not hesitate to contact us.

Regards

HRP (K) S. C. KIPLANG'AT
GENERAL MANAGER, HUMAN RESOURCE AND ADMINISTRATION

✓ Encl.