FACTORS INFLUENCING UTILIZATION OF DIRECT GEOTHERMAL ENERGY IN KENYA. A CASE OF MENENGAI GEOTHERMAL PROJECT IN NAKURU COUNTY.

BY

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DECLARATION

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

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DEDICATION

This research study is dedicated to my beloved Father Mr. Wycliffe Kaitano who has been my anchor, my mother Mrs.Violet Kaitano for her encouragements, My grandparents including the (late Francis Ligami Luyanje and Dorcas Musanga Ligami),my husband and my beautiful daughter Hayleey Muhadia.

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ABBREVIATIONS AND ACRONYMS

IPCC	United Nations Intergovernmental Panel on Climate Change
OECD	Organization for Economic Cooperation and Development
SDGS	Sustainable Development Goals
MDGS	Millennium Development Goals
SREP IP	Scaling-Up Renewable Energy Program Investment plan
NIMBY	Not in My Back Yard
RET(s)	Renewable Energy Technology(s)
ETS	Emission Trading Schemes
CDM	Clean Development Mechanism
JI	Joint implementation
RES-E	Renewable Energy Sources-Electricity
GHP	Geothermal Heat Pumps
GSHP	Ground Source Heat Pumps
GEOCOM	Geothermal Communities
RES	Renewable Energy Sources
UNEP	United Nations Environmental Programme
ARGeo	African Rift Geothermal Development Facility
FYROM	Former Yugoslav Republic of Macedonia
UNDP	United Nations Development Programme
GDC	Geothermal development Company

ABSTRACT

Geothermal utilization is commonly divided into two categories; electric production for power and direct utilization, however, electricity strategic value has been, rightly, superior to any possible commodity that uses direct geothermal as a result, putting a strain on the power infrastructure and In turn, failing to achieve great supplement for geothermal power developments .Therefore, study sought to establish Factors Influencing Utilization of Direct Geothermal Energy in Kenya. The study was based on the variables of community support, government policy, technology and public awareness. Literature review supporting the study is documented. The research utilized descriptive survey research to conduct a study to an area of a total target population of 2545 households. The data provided by Kenya population and Housing census, 2009 is already in strata therefore, formula by Nassiuma (2000) applied to get the sample, For GDC expert purposive sampling was conducted to single out the department to be sampled, the direct use department was selected and census conducted on the staff of 9. Proportionate random sampling was applied to the two sub locations to determine each sub location proportion to participate in the research. For data collection procedure, systematic random sampling was done to determine who was to be included as a sample. Structured questionnaire was used to collect data. The content validity of the research instruments was established in order to make sure that they reflect the content of the research topic. Moreover, Cronbach's alpha reliability coefficient was employed to test the internal consistency. A threshold of reliability coefficient of 0.7 and above was sought. Before administering the questionnaire permission from the relevant authority including NACOSTI was sought. Data collected was analyzed Statistical package for Social Sciences (SPSS) version 22 to generate frequencies, percentages, means and standard deviation and presented inform of tables .Pearson correlation coefficients were established to help researcher draw various conclusion on the relationship between independent and dependent variable. Inferential statistic indicated a correlation of ($r=-.219$, $P<0.01$) between community support and direct use, it also indicated significant correlation of; ($r=.999$, $P<0.01$) between government policy and direct use, (-.413, $P<0.01$) between technology and direct use, and (.995, $P<0.01$) between Public awareness and direct use. The research concluded that GDC should facilitate utilization of direct geothermal energy and further recommended that focus should be emphasized on sustainability of direct use projects in future and the remaining aspects contributing to utilization of direct geothermal energy.

CHAPTER ONE
INTRODUCTION

1.1 Background of the Study

The climate is changing due to accelerated human activity that in turn might lead to potential destructive consequences on habitation, agricultural patterns and species diversity (IPCC, 2007a). On comparing the impact of climate change in developed and developing countries, the effects are more in developing countries, with cited cases of severe droughts, floods, water shortage, severe food shortage, threat to national security (IPCC, 2001). To explain this phenomenon, studies indicate that many of the observed and projected climatic changes are considerably greater in temperate latitudes where many developed countries are located (IPCC 2001a). Secondly, African countries are faced with challenges of greater technical and financial resources and stronger institutional base, both of which provide a better enabling environment for adaptation planning (OECD, 2006) in cases of such calamities.

As a measure to combat climate change and maintain both a sustainable economy that is capable of providing essential goods and services to the citizens of both developed and developing countries, there is need for a major shift in how energy is produced and utilized (Nfah et al., 2007; Kankam and Boon, 2009). In Kenya, vision 2030 national development goals considered geothermal energy as clean energy for socio-economic transformation visualized in the country (SREP IP, 2011). These energy falls within the Kyoto protocol and the Millennium development goals (MDGs) that recently transformed to Sustainable Development Goals (SDGs) in 2015.

Geothermal energy is clean energy that originates from radioactive decay of minerals, and from solar energy absorbed at the surface. Geothermal energy can be tapped in two ways. One involves heat extracted using water from boreholes drilled to several kilometers below the surface and the other is the direct form, which is well established outside Australasia (Banks 2008, Brandl 2006, Preene and Powrie 2009). It has been estimated that there are over 3 million installations in operation around the world (Lund et al, 2010) and at least 24 countries working towards the access in the year 2013 (Matek, 2014). Exploration of geothermal development in Kenya started in the 1950s with exploration studies .Drilling of the first geothermal exploration wells in Olkaria was done between 1956 and 1959, this wells never discharged and therefore, were later abandoned (Karingithi, 2012; Saitet & Muchemi, 2015). Further assessment of the geothermal resource was however undertaken later in the 1960s leading to the drilling of more wells between 1971 and 1976. The move was positive, thus, lead to the first 45MW power plant between 1981and 1985 (Karingithi, 2012). At the moment, Kenya is one of the leading countries globally with vast geothermal resources estimated at 7000 to 10, 000 MW from geo-scientific surface exploration surveys (Simiyu, 2010; Ngugi, 2012; Mulaha, 2013; Omenda & Simiyu, 2015).

The direct or non-electric utilization of geothermal energy is the immediate use of the heat energy rather than electricity generation. The direct use of geothermal energy is not only environmentally friendly but also one of the oldest and known ways of utilizing heat energy (Dickson and Fanelli, 2003). Traditionally, natural hot springs and fumaroles found in some parts of Kenya have been utilized by residents for worship and offering of sacrifices, particularly when afflicted with ailments that were difficult to cure (Tole, 2002). Despite the fact that over 90% of geothermal utilization in Kenya is in the generation of electrical power, in recent years direct uses have started to feature, an example is the use of geothermal fluids to dry pyrethrum flowers and condense steam for drinking by farmers at Eburru village, near Naivasha and more uses are being adopted in green houses and bathing (Mariita, 2010). Other known ways include: refrigeration by ammonia absorption, digestion in paper pulp, Drying, Alumina by Bayer's process, Evaporation, space heating (building and greenhouses), air conditioning, soil warming, Animal husbandry, swimming pools, de-icing and fish farming, however, it should be noted that these uses depend on the energy in the fluid (Lindal, 1973).

1.2 Statement of the Problem

Geothermal utilization is commonly divided into two categories; electric production for power and direct utilization. Though direct utilization of geothermal energy is a serious business in industrialized Asia, North American and Central and Eastern European countries (Lund and Boyd, 2015) .Africa is yet to take advantage of the same, in Kenya for example, studies by Mwangi (2005), kiruja (2011), and Mburu, (2012) supports this assertion by stating that the non-electric use of geothermal energy has not been awarded the necessary attention. Instead, electricity strategic value has been, rightly, superior to any possible commodity that uses direct geothermal, as a result, putting a strain on the power infrastructure. This in turn, refutes great supplement for geothermal power developments, economic benefits, and environmental acceptability accompanied by the direct geothermal use. Therefore, the study sought to establish the Factors influencing utilization of direct geothermal energy in Kenya.

1.3 Purpose of the Study

The purpose of this study was to establish the factors influencing utilization of direct geothermal energy in Nakuru County.

1.4 Objectives of the Study

This study was based on the following objectives:

I. To establish the extent to which community support of geothermal energy influences utilization of direct geothermal energy.
II. To ascertain the extent to which government policy influences utilization of direct geothermal energy.
III. To assess how technology influences utilization of direct geothermal energy.
IV. To examine the extent to which public awareness of influences direct geothermal energy utilization.

1.5 Research Questions

The study was guided by the following research questions:

I. How does community support of geothermal energy influence utilization of direct geothermal energy?
II. To what extent does government policy influence utilization of direct geothermal energy?
III. How does technology influence utilization of direct geothermal energy?
IV. To what degree does public awareness of geothermal energy influence utilization of direct geothermal energy?

1.6 Significance of the Study

It was expected that the study will result to findings that will; highlight on the importance of community support on improving utilization of direct geothermal energy. Moreover, the findings were expected to provide highlights on the key role of government policies on attracting investments towards projects, thus enabling utilization of direct geothermal energy. The findings were also to highpoint the influence of existing technology on utilization of direct geothermal energy. Fourthly, the knowledge generated on the study was expected to inform the key stakeholders on importance of geothermal energy awareness to the uptake of projects that are geared by direct geothermal energy. Lastly, the findings of the project were anticipated to contribute to the existing body of knowledge on utilization of direct geothermal energy within areas near geothermal resources.

1.7 Delimitation of the Study

The study covered households closest to Menengai geothermal development project, a project area situated in Nakuru County and covers an area of about 7,000 km2 with a target population of 2545 households and a sample size of 106. In addition, insight from GDC direct use department was sought targeting population 9 staff members.

1.8 Limitations of the Study

The factors likely anticipated to pose challenges to the study were rescheduling of appointments on the part of respondents this was avoided by making sure that respondents with busy schedules were called in good time for the purpose of appointment scheduling. In addition, The respondents were also expected to be suspicious towards the reasons for the study these was mitigated by getting approval letters from the relevant different authorities and also assurance that information given would serve purposely for research and therefore confidential. Finally, the challenge of low literacy level on the part of the respondent was overcome by use of translators of the local dialect.

1.9 Assumptions of the Study

This study assumed that the respondents gave answers correctly and truthfully. In addition, the sample size also assumed the correct representation of the population, and lastly, the data collection instruments underwent validity for the purpose of measuring the correct constructs.

1.10 Definition of significant terms used in the Study

Utilization: Is the act of putting to use

Direct Geothermal energy: Refers to the immediate use of the energy for both heating and cooling applications in the past used hot springs for bathing, cooking food, and loosening feathers and skin from game. Today, use include heating swimming pools and baths or therapeutic use, space heating and cooling, agriculture, aquaculture, and providing heat for industrial processes and heat pumps.

Community Support: providing things necessary for existence by social group of any size whose members reside in a specified locality.

Government Policy:	Is a deliberate system of principles to guide decisions and achieve rational outcomes set by a collective group of people that exercises executive authority in a state.
Technology:	Is the collection of techniques, skills, methods and processes used in the production of goods or services or in the accomplishment of objectives.
Public Awareness:	understanding of a situation or subject at the present time based on information or experience by the people constituting a community, state, or nation.
Community:	Is a social group occupying a defined geographical area within the localities of a resource.
Geothermal:	Thermal energy contained in the rock and fluid that fills the fractures and pores within the rock in the earth's crust.

1.11 Organization of the study

The study is organized into five chapters. Chapter One contains the background of the study, covering areas such as problem statement, research questions and objectives. The chapter also outlines the significance of the study and the basic assumptions. The chapter also contains delimitations and limitations of the study and the definitions of the significant terms used in the study. Chapter two contains literature review under themes of acceptance, policies, technology and public awareness. The study also contains theories that guide the study and formulation of conceptual framework. Chapter three contains the research methodology used in this study that captures the research design, target population, sample size, sampling procedure, methods of data collection, validity and reliability of the instruments used. Operational definition is also explained in a table, data analysis procedures that were used, and finally ethical considerations.

Chapter four contains analysis, presentation and interpretation of findings arising from data analysis using techniques described in chapter three. These findings are presented in form of tables. Chapter five contains summary of the findings, discussions, conclusion and the research recommendations. Finally, Areas of further study have also been suggested.

CHAPTER TWO
LITERATURE REVIEW

2.1 Introduction

This chapter gives an insight into the literature by other scholars and researchers on studies that are related to factors influencing utilization of direct geothermal energy. It reviews the literature that is related to the objectives of this study. In addition the theoretical framework, success stories and a critical review on the major issue and gaps of the past available reviews and results from other researchers in the same field of study are given, also the conceptual framework model is also presented after the review of the literature .Finally, the summary of the study highlighting the main ideas and issues relating to the study is given.

2.2 Community Support and Utilization of Direct Geothermal Energy

Community support is necessary for the success of any project; this can be achieved through community participation and inclusion. However, attaining community support is faced with challenges of conflicting ideologies, beliefs and values.

To understand community support scholars have developed the concepts of "social acceptance" and "NIMBISM". Social acceptance refers to the fact that the development of renewable energy technologies depends on the willingness to accept the key aspects of the innovation that they imply among society and its different actors (consumers, producers, authorities, etc). Wüstenhagen et al (2007) identify three dimensions of social acceptance as far as renewable energy innovations are concerned: socio-political, community and market. According to Wüstenhagen et al (2007), the socio-political acceptance level describes higher level perspective on renewable energies this category includes general opinions from the public and key stakeholders and the policy framework within a given country. It concerns the broad societal consensus (or lack thereof) that renewables have positive consequences, what Ek (2005) has called public attitudes towards energy technologies. Community acceptance means the practical acceptance of site selections within the affected communities thereby avoiding the NIMBY syndrome, community acceptance is influenced by three factors; Procedural Justice: Fair decision process with participation possibilities for all relevant stakeholders, Distributional

Justice: System of sharing costs and benefits, Trust: Trust of the community into investors and stakeholders from outside the community. Recent studies have illustrated how perceptions of fairness and levels of trust are implicated in the Community acceptance of renewable energy developments. However, NIMBY effect represents a social dilemma, that is, a situation in which individual strategies clash with collective interest (Frey and Oberholzer-Gee 1997).

Disputes over land usage clearly have a long history, with past struggles sharing many features in common with contemporary arguments. However, According to DuPont (1981), public opposition should not sway developers because 'the fear they feel is out of proportion to the actual risks...This is phobic thinking'. To disagree, Devine Wright (2006) states that reasons for local opposition are varied and cannot simply be characterized as ignorant or irrational, most commonly cited reasons for opposition of renewable energy are inappropriate scale of development, an unacceptably high ratio of local costs to local benefits and a lack of adequate communication and consultation with local residents by developers (Sinclair and Lofstedt, 2001;Toke, 2005;Upham and Shackley, 2006;Upreti,2004) for example in studies by (Wynne 1992, 1996, Irwin 1995, Petts 1997) indicate that members of the public are able to assimilate even very complex scientific information if they can see the practical gains from doing so and conversely may choose to ignore information if they do not trust those who are giving it or if they see no advantage to be gained from understanding it .

Analyzing survey data from citizens whose community was faced with a decision to site a hazardous waste incinerator, Hunter and Leyden (1995) found that there was little evidence for concern about property values, but concluded opposition was related to the primarily to lack of trust in government, fear of health consequences and other ideological or demographic factors: Of particular relevance to Renewable energy, is a studies such as of Devine Wright(2005) that provides a useful overview of empirical research on public perceptions of wind farms which indicates that complaints usually focus on visual, acoustic, socio-economic, environmental and technical aspects.

However, Wynne (2006) caution against assuming that lack of explicit concern or opposition towards a technology indicates support. Thus survey research may over estimate public support for Renewable Energy Technology (RET) and as a consequence construct a gap between generalized support and local opposition where one does not exist (Ellis ,2006).In support, Burningham , Barnett & Thrush (2006), illustrate NIMBISM seems to be fairly culturally specific, being used to describe opponents to developments in relatively rich communities and ‘developed’ countries but much less likely to be used of opponents in poorer communities or ‘developing’ countries. This may be because poor communities and ‘developing’ countries are keener to embrace the development of new infrastructure as a sign of investment and progress and thus opposition is less prevalent.

Research into public attitudes towards renewables indicates that people would welcome opportunities for greater involvement in renewable energy development (Devine-Wright, 2005a; Gross, 2007; Upham and Shackley, 2006, 2007).Some of the strongest evidence comes from studies of local opinion of a proposed biomass gasifier in rural Devon; following an intensive local campaign, the gasifier was refused planning permission, a decision favored by most people surveyed. However, a recent repeat survey revealed that 69% would support a smaller project proposed by a local group for the same site, if it was controlled by the community (Upham and Shackley, 2007; Upham, 2007). As a result it is increasingly stated that there should be a higher degree of public participation in local energy planning and one way to achieve this could be through the development of decentralized, community-based renewable energy schemes, particularly in rural areas (Giddings and Underwood,2007;Kellett, 2007).

In UK, Studies indicate that In terms of social class, there seems to be a positive correlation between income and class, and levels of support for both renewable energy and nuclear power (ICM Research for BBC News night, 2005). Also in Finland, men and high income earners have in recent studies been more supportive of nuclear power (Syri , 2012). Although some studies assume that negative perceptions towards renewable energy are caused by the lack of knowledge and public understanding, there is limited evidence that more informed individuals are accepting renewable energy technologies (DTI, Scottish Executive et al., 2003).Empirical findings from the UK suggest that political beliefs are correlated with social acceptance of different low carbon technologies (Devine-Wright, 2008). Populous (2005) indicated that 37% of individuals indicating support for the Conservative party were supportive of new nuclear power stations (in comparison to only 12% of labor supporters and 14% liberal democrat) while being less significantly supportive of new renewable energy developments (62% as against 86% and 84% respectively). Social acceptance is a parameter for which a project blends and resonates with the needs of the host community and therefore major determinant of the sustainability of any development project.

2.3 Government Policies and Utilization of Direct Geothermal Energy

Government policies play a critical role on the implementation of any project. When such policies are favorable to the investor then clearly there would be a multiplying effect created the by implementation of any given project that most at times works positively towards the economy of a given state.

However, assessing the role of policy in inducing technological change requires awareness of the dimensions involved (OECD, 2009).The influence of policy on innovation can be analyzed on a firm level or on a country level. Nevertheless, one has to differentiate between the drivers of and barriers to technological change, the elements of technological change, and, last but not least, between technological change as such and the impacts from it. The theoretical literature suggests that government intervention in terms of regulation and implementing environmental policies is necessary in order to correct for externalities (Weitzman, 1974).Nonetheless, Policy choice and design is decisive influential driver of clean energy technology innovation and adoption (Popp et al., 2011). Depending on the type of market and the policy goal being pursued by public authorities, a variety of instruments and policies promoting renewable energies are available. The policies are differentiated into market-pull whose policies aim at increasing the demand for renewable energy, and technology-push whose policies primarily aim at increasing the incentives for firms to generate new knowledge develop new RETs or improve existing ones by reducing the negative effects caused by the imperfects of innovation (Groba and Breitschopf, 2013).

2.3.1 Market-pull policies

Market or demand-pull policies aim at increasing renewable energy use by creating demand for Renewable Energy Technologies (RETs).The environmental economics literature generally agrees that market-pull policies not only boost the utilization of technologies but also induce innovation (Newell et al., 1999) these policies can generally be differentiated into market-based approaches and command-and-control measures. Market-based approaches encourage firms to innovate through market signals and incentive setting, which still leaves them the flexibility to choose the least costly options. Command-and-control policies, such as technology standards, leave relatively little room to maneuver as they principally comprise explicit directives and performance standards (Popp et al., 2010).

2.3.2 Technology-push policies

The technology push policies have two aspects the technology-neutral policies and the technology-specific policies.

Technology-neutral policies such as pricing carbon through taxes or emission trading schemes (ETS) result in cost-efficient mitigation measures, provided no further market failures exist (Rosendahl, 2004, Stern, 2007, Fischer and Newell, 2008).Studies conducted in respect to renewable energies are limited (Hoffmann, 2007, Rogge and Hoffmann, 2010). However, Popp (2003) there indicates a positive effect of the US sulphur emission trading on pollution control innovation. Taylor et al (2005) concludes that both market-based, demand-pull policies and command-and-control measures induce innovation. With respect to the European Union (EU) ETS, Gagelmann and Frondel (2005) find that the potential innovation effect was limited in its early phase (2005-2007) due to the large, free emission allocations and unrestricted Clean Development Mechanism (CDM) and Joint Implementation (JI) credit use.

However, in a qualitative study, Rogge and Hoffmann (2010) find that the EU ETS does affect the rate and direction of technological change of power generation technologies in large-scale, coal-based power generation, but only marginally with respect to renewable energies. To agree, Egenhofer et al.(2011)underline that the carbon price and its volatility under the EU ETS is an important element for investment decisions in climate-friendly innovation, but that low prices, the uncertainty of price development and over-allocation of emission rights undermine and predictability of the market scheme require separate renewable energy policies .Similarly, based on case studies in the German power sector, Rogge et al.(2011)find that the impact of the EU ETS on innovation has remained limited due to the lack of stringency and predictability providing insufficient incentives for corporate innovation activities. They also point out the importance of market factors and the variety of impacts across technologies and firms which highlight the need for an appropriate mix of additional policies to overcome environmental and innovation market failures. Recently, Schmidt et al. (2012) have found that the EU ETS has limited effects on innovation, long-term emission reduction targets and additional technology-specific policies are important innovation determinants at the corporate level.

Direct technology-specific support policies for renewable energies, like feed-in-tariffs, are necessary complements in the light of the knowledge about market distortions and path dependency in socio-technical systems (Haas et al., 2004, Sijm, 2005, Bennear and Stavins, 2007, Del Rio, 2009, Gerlagh et al., 2009, Aldy et al., 2010, Lehmann and Gawel, 2013). Moreover, technology-specific policies aim at increasing the specific demand for renewable energy technologies. Various studies indicate, a positive effect of Renewable Energy Sources-Electricity(RES-E) , support schemes on deploying renewable energy technologies for electricity generation (among others: del Río González and Gual, 2007, Lipp, 2007, del Río González, 2008, Lesser and Su, 2008, Yin and Powers, 2010, Haas et al., 2011, Dong, 2012, Groba et al., 2013). Kemp et al. (1998) and Nill and Kemp (2009) suggest that government should use technology-specific, market-pull policies to create niche markets and protect new innovations from competition with established technologies. Peters et al. (2012) use existing renewable electricity capacity as a proxy for market-pull policies and find that strong market-pull measures have a positive effect on the innovative output in a country based on patents.

2.3.3 Policy mix of market-pull and technology-push policies

Grubb et al (1995, 2002) highlight the importance of market-pull policies as an incentive to technology diffusion throughout the market. Hoffert et al (2002), insist that technology-push policies are decisive for generating new technologies that can be brought to market maturity. However, the theoretical and the case studies on the subject agree that successful technological change in renewable energies requires a mix of technology-push and market-pull policies to induce innovation and expand renewable energy utilization (Grubler et al., 1999, Grubb, 2004, Neuhoff, 2005, Bürer and Wüstenhagen, 2009, Johnstone et al., 2010).

By analyzing the innovation chain from basic research, through applied R&D, and demonstration to the commercialization of a new technology, product or process, Grubb (2004) highpoints that policy supports of varying intensity and direction is required. Grubb (2004) as well as Bürer and Wüstenhagen (2009) stress that public grants as well as basic and applied R&D is required during the early phase of the innovation chain, while market-pull policies are necessary during later phases to reach full commercialization. The study of Johnston et al.(2010), also indicate that both demand-pull and technology-push instruments have a significant influence on the development of new renewable energy technologies In the context of applying different policies to the various stages of technology development, the national system of innovation literature is also important. This provides a holistic picture of the role of institutions (market, research, education, and other sectors), incentive structures, networks in the innovation process, and technology characteristics (Edquist, 2006).

A study by Foxon et al. (2005) applied a system of innovation approach to the UK and found that wind onshore technology development here lagged behind other countries due to less favorable policies. Foxon and Pearson (2007) then analyzed policy processes in the UK and found that renewable obligations failed to promote RET innovation because this instrument, among other things, does not account for the different stages of technology development and commercialization .Similarly, Bergek and Jacobson (2003), who analyzed the wind industry in Germany, Denmark and Sweden; Marinova and Balaguer (2009)who looked at the photovoltaic industry in Australia, Germany and Japan; Negro et al.(2007)who analyzed the innovation system in Denmark focusing on biomass; and Hekkert et al (2007)who explained the rapid diffusion of cogeneration technology in the Netherlands. Del Rio and Bleda (2012) show that FITs are likely to be superior to other policy instruments such as quotas, tradable green certificates and tendering. However, they also highlight that complementary instruments, specifically R&D support, are also required and that the innovation effects depend strongly on specific policy design elements. To conclude, National innovation systems and the mix of implemented policies are important determinants of the technological change process. In addition, specific policies targeted at respective technology development phases are required as much as technology-specific promotion approaches to enhance the development of less mature technologies (Groba and Breitschopf, 2013)

2.4 Technology and Utilization of Direct Geothermal Energy

Technology is the driving force of adaptation and implementation of all projects, if the technological knowhow of any project is easily replicated then the success project is positive given other variables remain constant.

The Diffusion of Innovations theory (Rogers, 1995) for example, is a model which describes patterns of technology adoption and assists in predicting whether and how a new invention or technology will be successful. He adds, the rate of adoption of innovations is influenced by five factors: relative advantage (extent to which technology offers improvements over available technology); compatibility (consistency with existing values, past experiences and needs); complexity (difficulty of understanding and use); trial ability (the degree to which it can be experimented with on a limited basis); and observability (the visibility of its results). The Theory of Planned Behavior (TPB; Ajzen, 1985) proposes that intentions and perceived behavioral control (PBC) are the proximal determinants of behavior, also, (Ajzen, 1991); indicates that Attitude and social pressure determines motivation for use of a given technology.

Technology has a strong impact on economy growth and on a macro level, it is assumed that technologies once created, are optimally deployed (OECD, 2009).Development should be accelerated in order to make RETs cheaper, more efficient and better adapted to large-scale use (Hoffert, 2002;Vollebergh and Kemfert, 2005, Braun et al., 2010, Acemoglu et al., 2012). Knowledge sharing and coordination, joint R&D, technology transfer, and technology deployment mandates, standards, or incentives, lower the costs of mitigation technologies, resulting in the greater likelihood that countries will implement significant GHG reductions (OECD,2009).In addition, positive role of international technology-oriented agreements, as part of the architecture of an international climate change policy, has become clearer (de Coninck, et al. 2008, Justus and Philibert 2005) as outlined by Justus and Philibert, the benefits include; synergies in research, cost saving and risk mitigation, acceleration of developments, harmonization of standards, and reduced costs of national deployment support policies, for example, the IEA Wind Agreement between four participating countries reduced the total cost of aerodynamic testing to US$ 2-4 million, rather than a projected total cost of $12 million that would have been spent by the countries working individually (OECD, 2009).

2.4.1 Geothermal energy

Geothermal energy is generally classified as a renewable resource, where ‘renewable’ is a situation in which the energy removed from the resource is continuously replaced by more energy on time scales similar to those required for energy removal (Stefansson, 2000) similarly, detailed modeling studies Models predict that replenishment will occur in hydrothermal systems on time scales of the same order as the lifetime of the geothermal production cycle where the extraction rate is designed to be sustainable over a 20 to 30 year period (Axelsson et al., 2005a, 2010b). On the other hand, (Pritchett ,1998; Mégel and Rybach ,2000; O’Sullivan and Mannington ,2005) tend to differ by stating that economic reasons that have led to high extraction rates from hydrothermal reservoirs have resulted in local fluid depletion that exceeded the rate of its recharge. Authors have defined geothermal fluids differently; some authors have done so by using temperatures while others have used enthalpy (Dickson and Fanelli, 2004).Nevertheless, enthalpy is the most preferred criterion as indicated by different authors on Table 2.1 below. In addition, Depending on the enthalpy, geothermal fluid can be utilized either for electricity generation or direct applications. However, the direct utilization of geothermal energy is underutilized (Mwangi, 2005, kiruja, 2011, Mburu, 2012). Electricity generation is the most important form of utilization of high-temperature geothermal resources while low to medium resources are better suited for non-electric (direct) application (Mburu ,2010) as indicated on Table 2.2.

Table 2.1: Classification of geothermal resources (oC) (Dickson and Fanelli, 2004)

	(a)	(b)	(c)	(d)	(e)
Low enthalpy resource	<90	<125	<100	<=150	<=190
Intermediate enthalpy resource	90-150	125-225	100-200	-	-
High enthalpy resource	>150	>225	>200	>150	>190

a) Muffler and Cataldi (1978); b) Hochstein (1990); c) Benderitter and Cormy (1990); d) Nicholson (1993); e) Axelsson and Gunnlaugsson (2000).

Table 2.2: Basic technology commonly used for geothermal energy (Mburu, 2010)

Reservoir Temperature	Reservoir Fluid	Common use	Technology commonly chosen
High temperature, >220°C	Water or Steam	Power Generation Direct Use	Flash steam; Combined (flash and binary) cycle Direct fluid use; Heat exchangers;Heatpumps
Intermediate temperature, 100-220°C	Water	Power Generation Direct Use	Binary cycle Direct fluid use; Heat exchangers;Heatpumps
Low temperature, 30-150°C	Water	Direct Use	Direct fluid use; Heat exchangers;Heatpumps

2.4.2 Direct geothermal applications and technologies

Direct geothermal energy has many applications as indicated below and even further applications discussed in chapter 2.8 in the international and regional cases .In addition, different technologies have also been highlighted.

2.4.2.1 Heat Exchangers

Kevin Rafferty in his Direct Use Geothermal Applications for Brazed Plate Heat Exchangers suggests that, most geothermal fluids used for direct use purposes contain various Chemical species which can be detrimental to conventional materials of construction. For this reason, the standard design practice is to isolate the geothermal fluid from the balance of the system through the use of a heat exchanger. In the majority of applications, the plate and frame heat exchanger has been the design of choice for this duty. Plate and frame heat exchangers offer many advantages for geothermal applications including their availability in corrosion resistant materials (stainless steel) at reasonable cost. In addition, this design permits disassembly for cleaning or the addition of plates to accommodate increased heating loads. The units are very compact and efficient with heat transfer rates 3 to10 times those of shell and tube exchangers.

Rafferty adds, In Very small applications (less than approximately 20 ft2 heat transfer area), however, the cost of plate and frame heat exchangers becomes uneconomic. These applications would include the space and domestic hot water heating for residences and small buildings, and small commercial and industrial process applications. Recently, a low-cost version of the plate heat exchanger, the brazed plate heat exchanger has become available. Due to their simpler construction, these units can be economically produced in very small sizes. Considering the reduced cost (as little as 40% of a plate and frame unit for the same duty), these exchangers could greatly enhance the economics of small direct use geothermal.

2.4.2.2 Geothermal Heat pumps systems for Aquaculture, Greenhouse Heating, and swimming pool heating

Andrew Chiasson in Aquaculture and Geothermal Heat Pump Systems, studies feasibility of aquaculture tank, greenhouses, and swimming pools heating with geothermal heat pump (GHP) systems, with heating loads, were computed for three climates across the U.S. The net present value of a 20-year life-cycle was determined for various GHP base-load fractions, the results of this study show that the practice of covering aquaculture tanks with greenhouse-type structures can reduce heating demands by 55%. The economic analysis has shown that the feasibility of heating aquaculture tanks with closed-loop GHP systems is strongly dependent on the natural gas cost and the ground loop installation cost. The lowest life-cycle cost was observed when the closed-loop GHP system handles only a portion of the total annual heating requirement. At natural gas rates of $1.00/thermo ($0.35/m3), depending on loop installation costs and whether or not the aquaculture tanks are covered, a closed-loop GHP system sized at 7%-25% of the peak load could be installed to handle from about 25%-70% of the annual load. The economics of open-loop systems for the cases examined, as may be expected, are more attractive than closed-loop systems. In all situations examined, at natural gas prices of $1.00/thermo ($0.35/m3), the lowest life-cycle cost was observed at the GHP system sized at about 40% of the peak load. At that size, an open-loop system could handle over 80% of the annual heating load. At low to moderate installation costs of $200-$700/ton ($57/kW-$200/kW), over 90% of the annual heating load could be handled.

In greenhouses, this study has examined the feasibility of greenhouse heating with closed-and open-loop GHP systems. Heating loads were computed for four climates across the U.S. The net present value of a 20-year life-cycle was determined for various GHP base-load fractions. The results of this study show that the feasibility of heating greenhouses with closed-loop GHP systems is strongly dependent on the natural gas cost and the ground loop installation cost. It would not be economically justifiable to heat any portion of a greenhouse using a closed-loop GHP system unless loop installation costs were as low as $4/ft. to $5/ft. ($13/m to $16.40/m) and natural gas prices exceeded $0.75/thermo ($0.26/m3). This represents a very marginal situation at 2005 rates. On the contrary, for the cases examined, open loop systems appear to be quite economically feasible above natural gas rates of about $0.60/thermo ($0.21/m3).

Chiasson also adds that, Space heating, cooling, and outdoor swimming pool heating loads were computed for a residential building in 6 varying climates across the U.S. A vertical bore ground loop field was sized for each case with and without the pool. The results of this study show that ground loop lengths may be reduced by up to about 20% in southern U.S. climates with the addition of a pool. However, required ground loop length may need to be doubled in northern U.S. climates. A contour plot was presented showing the potential reduction in ground loop size as a function of the total annual heating load for the building, total annual cooling load for the building, and total annual heating load for the swimming pool. A simple economic analysis showed that it would not be feasible to incorporate a swimming pool into a GHP system in northern U.S. climates due to the extra ground loop required. On the contrary, immediate savings could be realized in southern U.S. climates.

2.4.2.3 Ground source heat pumps

According to Lienau, Boyd and Rogers (1995) in this whole article on ground heat pump, states, the economics of ground-source heat pump (GSHP) systems are represented by the simple payback reported in the case studies. The survey groups are compared first as residential systems, and then as school and commercial systems. According to the New York report (Hughes, 1985), "under no circumstances were earth-coupled heat pump systems found to be competitive with natural gas." Since 1985, when the New York systems were installed, there have been improvements in the efficiencies of ground source machines; However in most cases, the economics is still marginal or not competitive with natural gas. In addition, 37 Based on the results of the NRECA/University of Alabama survey, it is possible to characterize, in general, the economics of a typical 2-1/2 ton GSHP system. Because many GSHP systems are installed in new homes and the increased capital cost is financed through the mortgage, it is possible to determine where the break-even point occurs for the homeowner for a given set of conditions.

Using the survey data it is apparent that the average national cost for a 2-1/2 ton GSHP system with a vertical loop would be $5500 for the heat pump and ductwork plus $2250 ($900/ton) for the loop. This compares to $4000 for a 2-1/2 ton 10 SEER air-source heat pump system installed. As a result, the incremental capital cost of the ground source system is $7,750 - $4,000 = $3,750.Usingdata from a previous evaluation (Kavanaugh, 1992) of GSHP, it is possible to evaluate the economics of GSHPs verses ASHPs. A newly constructed well insulated (R-19 walls, R-44ceiling,and .5 air change/hr) 1740 ft2 home was modeled to determine the electrical energy requirements of two different systems: a 10 SEER/7.15 HSPF air-source heat pump and a 13.3 EER/2.8 COP ground-source heat pump with 180 ft/ton vertical bore. Electric resistance domestic hot water heating was used for both systems and super heater was included on the GSHP system 40.

In the case of residential systems, homeowners usually include the first cost of the HVAC system in the mortgage. An economic evaluation of life-cycle costs is more meaningful than simple paybacks. This could result in a break-even value for the electric rates in the area where the GSHP installation occurs. When comparing two electrical systems (i.e., GSHP vs. air-source heat pump), the higher the electrical rate the greater the GSHP savings. In comparing GSHP to natural gas, a higher gas rate and lower electrical rate will make the GSHP dollar savings more attractive. In the cases of school and commercial buildings, a more complex utility rate structure may be imposed on the system. The customers are billed for energy used in terms of kWh and also for the peak rate (kW) or demand charge at which he uses that energy. Electric rates and the way they are applied vary from utility to utility and can have a profound effect on savings. Recognizing all the potential influences upon school and commercial building energy use, predictions of savings to be achieved with GSHP systems becomes a very site-specific endeavor.

2.4.2.4 Industrial use of direct geothermal energy

Andrew Chiasson, in green fuels of Oregon: Geothermal Energy Utilization for Biodiesel Production reveals that green fuels of Oregon makes extensive use of their geothermal resource for many heating purposes. Uses of geothermal energy include radiant floor space heating of the biodiesel production building, in addition to use in the production of biodiesel itself. From the biodiesel facility, the geothermal water is cascaded to greenhouses when various organic vegetables are grown, and to an aquaculture operation. In addition, Chiasson discusses the Creamery Brewpub and Grill that use direct geothermal energy from the Klamath Falls geothermal district heating system for all its heating purposes. Uses of geothermal energy include space heating of approximately 11,000 ft2 (1,022 m2) of restaurant/pub space, snow-melting of about 1,000 ft2 (93 m2) of sidewalks, and generation of hot water for the brewing process. Other industrial use include heap leaching of precious metals, vegetable dehydration, grain and lumber drying, pulp and paper processing, diatomaceous earth processing, fish processing and drying, chemical recovery, and waste water treatment among other available uses discussed in Industrial Applications by Paul J. Lienau and John W. Lund.

2.5 Public awareness and Utilization of Direct Geothermal Energy

Awareness is a crucial component of any initiative; with awareness, knowledge of existence of a given project is created, that eventually results into creation of interest towards that idea or project.

To agree, Duffield and Sass, (2003), cite lack of awareness of the direct uses of geothermal energy as the greatest impediment to the growth of enterprises in geothermal utilization. Public awareness and acceptance are among the essential factors that facilitate geothermal energy potential resources (Kepinska & Kasztelewicz, 2015).However, it is necessary to take into account several major factors of various nature including social, economic, environmental, technological and scientific ones. These factors can be included in several groups of subjects (Czaplicka-Kolarz, Pyka [eds], 2010); Position of energy in the hierarchy of social values, priorities in the implementation of energy policy, the level of knowledge on energy sources, the level of support for the use of various sources of energy priority areas of research related to energy, adopted the RES share in energy mix and energy costs, energy savings.

In Europe, research conducted by The consortium of partners from those countries implementing the Geothermal Projects referred to as Geothermal communities (hereinafter referred to as GEOCOM) co-funded by the European Commission within the 7th Framework Programme since January 2010 (www.geothermalcommunities.eu), was undertaken to demonstrate the cascaded use of geothermal energy for district heating, with small scale RES(Renewable Energy Resources) integration and addition of new technology or features to older systems for efficiency and effectiveness measures. The study brings into perspective the current state of public perception that is ; to define the current social circumstances accompanying the efforts to introduce more geothermal into the energy markets and to suggest some educational and promotional measures to build further public acceptance and awareness for geothermal uses in Project partners' countries as well as in Europe. The research included cross-national, comparative analysis of public understanding and attitudes towards geothermal energy (Kepinska & Kasztelewicz, 2015).

Though in Africa such research is yet to be reported, a study conducted by Zemedkun & Wekesa (2014) indicate the use of the South-South Cooperation (SSC) elements/attributes employed in the UNEP African Rift Geothermal Development Facility (ARGeo) Program. This is in pursuit of regional cooperation and exchange mechanisms through replication of best practices and synergy among various countries in East Africa region. Two or more developing countries pursue their individual or collective development through cooperative exchanges of knowledge, skills, best practices, resources and technical know-how. The program also aims to encourage and create self-reliance of developing countries, by enhancing their capacity to find answers to their development problems. In addition, UNEP ARGeo mobilized upstream policy support for geothermal development and also facilitated various geothermal policy dialogue and exchange among policy makers and private developers to set up a clear and coherent geothermal policy, legislation and institutional and regulatory frameworks. The Kenya Renewable Energy Policy 2013 that includes Geothermal Act was used as a model to review the existing energy policies of Rwanda, Uganda and other East African countries. Finally UNEP has created awareness on has how the East African geothermal resource can be harnessed towards the realization of increasing renewable energy mix and enhancement of universal access. This was done through organization of a high level group visit to Olkaria geothermal power plant and Menegai geothermal drilling (Zemedkun & Wekesa, 2014).

However, this approach limits the spread of information to a small number of policy makers and private developers. In addition, acceptance of projects put up may be hindered due to propaganda brought forth by political interests also in some instances some of the concepts used may be complex to some of the policy makers and private investors, these might lead to either disposal of ideas or skepticism about the credibility of an idea. Moreover, Innovation is limited to the few who most at times are burdened with meetings and forums therefore inhibiting the process of creativity and development within the organization. It can be concluded by saying ‘Individuals expand their knowledge when others share their knowledge, and one’s knowledge is combined with the knowledge of others to create new knowledge’ (CIO Council, 2001).

According to the GEOCOM experts conducting a research on the State of knowledge on possibilities of geothermal energy uses in the states of FYROM (Former Yugoslav Republic of Macedonia), Hungary, Italy, Poland, Romania, Serbia and Slovakia the findings were; the level of public knowledge on RES and possibilities of their uses is generally poor , with more optimistic picture for FYROM(Former Yugoslav Republic of Macedonia) ,Slovakia (55 – 60% of “sufficient” ranks) and Hungary – whose status on knowledge was evaluated as sufficient by 85% of experts. In no case the experts evaluated the public knowledge on RES as good .Regarding the situation in all seven GEOCOM states, 40% of all evaluations indicated the respective knowledge as sufficient while 60% as poor. On such a background, the public knowledge on geothermal energy as one of the RES mix component, is even worse: the ranks ”poor” dominate for Italy the “lack of” knowledge is counted as 80%. The two only states with the significant share of higher evaluations defined as “sufficient” level of knowledge are Hungary (50%) and Slovakia (75%).This more positive image is made up of several factors (e.g. access to information, relatively frequent uses, opportunities to see the installations, positive experience of using geothermal water(numerous geothermal bathing and spa centers, etc.).Taking into account responses from all countries, the level of public knowledge on geothermal was evaluated as sufficient by ca. 18% of experts only; prevailing is the rank “poor” (70%) or even lack of knowledge (12%). The Observations and experience of experts indicated that the relevant substantive knowledge is sometimes weak or superficial, which results, among others, in unsatisfactory level of some documents and regulations, quality of social dialogue, efficiency of cooperation with professionals and NGOs (such entities are sometimes neglected by the governmental agencies in the process of preparing legal and regulatory documents, and their expertise and knowledge are not used sufficiently).

Fortunately, there was positive examples of such cooperation in Hungary, where geothermal NGO was appointed to elaborate apart of NREAP related to geothermal energy uses' development by 2020 – this path should be followed by others. In all cases, there was either, lack of or poor knowledge of national and EU documents related to RES and geothermal. Partly sufficient level of this knowledge is theoretical in Hungary and Macedonia only). On the other hand – as indicated by experts from Slovakia, where public awareness on renewables was generally at sufficient (or even good) level, such documents and strategies were generally poorly or not at all known to the public, as they were not sufficiently disseminated. In respect to all the GEOCOM states, experts evaluated that respective public knowledge is missing (35%) or its level is poor (ca. 45%); the percentage of "sufficient" ranks was low (10% of responses) .In addition, State of knowledge on possibilities of geothermal energy uses indicated that; all countries were in large consensus as to the main types of direct uses both from economic and social points of view: space heating ,agriculture ,balneotherapy and recreation (ca. 25% of each use) with some higher percentage of space heating (30%) where social criterion is concerned. Though the study has explored various significant areas of awareness, the issue concerning public knowledge on policies regarding public use of geothermal resources is yet to be explained in many countries like Kenya the geothermal resources are protected .

2.6 Theoretical Framework

This study was guided by theory of progressive utilization, also known by the acronym PROUT, which is a collection of socioeconomic and political ideas propounded by Indian philosopher and spiritual leader Prabhat Ranjan Sarkar in explaining the factors influencing utilization of direct geothermal energy.

According to Sarkar, the universe is composed of five rudimental factors: ethereal, aerial, luminous, liquid and solid factors. The ethereal factor is the physical space. The aerial factor consists of all the gases; the luminous factor of light and fire, the liquid factor of water, oil, etc. and the solid factor of minerals, wood, solid metals, etc. all these five rudimental factors constitute resources available to society for utilization. However, little effort to explore the maximum utilization of natural resources has been achieved (acceptance of use), yet there is ample scope in nature's resources to provide a congenial living environment for each living being. For example, the tremendous amounts of unharnessed energy of the universe. Mwangi (2005) acknowledges this when he states that direct utilization in Kenya has not been given the necessary attention. In defense for underutilization, he asserts that utilization has to be coupled with awareness of the economic value as well as the more qualitative, life-appreciating value. Also, educating human beings about their rights – social, economic, mental, and spiritual –

expands knowledge; and the full application of those rights refines science hence, in respect to education, PROUT avidly encourage raising awareness .

According to the Progressive Utilization Theory, Mundane potentialities, which are latent in land, water, sunlight, air and ether should be utilized maximally and properly. However, for geothermal energy, studies indicate electricity strategic value as, rightly, superior to any possible commodity that uses direct geothermal (Taqwim, S. & Pratama, B.H, 2015), as a result, the technology, reliability, economics, environmental acceptability accompanied by utilization of direct geothermal energy (fridleifsson, 1998) and even further, a great supplement for geothermal power developments and potential market (Mburu, 2008) has not been realized by the available market .Proper utilization means maximum utilization, balanced utilization and progressive utilization of each and everything. However, growing electricity demand is putting a strain on the power infrastructure (SREP IP, 2011) that leads to constant plans for drilling activities for electricity. In order to realize the goal of self-sufficiency, local people will hold economic power, enabling local raw materials to be used to promote their economic prosperity.

However, this can be argued from the political point of view that the geothermal resource is a public utility resource, there cannot call for community participation. Though, Sarkars view can be challenged in this context, he advocates for a balanced and practical approach, he proposes “a three-tiered economic structure that is, small scale privately owned businesses, medium scale cooperatives and large scale key industries managed by the immediate government.” (Sarkar, 1984).However, Sarkar adds that Housing materials should be manufactured and distributed by the state government (through the mechanism of autonomous bodies) or by large cooperatives supported by the state government, he continues by stating that when an industry is declared to be a key industry by an appropriate government authority, it comes under state control and central planning (Sarkar, 1984), as in the case of the government and Geothermal Development company.

Moreover, local raw materials should not be exported to another unit, as they often are in the free market system, but rather, industrial centers will be built up wherever raw materials are available, an example of the current scenario is the Oserian flower farm where direct heat is transported to flower farms near olkaria. Following this policy will create industries based on locally available resources and provide full employment for local inhabitants; However, Sarkar is explicit about the dangers of business people having a dominant role in the rural economy. He defines business people as “those who profit by trading and broking without being directly involved in production”. Such people should not own arable land, nor should they act as intermediary merchants creaming off the profit. He is also opposed to the feudal-like system where peasants work hard but must deliver their harvest to a wealthy landowner, Sarkar further argues that business people be given scope to gain control of key commodities key commodities such as oil, steel and communications, he sums up by stating, The less private enterprise is provided with business opportunities and the more production and distribution are carried out through cooperatives and autonomous bodies, the better, (Sarkar, 1998, p142).

Therefore, un-utilization of physical wealth leads to uneven distribution and great injustices. Maximum utilization of resources ensures guaranteed employment and productivity improvements that eventually increase the purchasing capacity of all residents, ensuring rising standards of living, which is a goal of any economic philosophy that plans systematically, not haphazardly, for the welfare of all people, not just a few such example can be given to most developed industrialized countries in Asia, North American and Central and Eastern European countries (Lund and Boyd, 2015). In addition, Prout also promotes economic decentralization that is; each sector of the economy must strive for maximum development, and all sectors must strive for maximum decentralization. This policy leads to diversity of production in goods and economic sectors and diversity of production location. Economic decentralization is impossible under capitalism, because capitalist production always aims at maximizing profit. Capitalists prefer centralized production, which leads to regional economic disparity and imbalances in the distribution of the population. In the decentralized economy of Prout, emphasis is on production for general consumption, and the minimum requirements of life will be guaranteed to all. All regions will get ample scope to develop their economic potentiality, so the problems of floating and migrant populations and overcrowding in urban centers will melt away. In regards to policies, he asserts that principles of Prout are unchanging, but policies must adjust with circumstance. However**,** various plans for a better organization of the economy and for economic democracy are good in theory .He continues by stating that the proper use of any object changes according to changes in time, space and person. He further, explains in regards to technology by stating, Science is “for service and blessedness,” hence for the benefit of society as a whole. For this reason it must be under moralist (sadvipra) control.

2.7 Conceptual Framework

The conceptual framework identifies and indicates the effects of independent and the dependent variables. The conceptual frame work in this research will help the researcher identify the various factors influencing utilization of direct geothermal energy.

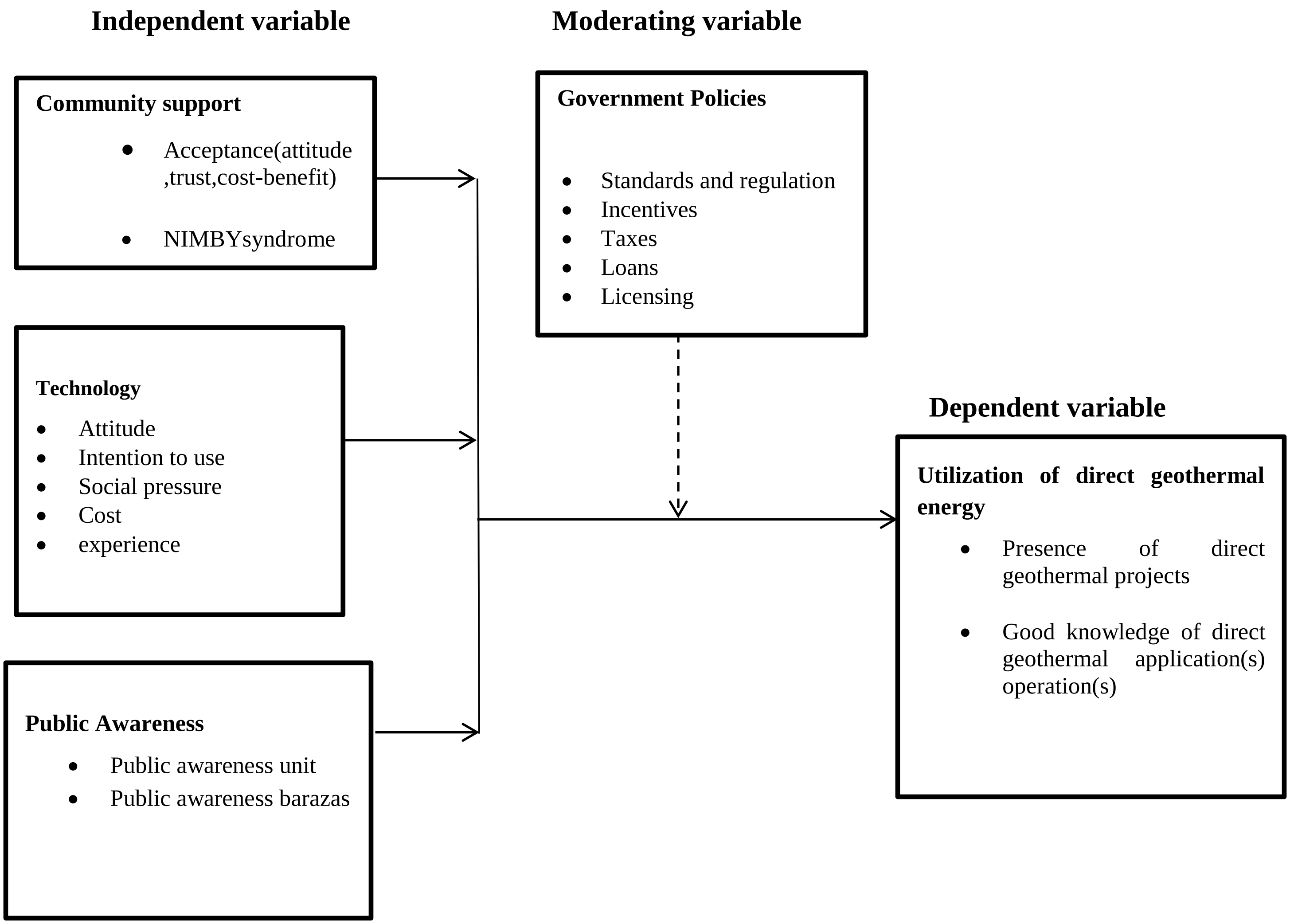

Figure 1: Conceptual Framework

2.8 Successful Use of Direct Geothermal Energy at International and Regional level.

There many cases that could be listed as successful in the use of the direct geothermal energy. However, Kenya's economic backbone is Agriculture; in addition, currently climate change has seen areas within the country face food shortage and severe droughts in arid and semi-arid regions that have led to death of both Humans and Livestock. In other cases like Turkana security has been challenged with issues of cattle raiding and food shortage.

2.8.1 Agricultural Cooperative in Szentes - southern Hungary

Geothermal Agriculture in Hungary main hydrological systems is associated with geothermal fluids. Approximately 420 acres (200 ha) of glass and plastic covered greenhouses are heated with geothermal energy. In addition, 2,500 acres (1,000 ha) of temporarily covered plastic tents of "tunnels" are also heated. Vegetables are grown in about 25% of the greenhouses covered by glass and in 95% of those covered with plastic. The most important vegetable grown are peppers, tomatoes and cucumbers. The remaining greenhouses are used for nursery stock, ornamental and cut flowers. Besides greenhouse heating, geothermal waters are used at animal farms, for space heating and hot water supply (approximately 5 to 8% of the greenhouse heating load).Geothermal waters are used for heating purposes at 50% of the farms, where the heat is cascaded for all of the above purposes.

More recently; Automatic controls have been introduced in a number of agricultural farms. These systems save energy and increase crop yields, thus providing a rapid payback period(estimated at one year).There are two sites in the country where the geothermal heating system for greenhouses is fully computerized The best example of this modern installation is the" Arpad" Agricultural Cooperative in Szentes in southern Hungary. Here 18,500 acres (7,500 ha) of land are used to grow vegetables (tomatoes, cucumbers, lettuce, yellow peppers, and the main crop of red peppers for paprika).Geothermal fluids are used to heat 54 acres (22 ha) of glass greenhouses and 37 acres (15 ha) of plastic tents Approximately 70% of their produce is exported. Fourteen wells, 5,900 to 7,900 feet (1,800 to 2,400m)deep and located 2 to 3 miles (3 to 4 km) away, provide 169 to 194^{o}F (76 to 90^{o}C) water to the complex. These wells also provide water for heating buildings and for animal breeding. A total of 1,200,000 turkeys; 600,000 geese and 1,800 cows (600 for milking) are raised each year.

2.8.2 Geothermal Agriculture in Tunisia – Kebili

There are about 1,500 ha exploited for geothermal resources; 96% for agricultural purposes: 77% for irrigation of oases and 19% for greenhouses. The remainder (4%) is used for bathing (hammams); tourism (hotels and pools), washing and animal husbandry heating and irrigation of greenhouses are one of the largest low enthalpy energy consumers in agriculture. There are around 940 ha worldwide heated using geothermal energy, which represents 12% of the total energy use. In Tunisia, in addition to irrigation of oasis, the geothermal water is used for heating plastic greenhouses. In addition, farmers in the Kebili area utilize the physical method. The geothermal water is combined with solar radiation (solarisation) and used to disinfect the soil. The idea is to irrigate the total area of the greenhouse in summer time also animal husbandry is also practiced.

The utilization of geothermal energy recently started in the country as an experiment. The results were very encouraging and led to the idea of a Geothermal Utilization Project in Agriculture (PUGA-project, TUN/85/004) financed by the UNDP. In 1986 the government started to use geothermal energy in greenhouses in southern part of the country. After one year, many demonstration projects in several places had been established with the collaboration of the Energy Agency (AME) and the Rural Development Programme (PDRI). The exploitation of geothermal resources for heating greenhouses on the edge of the desert represents a promising development alternative.

2.9 Knowledge Gap

Studies conducted on direct geothermal energy use have identified uses such as greenhouses, swimming, bathing and balneology, residential heating or cooling and hot water supply, aquaculture, pyrethrum drier, water harvesting among others as provided by the lindal diagram. In Kenya, sited cases of drying pyrethrum flowers and condensing, steam for drinking water by farmers at Eburru village, and green houses in Oserian have been highlighted as some of the ways direct geothermal energy has been used. In addition, and pre-feasibility for crop drying conducted by in October 2013 by The United States Agency for International Development and geothermal as one of the partners also make up as part of proven ways of direct geothermal use.

However, the knowledge of use of such resource is in the hands of very few people that either refuse to share it with the public population or the organization policy does not permit. Moreover, policy on the use of geothermal resource is unknown to the public. According to the laws of Kenya governing geothermal energy, all un-extracted geothermal resources under or in any land shall be vested in the Government subject to any rights which, by or under any written law, have been or are granted or recognized as being vested in any other person. In order to utilize such a resource, the Minister of Energy is in charge of issuing of the license, which under law is not transferable and renewable after one year. This law retards the implementation of private sector utilization of direct geothermal resource.

Geothermal resource ownership and legislature is unknown to the community, for instance in Kenya, concerns of the local community about the geothermal power development were ignored by the government; the result is protests with massive violence against the community. Though it is clear that land where geothermal energy resource rests is State land under the Kenyan law governing geothermal resources, awareness of such a law to the local community has not been done. In addition, the resource being a State resource kills the true meaning and role of community participation, since the surrounding community has no direct claim of such a resource. It is no wander Madiang (2013) study of factors influencing community participation in geothermal resource indicated low community participation.

2.10 Summary of Literature Review

From the foregoing reviewed literature, it is clear that renewable energy resources such as geothermal energy are very important .However, many developing countries within the rift, are yet to explore the potential of direct geothermal energy due factors such as social support, Government policies ,technology and public awareness. Conversely, governments worldwide have started introducing all forms of programmes that are enabler’s of direct geothermal use. This is working positively to their economies. In Kenya however, concentration has been on electricity and therefore making the use of direct energy marginal. The literature contains some of the well implemented projects using direct geothermal that can be replicated.

CHAPTER THREE
RESEARCH METHODOLOGY

3.1 Introduction

This chapter gives the methodological procedures that were used in data collection and analysis. The discussion include the research design; location of the study; population of the study; sampling procedure and sample size; instrumentation; data collection; and data analysis.

3.2 Research Design

A research design is the general plan of how one goes about answering the research question (Saunders et al, 2009).The study used descriptive Survey research design. This design was most appropriate for the type of objective which was to determine the factors that influence the utilization of direct geothermal energy in Kenya.

This research was both explanatory and descriptive. It is explanatory in the sense that the problem is examined with an aim of establishing the casual relationships between variables (factual and attitudinal information or research questions about self-reported beliefs, opinion, characteristics of present or past behaviors (David and Sutton, 2004; Gray, 2004; Neumann, 2000). On the other hand, it qualifies as descriptive since it sought to portray the phenomenon through describing events, situations and processes. In addition, data collected from respondents about their opinions and experiences was fit for the purpose of generalization of findings to the population the sample intended to represent (Gall, Borg and Gall, 1996).

3.3 Target Population

Cooper and Schindler (2003) describe a population as the total collection of elements whereby references have to be made. The populations of interest for this study were household adult heads of the 2545 households neighboring Menengai Geothermal Project and the direct use department of GDC. The Menengai Geothermal project is located within the Menengai Caldera in Wanyororo and Kirima Sub-Locations in Ndungiri/Kirima Location of Bahati Division in Nakuru North District, Nakuru County, situated at an altitude of 1859m above sea level within the Great Rift Valley (Madiang, 2013). The target population is 2545 households out of which only household heads classified as adults was sought. The 2009 Population Census Report of the two sub-Locations gives a summery in the table 3.1 below.

Table 3.1: Population in the Study Area

Sub-Location	Male	Female	Total	Households
Kirima	2103	2071	4174	1022
Wanyororo	3229	3253	6482	1523
Total	5323	5324	10656	2545

Source: Kenya population and Housing census, 2009

The target population from Geothermal Development Company is Nine (9) staff members of direct use consisting of two (2) females and seven (7) males.

3.4 Sample Size

The sample size of the number of respondents was obtained using the formula by Nassiuma (2000) indicated below;

Equation: Formula for determining Sample Size

$$n = \frac{NC^2}{C^2 + (N-1)e^2}$$

Where,

n = Sample

N = Population

C = Covariance

e = Standard error

Nassiuma (2000) asserts that in most survey, a coefficient of variation in the range of 21% to 30% and a standard error in the range of 2% to 5% is usually acceptable. In this study *c* was taken as 21% and *e* to be 2%. Applying the formula:

$$n=\frac{2545(0.21)^2}{(0.21)^2 + (2545-1)(0.02)^2}$$

= 105.7121

Therefore the desired sample was 106 households' heads.

Expert Purposive sampling was used in GDC to single out the department dealing with direct use. However, census was applied in this department since the staff members are 9, this is relatively small target population eliminated the necessity of sampling. In addition, census method eliminated the sampling bias which would otherwise compromise the accuracy of the study findings. This implies that, the results that were obtained from this method have a greater degree of generalizability when compared to sampling.

3.5 Sampling procedure

First, proportionate stratified sampling was used in distributing the sample of 106 households in the 2 administrative sub-Locations. This ensured that the sample was proportionately and adequately distributed among the 2 sub-Locations, and according to the population of each sub-Location. Since the Kenya's Population and Housing Census 2009 displays the sample frame of the 2 sub-Locations, each sub-Location (stratum) was allocated a portion of the sample by dividing the total number of households in that sub-Location by the total number of all households in the 2 selected sub-Locations and then multiplied by the sample size (106).This resulted into a sample of 63 for Wanyororo sub-Location and 43 households for Kirima Sub-Location.

3.6 Data Collection Instruments

The study employed structured questionnaire to collect the primary data from the respondents. This means that the study was limited to the findings from analysis of primary data. Mugenda and Mugenda (2009) observed that, questionnaires are frequently used in quantitative social research. In addition, the questionnaires were convenient for the task in that they could be easily and conveniently administered with the study sample. Moreover, the use of questionnaire was cost effective, less time consuming as compared to the use of interview and easy to analyze. The researcher used primary and secondary sources of data for this study.

The structured questionnaire comprising of closed and open-ended questions was divided into 2 parts: -Part 1.Personal information or the general demographic data of the respondent and; - part 2 contained the questions related to factors influencing utilization of direct geothermal energy.

3.6.1 Validity of instruments

The content validity of the research instruments was established in order to make sure that they reflect the content of factors influencing utilization of direct geothermal energy in Kenya. First, the researcher went through the instruments and compared them with the set of objectives to ensure they contain all the information that answers the set questions and addressed objectives.

In addition, the supervisor was also consulted to scrutinize the relevance of the questionnaire items against the set objectives of the study. The instruments finally underwent piloting on a population similar to the target population; a local community surrounding Eburu project and two GDC management staff. According to Connelly (2008) the extant literature suggests that a pilot study sample should be 10% of the sample projected for the larger parent study. Therefore 10 household heads from the community near Eburu project and 1 manager from GDC were chosen as part of the pilot study. The objective of piloting was to eliminate any ambiguous items, establish if there are problems in administering the instruments, test data collection instructions, establish the feasibility of the study, anticipate and amend any logistical and procedural difficulties regarding the study, and allow preliminary (dummy) data analysis.

3.6.2 Reliability of the Research instrument

Cronbach's alpha reliability coefficient was employed to test the internal consistency. A threshold of reliability coefficient of 0.7 and above was sought. This is in line with Makgosa (2006) who notes that Cronbach's Alpha of less than 0.5 indicates unreliability of the variables hence cannot be used to deduce findings and a high Coefficient of 0.7 implies that items correlate highly among themselves that is there is consistency among the items in measuring the concept of interest. An adjustment on the instruments was done, where a lower reliability coefficient was released. The results on reliability of the research instruments are presented in Table 3.2 below.

Table 3.2: Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.762	.755	35

The overall Cronbach's alpha for the five categories is 0.762. The findings of the pilot study show the all the three scales were reliable as their reliability values exceeded the prescribed threshold of 0.7 (Mugenda & Mugenda, 2008).

3.7 Data Collection Procedure

A systematic random sampling procedure was employed. This approach was chosen because it ensures an equal probability of inclusion of each unit in the population than simple random sampling (Nassiuma and Mwangi 2004). The procedure involves drawing a sample of size n from a population consisting of N units in such a way that starting with a unit corresponding to a number r chosen at random from the numbers 1,2….,k every k^{th} unit is selected. The number k is taken as the nearest integer N/n and is called the random interval. The number r picked at random is called the random start.

For Kirima sub-location=1022/43 = 24

For Wanyororo sub-location=1523/63=24

To get a random start number between 1 and 24 was randomly picked from a container. In this study the number 4 was picked and from the list obtained every 24 th number (HH) was selected from the list until a total of 43 and 63 households was obtained from the list for kirima and Wanyororo respectively.

3.8 Data Analysis Techniques

Data analysis refers to examining what has been collected in a survey and making deductions and inferences (Kombo and Tromp, 2000). The collected questionnaires were checked to ensure that they are adequately and appropriately filled. The foregoing minimized chances of non-responses and extreme outliers. The raw data was then keyed and summarized in excel and analyzed in SPSS version 22 in form of descriptive data by use of frequency, percentages ,means and standard deviation .descriptive statistics was chosen because it describes the opinions of the respondents regarding the various constructs under study. In addition correlation coefficients and regression was used to infer the findings to the general population the sample represented.

3.9 Ethical Considerations

The researcher before undertaking the research briefed the respondents on; the objectives of the study, the research instrument, and how the finding of the study was to be utilized. This was done for all respondents. This was meant to avoid any misunderstandings that would crop up during the interview. Consent of the informed target respondents was also requested before any interview begun; those unwilling to take part in the interview were replaced by their immediate neighbors. The researcher in addition assured the respondents of utmost confidentiality of the information given. Finally, the researcher got approval from the Management of Menengai Geothermal Power Project before conducting the research with the direct use team and Ministry through the National council of Science, Technology and Innovation (NACOSTI).

3.10 Operational definition of variables

Table 3.3 gives the variables, measurable indicators, data collection and analysis instruments. An operational definition is a demonstration of a process such as a variable, term, or object in terms of the specific process or set of validation tests used to determine presence and quantity. The dependent variables operationalized as shown in the table 3.3.

Table 3.3: Operational Definition of Variables

Variable	Operational Definition	Measurements	Measurement Scales	Study designs	Tools of data analysis
Research objective 1	To establish the extent to which community support of geothermal energy influences utilization of direct geothermal energy.				
Independent variable Community support	Level and extent of local opposition and how drivers to acceptance have been utilized to achieve direct use utilization by the community.	1. NIMBYsyndrome 2. Acceptance(attitude, Trust,cost-benefit ratio)	Interval scale	Qualitative and Quantitative	Descriptive statistical analysis by computing the means, standard deviation of responses to questionnaire items
Research objective 2	To ascertain the extent to which government policy influences utilization of direct geothermal energy.				
Independent variable Government policy	Government existing policies effect towards accelerating GDC and community uptake of direct use	1. Standards and regulation 2. Incentives 3. Taxes 4. Loans 5. Licensing	Nominal scale	Qualitative and Quantitative	Descriptive statistical analysis by computing the means, standard deviation of responses to questionnaire items
Research objective 3	To assess how technology influences utilization of direct geothermal energy.				
Independent variable Technology	Technological drivers of Technology in relation to uptake of direct use by both GDC and	1. Attitude 2. Intention to use 3. Social pressure	Interval scale	Qualitative and Quantitative	Descriptive statistical analysis by

	community	4. Cost 5. experience			computing the means, standard deviation of responses to questionnaire items
Research Objective 4	To examine the extent to which public awareness of influences direct geothermal energy utilization.				
Independent variable Public awareness	Contribution of the number quality public awareness initiatives targeting community for utilization of direct use	1. Public awareness unit 2. Public awareness barazas	Ordinal scale and interval scale	Qualitative and Quantitative	Descriptive statistical analysis by computing the means, standard deviation of responses to questionnaire items
Dependent variable Utilization of direct energy	Level and evidence of utilization of direct geothermal energy	1. Presence of direct geothermal projects 2. Good knowledge of direct geothermal application(s) operation(s)	Interval scale	Qualitative and Quantitative	Descriptive statistical analysis by computing the means, standard deviation of responses to questionnaire items

CHAPTER FOUR
DATA ANALYSIS, PRESENTATION AND INTERPRETATIONS

4.1 Introduction

This chapter discusses the interpretation and presentation of the factors that influence utilization of geothermal energy sector in Kenya. The research made use of frequency, percentages, mean and standard deviation to present data.

4.2 Response Rate

The study targeted 106 households neighboring Menengai geothermal project. From the study, 88 out of the 106 sample respondents from the community filled-in and returned the questionnaires making a response rate of 83% from the community and 100% from GDC as per the Tables 4.1 and 4.2.

Table 4.1: Questionnaire return rate from the community

	Frequency	Percentage
Respondent	88	83
Non-Respondent	18	17
Total	106	100

Table 4.2: Questionnaire return rate from GDC

	Frequency	Percentage
Respondent	9	100
Non-Respondent	0	0
Total	9	100

According to (Mugenda & Mugenda, 2008) a response rate of 50% is adequate for analysis and reporting; a rate of 60% is good and a response rate of 70% and over is excellent; therefore, this response rates were excellent for analysis and reporting.

4.3 The Demographic Data of Respondents

Respondent's personal information was sought with respect to gender, age and the level of education. The socio demographic questions were important; to ensure total inclusivity in terms of gender, age and education level. In addition the questions were asked in order to ensure that the right target group was reached in this case household heads of age above 18 years of age which according to the Kenya's constitution are classified as adults.

4.3.1 Gender of the Respondents

The research sought to involve both genders as respondents with the view of attaining balanced opinions. The following were analysis in respect to gender as in table 4.3.

Table 4.3: Gender Frequency of Respondents

	Frequency	Percent
Female	36	37.1
Male	61	62.9
Total	97	100.0

From the data that was collected, it can be determined that 62.9% were males while 37.1% were females. This indicates that the larger half of the respondents were male respondents.

4.3.2 Age of Respondents

The study sought to establish the ages of respondents to ensure that only adults participated in the study and all ages from 18 years and above were adequately represented. The analysis is as in table 4.4.

Table 4.4: Frequency and percentage

Age limits	18-20	20-30	31-40	41-50	51 and above	Total
Frequency	4	27	34	16	16	97
Percentage	4.1	27.8	35.1	16.5	16.5	100

The results show that the majority of respondents who participated were of the ages between 31-40 years with a percentage of 35.1%. This is followed by ages 20-30 with a percentage of 27.8%, ages 18-20 had the least number of respondents with a percentage of 4.1%.

4.3.3 Level of Education

The study also sought to establish the education level of respondents. The purpose of the question was to determine the literacy level of the community and staff of GDC. This information was necessary since application of direct geothermal requires minimal technical knowledge therefore can be applied with people with very low education levels. Table 4.5 contains the analysis.

Table 4.5: Frequency and percentages related to Level of Education

	No education	Primary	Secondary	College/ University	Total
Frequency	8	33	31	25	97
Percentage	8.2	34	32	25.8	100

The study results revealed that most respondents had primary education with 34% and only 8.2% could be said to have no education. In general 91.8% had attained education levels sufficient in application of direct geothermal energy.

4.4. The Analysis of Variables in relation to direct geothermal utilization

In the research analysis the researcher used Likert scale rating of 5 to 1; where 5 is the highest and 1 the lowest. Opinions given by the respondents were rated as follows, 5 = Great extent or Very high, 4 = Moderate extent or High, 3 = Neutral, 2 = Disagree and 1= Strongly Disagree. In addition, Nominal Scale was also used where Yes=1, No=0 and Not Known=2 and lastly Ordinal Scale ranging from 1 as the least to 5 as the most. Analysis for mean, standard deviation, correlation and multiple regressions were based on this ratings scale. A standard deviation greater than 1.0 illustrates extremes in opinions.

4.4.1 Community support

This study was determined to establish whether community support influences utilization of direct geothermal energy. Community support has been considered as a key determinant to the success of any community project. Respondents from the community and GDC were required to respond to set questions related to direct use of geothermal resources. The scale used was the Likert scale that ranged from Great extent=5, moderate scale=4, Non-committal=3, Small extent=2, No extent=1. The results of the study are as in table 4.6 and 4.7.

Table 4.6: Analysis of community opinions regarding community support and direct use

Questions relating to Community support	n	Mean	Std. Deviation
1. To what extent is geothermal energy important for you?	88	2.7273	1.79224
2. Is there any harm you think is as a result of GDC project?	88	2.2841	1.48517
3. Are efforts by geothermal energy good and beneficial to the community?	88	2.7500	1.69685
4. Are community members a happy that the geothermal project is in neighborhood?	88	2.6136	1.54199

5. In your own opinion, how would you rate the level of households with electricity?	88	2.5000	1.35613
6. Have there been incidences of demonstrations against the GDC project?	88	1.9091	1.35304

The opinion statement that geothermal energy is important had a mean score of approximately 3 and a standard deviation of 1.8. This shows that the community is non-committal on importance of geothermal energy. The opinion statement that there is harm related to existing geothermal resource had a mean score of 2 and a standard deviation of 1.5. This shows that though community members believe that there is some harm caused by the geothermal project it has not raised much alarm yet. The opinion statement that efforts by geothermal energy are good and beneficial yielded a mean of 3 and a standard deviation of 1.7. This indicates that the community is not sure whether efforts by GDC are good or bad and they are also indifferent about the geothermal project, the level of households with electricity is moderate with a standard deviation of 1.4. There have been demonstrations to a small extent this is indicated by a mean of 2 and a standard deviation of 1.4.

The mean score of answers to questions relating to community support and utilization of direct geothermal was 3, according to the Likert Scale this was a non-committal state. This could be interpreted as; the community is both in support and against utilization of direct geothermal energy. In addition, it can also be said that the community is less interested with direct geothermal energy or; the community is not sure about what direct geothermal energy really is or its latent capabilities.

Table 4.7: Analysis of GDC opinions regarding community support and direct use

Questions relating to community support	N	Mean	Std. Deviation
1. Are their plans to transfer direct geothermal energy projects to the community?	9	4.2222	.97183
2. Are there known negatives associated living within the neighborhood of geothermal resources?	9	2.3333	1.00000
3. Have GDC ensured that the communities near the project reap direct benefits from the resource apart from creation of employment?	9	4.2222	1.30171
5. Do you think that the community appreciates geothermal projects?	9	4.6667	.50000

The direct use team from GDC indicated that there are plans to transfer direct geothermal energy projects to the community by GDC with a mean of 4.22 and a standard deviation of less than 0.972 indicating a very low variation towards their opinions. The statement on known negatives associated with living within the neighborhood of the geothermal resource attracted opinions of a mean 2.33 indicating that the community living close to the Menengai Geothermal project was exposed some harm to a small extent with a standard deviation was 1.0. In another statement GDC Direct Use Department indicates that the community has reaped direct benefits apart from employment creation by giving a mean of 4. However, a standard deviation of 1.3 indicates a high variation in responses. GDC Direct Use Department is also of the opinion that the community appreciates geothermal projects by having a mean of 5 and a standard deviation of 0.5.

Generally, the responses from GDC team are for the opinion that there is community support towards geothermal project with a mean of 4.0. According to GDC, direct use team, they have full support from the community.

4.4.2 Government Policy

Government policy can influence projects directly or indirectly depending on the business environment the project operates. Government policies should be communicated; information and drivers enabling implementation of policies should be made available. Therefore, this study sought to establish the influence of government policy on utilization of direct geothermal energy by the community, and how these same policies influence implementation of direct geothermal projects by GDC. The scale used was Nominal Scale giving Yes=1, No=0.The analysis are indicated in table 4.8 and 4.9.

Table 4.8: Analysis of Community opinions regarding Government policies and direct use

Questions relating to Government policies	n	Mean	Std. Deviation
1. Have you attended sessions on use of direct geothermal energy by GDC?	88	.1477	.35686
2. Are there spare parts for direct geothermal equipment you know or have heard about?	88	.0341	.18250
3. Is information regarding standards and regulation on the use of direct geothermal energy available to you?	88	.0455	.20949
4. Is there law governing the use of direct geothermal energy you know?	88	.0227	.14989
5. Are you able to apply direct geothermal energy?	88	.0682	.25350
6. Do farmers within the community have support from the government for application of direct geothermal?	88	.0341	.18250
7. Is it possible to get information on licensing of use of direct geothermal?	88	.0568	.23282
8. Are there people within the community working for GDC?	88	.6023	.49223
9. Are there people within the community using direct geothermal energy?	88	.1818	.38790

By rounding off the means and standard deviation to the nearest whole number, the table indicated that the respondents had not attended or heard about any sessions regarding direct use, they did not know or heard of spare parts of direct geothermal equipment, they had no information regarding standards and regulation on the use of direct geothermal energy, they did not have knowledge on any law governing the use of direct geothermal energy, they had no idea of any direct use applications, The farmers within the community had no support from the government regarding direct use. The respondents also suggested that there was no information available regarding licensing, There are people working for GDC, however, the respondents quantified that number as few and finally, there are no community members using direct geothermal energy, each of the answer to the stated questions had a mean of 0 indicating No.

The mean and standard deviation to these responses was zero indicating No for most of the questions. Therefore, this study indicated that government policy facilitating utilization of geothermal energy was absent or the policies were available. However, since the government has GDC as a special purpose vehicle it has a direct relationship with GDC and an indirect relationship with the community thus accordingly GDC has the rights to progress utilization of direct geothermal energy.

Table 4.9: Analysis of GDC opinions regarding Government policies and direct use

Questions relating to government policy	N	Mean	Std. Deviation
1. Does GDC have investment schemes for direct geothermal utilization development?	9	.7778	.44096
2. Does the government taxation programme favor direct geothermal energy projects within local communities?	9	.3333	.50000
3. Is there a budget allocation for direct geothermal projects?	9	.8889	.33333
4. Is infrastructure available for geothermal development is sufficient?	9	.5556	.52705
5. Does the government policy allow for the transfer of direct geothermal energy to community projects?	9	.8889	.33333
6. Is the community excited about the existing geothermal project?	9	.7778	.44096
7. Are there external funds to support direct geothermal activities	9	.8889	.33333
8. Is there enough human resource for deployment of direct geothermal projects to the community?	9	.4444	.52705
9. Is there potential market for the use of direct geothermal energy?	9	.8889	.33333
10. Is GDC planning on training the community on access of licenses for direct geothermal use?	9	.7778	.44096

According to the GDC direct use team, there was an investment scheme for direct use development. However, the direct use staff thought that government taxation programme did not favor direct geothermal energy projects within local communities. The team was also in agreement that there was a budget allocation for direct use development and also suggested that infrastructure for direct use development was sufficient. Moreover, the GDC staff responded that the government policy allowed transfer of direct geothermal energy to community projects and the community was excited about the existing geothermal project. In support of direct use the staff indicated that they were also receiving funding from donors. However, it was highly noted that there was no enough human resource for deployment of direct geothermal projects to the community. Finally, GDC staff revealed that there is potential market for direct use and GDC is planning on training the community, towards access of licenses for direct energy use.

The general perspective of government policy by the direct use team yielded a mean of 1 when the means were rounded off to the nearest whole number indicating Yes for most of the questions. This indicates that the government policy towards developing direct use is available and enabling to direct geothermal utilization and development.

4.4.3 Technology

Technology is an important aspect when it comes to utilization of any resource. The research sought to investigate the way technology and its hidden drivers influence utilization of direct geothermal energy by both GDC and community. To investigate the research adopted the Likert Scale rating of Great extent=5, Moderate extent=4, Non-committal=3, Small extent=2,No extent=1 for GDC and Very high=5,High=4,Neutral=3,Low=2 and very Low =1 for the community. The results of the analysis of the respondents' opinions are as in table 4.10 and 4.11:

Table 4.10: Analysis of GDC opinions regarding Technology and direct use

Questions relating to Technology	N	Mean	Std. Deviation
1. Are there dangers associated with operation of the equipment?	9	2.6667	1.22474
2. Is the cost of maintenance high for a normal farmer?	9	3.7778	1.30171
3. Is research and development team working on new technology this year for direct geothermal energy?	9	4.0000	1.50000
4. Do you think countries in use of direct geothermal energy have experienced economic growth?	9	4.8889	.33333
5. Is the technology for direct geothermal affordable when used in community groups?	9	4.0000	1.50000
6. Is the technology associated with direct geothermal new to GDC?	9	2.8889	1.61589
7. Are there scholarships available on direct energy use development?	9	3.3333	1.58114
8. Does GDC experience challenges of emerging technological changes associated with direct geothermal use?	9	2.6667	1.41421
9. Is the cost of direct geothermal technology high for GDC	9	2.8889	1.36423

Direct use team indicated that the danger associated with operating direct use equipment can be rated as moderate with a mean of approximately 3 and a standard deviation of 1.2. In addition, the team also indicated that direct use is affordable when used in groups giving a mean of 4 and standard deviation of 1.5. The opinions of GDC staff supported the assertion that countries in use of direct geothermal have experienced economic growth indicating a mean of 5 and standard deviation of 0.3. Moreover, their responses suggest that the research and development team is working on new technology this year for direct geothermal energy use giving a mean of 4.0 and a standard deviation of 1.5. Direct use team indicates that the technology and emerging technological changes associated with direct use is moderately new to them with a mean of 3 and a standard deviation of 1.6.

In general, GDC team can be said to be non-committal or not sure regarding knowledge in technology in relation to direct use by having a mean of 3 and a standard deviation of approximately 1.4. In addition, these results may also suggest that only part of the team have sufficient knowledge in regards to direct geothermal utilization.

Table 4.11: Analysis of community opinions regarding Technology and direct use

Questions relating to Technology	N	Mean	Std. Deviation	Variance
1. How would you rate your experience with technology?	88	3.1136	1.51188	2.286
2. How would you rate your interest in the changing technology?	88	3.7500	1.46413	2.144
3. In your own opinion, what level of technology know-how is required in order to operate a direct geothermal energy project?	88	3.0114	1.65741	2.747
4. What is the level of experience you have obtained in operating advanced machinery in your line of work?	88	2.3182	1.45069	2.104
5. What is the level of Knowledge in the community regarding Green energy?	88	2.2386	1.32174	1.747
6. Would you apply direct geothermal technology if your neighbor applied it?	88	3.2159	1.91455	3.665
7. What is the quality of tomatoes and fish grown at the GDC farms in Menengai?	88	1.9545	1.46930	2.159
8. In your opinion, how is the cost of electricity?	88	3.3977	1.49743	2.242
9. How would you rate your interest in greenhouse farming?	88	3.6023	1.60129	2.564
10.The government should provide a chance for experience of direct geothermal energy in community projects	88	4.2955	1.40736	1.981

The table indicated that the respondents had a neutral experience with technology with a mean of 3.0 and standard deviation of approximately 1.5.However, they have a high interest in regards to emerging technology though the chance to participate in learning of technology is low. That could also explain the low level of knowledge in regarding green energy technology with a mean of 2.0 and a standard deviation of 1.3 showing the variation. In addition, they also show high interest regarding application of new technology and greenhouse farming therefore agreeing that the government should facilitate the chance of experiencing direct use by indicating a mean of 4.29 with a standard deviation of 1.41.

Technology has a neutral influence on utilization of geothermal energy when community data is analyzed. This indicates that the community has no full knowledge in regards to direct geothermal technology. In addition, the interpretation of results could be that the community is not interested with the direct geothermal technology therefore feels indifferent about it.

4.4.4 Public Awareness

The sought to establish how public awareness influences utilization of direct geothermal energy. The study in addition, sought to establish whether the number of initiatives resulted to more public awareness .The initiatives in this case were either projects, meetings or trainings. The study utilized the ordinal and Likert scale. The scales were; (less than 1) =1, (2-5) =2, (6-10) =3, (11-15) =4, (16 and above) =5. The results of the analysis are as in table 4.12 and 4.13:

Table 4.12: Analysis of community opinions regarding Public awareness and direct use

Questions relating to public Awareness	N	Mean	Std. Deviation
How many exhibitions have you attended organized by GDC?	88	1.1477	.44308
How many projects are supported by GDC?	88	1.3409	.58499
How many meetings have you attended organized by GDC related to health or development?	88	1.1932	.67565
How many barazas have you or your elder attended regarding GDC and Community relationship?	88	1.3636	.73001

How many Community members have been trained by GDC on the use of direct geothermal energy?	88	1.1364	.52919

The table indicates that the respondents have not been involved in issues concerning exhibitions, development, health and baraza meetings, and trainings. This is clearly indicated by the mean score of 1.2. Many of the respondents seem to agree by indicating a standard variation of less than 1.0.

The results for public awareness indicate that there are no initiatives undertaken by GDC to encourage public awareness therefore zero utilization of direct geothermal energy. The results are supported by a mean of 1 which according to the scale reflects less than 1.

Table 4.13: Analysis of community opinions regarding Public awareness and direct use

Questions relating to Public Awareness	N	Mean	Std. Deviation
How many exhibitions for direct geothermal use have been organized by GDC?	9	4.1111	1.36423
How many projects are supported by GDC?	9	2.4444	1.01379
How many meetings has GDC organized related to health or direct geothermal use development?	9	3.2222	1.39443
How many meetings has GDC organized related to licensing rights on the use of direct geothermal energy and geothermal land?	9	3.5556	1.58990
How many community organized meetings have GDC attended?	9	4.1111	1.36423

According to GDC direct use department, moderate exhibitions for direct use and community organized meetings have been attended by GDC, exhibiting a mean of 4. However, the variation in responses yielded a standard deviation of greater than 1.2. Generally, responses from direct use department indicate an average score of 3 that activities under the public awareness aspect have been conducted 6-10 times. However, a variation in their responses yielded a standard deviation of greater than 1.2.

To interpret, on average more than 6-10 public awareness initiatives have been held by GDC to facilitate and showcase utilization of direct geothermal energy to the public.

4.4.5 Utilization of Direct Geothermal Energy

To establish whether there is utilization of direct geothermal energy the researcher relied on observation and opinions from the respondents. The scale used was likert scale where; great extent=5, Moderate extent=4, Non –committal=3, Small extent=2 and No extent =1.The results of the analysis are as in table 4.14.

Table 4.14:Analysis of respondents' opinions regarding Public awareness and direct use

	n	Mean	Std. Deviation
Do community members apply geothermal energy in drying of maize?	97	.1031	.30566
Do community members use geothermal energy in fish ponds (Aquaculture)?	97	.0103	.10153
Are Tomatoes and Fish from GDC pilot project of quality?	97	.4227	.68973
Is there use of geothermal energy in pest control within the community?	97	.0309	.17402

The table indicated that on average, there is zero use of direct geothermal energy by the community by recording a mean of less than 1.0. This is strongly supported by an agreement by most of the respondents indicating a standard deviation of also less than 0.5.

4.5 Test of relationship among Variables

In this case, data collected was analyzed with the view of establishing the underlying relationship between the independent variables and dependent variables the study conducted correlation analysis which involved coefficient of correlation and coefficient of determination. In addition multiple regressions were conducted.

4.5.1 Coefficient of Correlation

In trying to show the relationship between the study variables and their findings, the study used the Karl Pearson's coefficient of correlation (r). This is as shown in the table 4.15. According to the findings, it was clear that there was positive correlation between the independent variables; government policy and public awareness, and negative correlation to independent variables;

technology and community support, and the dependent variable of utilization of direct geothermal energy. The analysis indicates the coefficient of correlation, are equal to 0.999, -4.413, 0.995 and -0.219 as in table 21 below for; government policy, technology, public awareness and Community support. This indicates very strong positive relationship between the independent variable; government policy, public awareness, and dependent variable of utilization of direct geothermal energy. In addition, there is strong and weak negative relationship between independent variable; technology and community support and dependent variable of utilization of geothermal energy respectively.

A weak correlation between community support and utilization of direct geothermal energy means that as community support increases or decreases, there is a lower likelihood of there being an effect towards utilization of geothermal energy. However, a strong negative correlated technology is one that has an advantage when conditions are worse. This relationship recognizes that the relative effectiveness of a technology depends on the current conditions. Further, efforts to develop technology might not necessarily increase utilization. For example, the current situation has not necessitated for direct geothermal utilization especially in agriculture within the neighborhood of the Menengai project. However, this might change if the community situation in regards to environmental conditions necessary for agriculture worsens. The weak negative correlation of community support illustrates that the increase of efforts to enable community support might not have any effect on the utilization of geothermal energy within Menengai area neighboring Menengai geothermal project.

The strong positive relationship illustrates an increase on positive government policies and public awareness will result in an increase on utilization of direct geothermal energy. Table 4.15 illustrates the correlations:

Table 4.15: Correlations

		Utilization of direct energy	Government policy	Technology	Public Awareness	Community support
Utilization of direct Geothermal	Pearson Correlation	1	.999**	-.413	.995**	-.219
	Sig. (2-tailed)		.000	.489	.000	.723
	N	5	5	5	5	5
Government policy	Pearson Correlation	.999**	1	-.400	.997**	-.188
	Sig. (2-tailed)	.000		.505	.000	.763
	N	5	5	5	5	5
Technology	Pearson Correlation	-.413	-.400	1	-.377	.615
	Sig. (2-tailed)	.489	.505		.532	.270
	N	5	5	5	5	5
Public awareness	Pearson Correlation	.995**	.997**	-.377	1	-.125
	Sig. (2-tailed)	.000	.000	.532		.841
	N	5	5	5	5	5
Community support	Pearson Correlation	-.219	-.188	.615	-.125	1
	Sig. (2-tailed)	.723	.763	.270	.841	

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

4.5.2. Coefficient of Determination

Table 4.16 showed that the coefficient of determination was 79.4%. Coefficient of determination explains the extent to which changes in the dependent variable can be explained by the change in the independent variables or the percentage change of variation in the dependent variable (utilization of geothermal energy) that is explained by all independent variables. From the findings this meant that 79.7% of project implementation is attributed to combination of the four independent factors investigated in this study**.**

Table 4.16: Coefficient of determination (R2)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.974[a]	.949	.797	33.14989

a. Predictors: (Constant), Public awareness, Technology, community support.

This means that 79.7% of the relationship is explained by the identified four factors; namely community support, government policy, technology and public awareness. The rest 20.3% is explained by other factors in the Renewable energy sector not studied in this research. In summary the four factors studied namely, community support, government policy, technology and public awareness relationship while the rest 20.3% is explained or determined by other factors.

4.5.3. Multiple Regression Analysis

The researcher conducted a multiple regression analysis as shown in Table 4.17 so as to determine the relationship between direct geothermal utilization and the four variables investigated in this study. However Table 4.18 shows that government policy is an excluded variable since it is on nominal scale.

Table 4.17: Multiple Regression Analysis

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	T	Sig.
1	Utilization of direct energy	18.319	36.941		.496	.707
	Technology	-4.233	1.277	-8.040	-3.314	.187
	Community support	.200	.176	.303	1.139	.459
	Public awareness	3.780	1.129	7.988	3.349	.185

a. Dependent Variable: Utilization of direct geothermal energy

Table 4.18:Excluded Variables[a]

Model		Beta In	T	Sig.	Partial Correlation	Collinearity Statistics Tolerance
1	Government Policy	25.995[b]	.	.	1.000	7.515E-5

a. Dependent Variable: utilization of geothermal energy

b. Predictors in the Model: (Constant), Public awareness, Technology, Community support

The regression equation was:

Y = 18.319 -4.233X1 + 0.200X2 + 3.780X3

Where;

Y = the dependent variable (utilization of geothermal energy)

X1 = Technology

X2 = community support

X3 = Public awareness

The regression equation above has established that taking all factors into account except government policies, (utilization of direct geothermal energy as a result of technology considered in case of worse environmental conditions, Community support and public awareness) at constant 1, utilization of geothermal energy among renewable energy sources will be 18.319. The findings presented also shows that taking all other independent variables at 1 unit. There would be a 4.2 decrease in utilization of geothermal energy given technology unless a worse unfavorable environmental condition occurs, a 0.2 increase in utilization given community support, and a 3. 8 increase in direct use given a unit increase in public awareness. This therefore implies that increase in community support will yield negligible increase in utilization of geothermal energy; an increase in technology will result to no change in utilization of direct geothermal energy unless unfavorable conditions occur that would lead to a very strong increase in utilization of geothermal energy such unfavorable conditions include; drought, minimal rainfall, unfertile soil, pest infestation, cold and any other condition that would extremely deter a farmers normal crop yield.

CHAPTER FIVE

SUMMARY OF FINDINGS, DISCUSSIONS, CONCLUSIONS AND RECCOMENDATIONS

5.1 Introduction

The chapter provides the summary of the findings from chapter four and discusses those findings. Conclusions and recommendations drawn focuses on the purpose of the study.

5.2 Summary of Findings

The study was conducted on 88 households and 9 direct use staff of GDC. The study findings indicate that community members surrounding Menengai geothermal project were indifferent regarding the already existing project. However, they believe that there is some harm arising from the project's operations. GDC on the other hand believes that there is community support of their projects. Though GDC direct use team agrees that there is some harm to a small extent that is as a result of the geothermal operations the team believes that the community reaps benefits from the project besides employment creation.

The findings revealed that government policies in existence allow for geothermal energy to be transferred to the community. According to GDC direct use team there is a budget to facilitate direct use development that is both government and donor funded with these resources GDC plans to transfer the knowledge of direct use to the community. However, the community findings reveal that direct use laws and regulations including licensing and information regarding direct use has not been shared by GDC. Further, GDC staff indicated lack of enough human resource though there are enough infrastructures for direct use development.

The study findings also shows that the technology available works best with community groups since direct use can only be used with projects close to the geothermal resource. However the interest towards direct use technology indicated a non-committal state. This could be explained with the findings that revealed there is no knowledge on direct use among community members. In addition, GDC team also seems to lack full knowledge about direct use technology.

Public awareness findings seem to indicate that though GDC may have held numerous initiatives on showcasing direct use, the target group reached did not focus on community members this is indicated by the findings from the community that illustrated lack of awareness. The community findings illustrate close to zero initiatives towards direct use.

Utilization of direct geothermal energy according to the findings is zero by the community. However, GDC has put up direct use pilot projects that have been operating since 2014.The pilot projects are Green house, Aquaculture, milk pasteurization and Laundry.

5.3 Discussions

Community support is a contentious issue within geothermal communities in Kenya. This could be explained by the fact that these communities are keen to embrace the development of new infrastructure as a sign of investment and progress and thus opposition is less prevalent (Barnett and Thrush, 2006). GDC has witnessed countable demonstrations from geothermal communities thus ended up concluding that there is community support. However, Wynne (2006) caution against assuming that lack of explicit concern or opposition towards a technology indicates support. On the other hand, the study has indicated community support does not out rightly lead to utilization of direct geothermal energy. In fact, the study results revealed that increase in community support may lead to a negligible change in utilization of direct geothermal energy. This is because according to Czaplicka-Kolarz, Pyka [eds] (2010), there are several factors considered before adopting a RES technology that include position of energy in the hierarchy of social values, priorities in the implementation of energy policy, the level of knowledge on energy sources, the level of support for the use of various sources of energy priority areas of research related to energy, energy costs, energy savings among others.

The government has mandated GDC to develop direct use. Moreover, according to GDC Direct use Department there is sufficient funding. Grubb (2004) as well as Bürer and Wüstenhagen (2009) stress that public grants as well as basic and applied R&D is required during the early phase of the innovation chain, while market-pull policies are necessary during later phases to reach full commercialization. However, research into public attitudes towards renewables indicates that people would welcome opportunities for greater involvement in renewable energy development (Devine-Wright, 2005a; Gross, 2007; Upham and Shackley, 2006, 2007).

Technology has a strong impact on economy growth and on a macro level, it is assumed that technologies once created are optimally deployed (OECD, 2009). Development should be accelerated in order to make RETs cheaper, more efficient and better adapted to large-scale use (Hoffert, 2002;Vollebergh and Kemfert, 2005, Braun et al., 2010, Acemoglu et al., 2012). Knowledge sharing and coordination can influence the rate of adoption of innovation. However, the study indicated, influence of technology on utilization of direct geothermal energy was negatively correlated .This could be explained by the fact that uptake of technology is influenced by five factors: relative advantage (extent to which technology offers improvements over available technology); compatibility (consistency with existing values, past experiences and needs); complexity (difficulty of understanding and use); trial ability (the degree to which it can be experimented on a limited basis); and observability (the visibility of its results**)**.

Awareness is a crucial component of any initiative; with awareness, knowledge of existence of a given project is created, that eventually results into creation of interest towards that idea or project. To agree, Duffield and Sass, (2003), cite lack of awareness of the direct uses of geothermal energy as the greatest impediment to the growth of enterprises in geothermal utilization. Public awareness and acceptance are among the essential factors that facilitate geothermal energy potential resources (Kepinska & Kasztelewicz, 2015). The study indicates public awareness towards utilization of direct geothermal energy has not been given the necessary attention. GDC has the mandate to create awareness on the potentials of direct use to the community.

5.3 Conclusions

From the summary of findings, pertinent conclusions concerning direct use were drawn. It is clear that communities living around Menengai geothermal project have no idea regarding direct geothermal energy. Though government policies permit development of direct geothermal use, and several scholars since as early as 2005 have indicated that direct geothermal is underutilized, not much has been achieved to date yet there is funding. In addition, the technology associated with direct geothermal energy is not clear to the community. Moreover, GDC seems to target a different market towards progressing direct use.

5.4 Recommendation

Based on the findings the research recommended the following:

The body responsible for direct use development should ensure that they create public awareness by use of community friendly mechanisms and insist towards the importance of direct use. In addition, collaboration with community groups should be done to ensure implementation of direct use projects. Maximum benefits from low temperature wells should be achieved hence contributing to economic growth and poverty reduction thus fostering their community relationship; GDC should integrate direct use as a major supplementary to power generation rather than considering it as a less important aspect; timely dispatch of information should be done to encourage direct use development and Information centers should be made available to the community and public for access of information on direct use. Though direct use technology has positive influence during unfavorable weather conditions it is necessary for GDC to pass it on to the community to contribute towards reduction of effects of climate change.

5.5. Suggestion for Further Studies

This study focused on factors influencing utilization of direct energy geothermal energy a case of Menengai geothermal project Nakuru County. The study recommends that future studies should consider research on sustainability of geothermal direct use projects and remaining aspects of 20.3% contributing to utilization of geothermal energy utilization. The subject should consider the best performing projects with highest cost-benefit ratio.

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APPENDIX 3: LETTER OF TRANSMITTAL

Sharon Rhodah Kaitano,

Masters Student,

University Of Nairobi,

P.O. Box 30197,

Nairobi

28th June, 2016

To The Direct Use Manager,

Geothermal Development Company Limited,

South –Rift Region,

P.O. Box 17700 – 20100

Nakuru.

REF: REQUEST FOR ACADEMIC SURVEY RESEARCH

I am a post graduate student at the University of Nairobi undertaking a Master of Arts degree in Project Planning and Management and currently conducting project research proposal as part of the fulfillment of the course.

I am kindly, requesting to conduct academic survey research targeting the management of direct use and direct use team at Menengai geothermal project and Naivasha with the title: **Factors influencing utilization of direct geothermal energy in Kenya: A case of Menengai Geothermal project.**
Any assistance you offer is highly appreciated.

Thank you in advance.
Yours' faithfully

Sharon Rhodah Kaitano

APPENDIX 1: Questionnaire to the community

Good morning / afternoon. Thank you for taking the time to be a part of this research that seeks to establish factors influencing utilization of direct geothermal energy. The questionnaire has sections A, B, C, D, E, and F. Please take note that your participation is highly appreciated. However, participation is voluntary.

SECTION A: Personal Details

1. What is your Gender
    - Male ☐
    - Female ☐
2. Age

18 – 20 years	
21 – 30 years	
31 – 40 years	
41 – 50 years	
51 years and above	

3. Level of education

No education	
Primary School	
Secondary School	
College or University	

SECTION B: Community Support

In this section, you are requested to tick √ against the number in the scale with regard to questions provided.

The scale options are

Great extent – 5
Moderate extent – 4
Non-committal – 3
Small extent – 2
No extent – 1

	1	**2**	**3**	**4**	**5**
To what extent is Geothermal energy important for you?					
Is there any harm you think is as a result of GDC project?					
Are efforts by geothermal energy good and beneficial to the community?					
Are community members a happy that the geothermal project is in neighborhood?					
In your own opinion, how would you rate the level of households with electricity?					
Have there been incidences of demonstrations against the GDC project?					

In your own opinion give one reason that makes you believe that community support has an influence on utilization of geothermal energy?

SECTION C: Government Policy

In this section, you are requested to tick √ **Yes** or **No** in the boxes provided.

	Yes	**No**
Have you attended sessions on use of direct geothermal energy by GDC?		
Are there spare parts for direct geothermal equipment you know or have heard about?		
Is information regarding standards and regulation on the use of direct geothermal energy available to you?		
Is there law governing the use of direct geothermal energy that you know t?		
Are you able to apply direct geothermal energy?		
Do farmers within the community have support from the government for application of direct geothermal?		
Are there loans for purchasing direct geothermal energy resources?		
Is it possible to get information on licensing of use of direct geothermal?		
Are there people within the community working for GDC?		
Are there people within the community using direct geothermal energy?		

In your own opinion give one reason that makes you believe that government policy has an influence on utilization of geothermal energy?

Section D: Technology

In this section, you are requested to tick [√] against the number in the scale with regard to questions provided.

The scale options are

Very High– 5
High – 4
Moderate – 3
Low – 2
Very Low – 1

	1	**2**	**3**	**4**	**5**
How would you rate your experience with technology?					
How would you rate your interest in the changing technology?					
In your own opinion, what level of technology know-how is required in order to operate a direct geothermal energy project?					
What is the level of experience you have obtained in operating advanced machinery in your line of work?					
What is the level of Knowledge in the community regarding Green energy?					
Would you apply direct geothermal technology if your neighbor applied it?					
What is the quality of tomatoes and fish grown at the GDC farms in Menengai?					
In your opinion, how is the cost of electricity?					
How would you rate your interest in greenhouse farming?					
The government should provide a chance for experience of direct geothermal energy in community projects					

In your own opinion give one reason that makes you believe that technology has an influence on utilization of geothermal energy?

SECTION E: Public Awareness

In this section, you are requested to tick √ against the number in the scale with regard to questions provided.

The scale options are

(16 and above)-5
(11 – 15) - 4
(6 - 10) - 3
(1 – 5) - 2
Less than one - 1

	1	2	3	4	5
How many exhibitions have you attended organized by GDC?					
How many projects are supported by GDC?					
How many meetings have you attended organized by GDC related to health or development?					
How many barazas have you or your elder attended regarding GDC and Community relationship?					
How many Community members have been trained by GDC on the use of direct geothermal energy?					

In your own opinion give one reason that makes you believe that Public Awareness has an Influence on utilization of geothermal energy?

SECTION F: Utilization of Direct Geothermal Energy

In this section you are requested to tick √ **Yes** or **No** in the boxes provided.

	Yes	**No**
Do community members apply geothermal energy in drying of maize?		
Do community members use geothermal energy in fish ponds (Aquaculture)?		
Tomatoes and Fish from GDC pilot project of quality?		
Is there use of geothermal energy in pest control within the community?		

In your own opinion give one reason that shows that there is utilization of direct geothermal energy…………………………………………………………………………………………….

……………………………………………………………………………………………………

APPENDIX 2: Questionnaire to the Direct use team GDC

Good morning / afternoon. Thank you for taking the time to be a part of this research that seeks to establish factors influencing utilization of direct geothermal energy. The questionnaire has sections A, B, C, D, E and F. Please take note that your participation is highly appreciated.

SECTION A: Personal Details

1. What is your Gender
    - Male ☐
    - Female ☐
2. Age

18 – 20 years	
21 – 30 years	
31 – 40 years	
41 – 50 years	
51 years and above	

3. Level of education

No education	
Primary School	
Secondary School	
College or University	

SECTION B: Community Support

In this section, you are requested to tick √ against the number in the scale with regard to statement provided.

The scale options are

Great extent – 5
Moderate extent – 4
Non-committal – 3
Small extent – 2
No extent – 1

	1	**2**	**3**	**4**	**5**
Are their plans to transfer direct geothermal energy projects to the community?					
Are there known negatives associated living within the neighborhood of geothermal resources?					
Have GDC ensured that the communities near the project reap direct benefits from the resource apart from creation of employment?					
Do you think that the community appreciates geothermal projects?					

In your own opinion give one reason that makes you believe that Community support has an influence on utilization of geothermal energy?

SECTION C: Government Policy

In this section, you are requested to tick | √ | **Yes** or **No** in the boxes provided.

	Yes	**No**
Does GDC have investment schemes for direct geothermal utilization development?		
Does government taxation programme favor direct geothermal energy projects within local communities?		
Is there a budget allocation for direct geothermal projects?		
Is infrastructure available for geothermal development is sufficient?		
Does the government policy allow for the transfer of direct geothermal energy to community projects?		
Is the community excited about the existing geothermal project?		
Are there funds to support direct geothermal activities		
Is there enough human resource for deployment of direct geothermal projects to the community?		
Is potential market for the use of direct geothermal energy?		
Is GDC planning on training the community on access of licenses for direct geothermal use?		

In your own opinion give one reason that makes you believe that Government policy has an influence on utilization of geothermal energy

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SECTION D: Technology

In this section, you are requested to tick √ against the number in the scale with regard to statement provided.

The scale options are

Great extent – 5
Moderate extent – 4
Non-committal – 3
Small extent – 2
No extent – 1

	1	**2**	**3**	**4**	**5**
Are there any dangers associated with operation of the direct use equipment?					
Is the cost of maintenance high for a normal farmer?					
Is research and development team working on new technology this year for direct geothermal energy?					
Do you think countries in use of direct geothermal energy have experienced economic growth?					
Is the technology for direct geothermal affordable when used in community groups?					
Is the technology associated with direct geothermal new to GDC?					
Are there scholarships available on direct energy use development?					
Does GDC experience challenges of emerging technological changes associated with direct geothermal use?					
Is the cost – benefit ratio for direct use not worth immediate investment?					
Are Spare parts for direct geothermal use equipment available to GDC?					

In your own opinion give one reason that makes you believe that technology has an influence on utilization of geothermal energy……………………………………………………………………

………………………………………………………………………………………………………

SECTION E: Public Awareness

In this section, you are requested to tick √ against the number in the scale with regard to statement provided.

The scale options are

(16 and above) -5
(11 – 15) -4
(6 - 10) -3
(1 – 5) -2
Less than 1 -1

	1	2	3	4	5
How many exhibitions for direct geothermal use have been organized by GDC?					
How many projects are supported by GDC?					
How many meetings has GDC organized related to health or direct geothermal use development?					
How many meetings has GDC organized related to licensing rights on the use of direct use and geothermal land?					
How many community organized meetings have GDC attended?					

In your own opinion give one reason that makes you believe that public awareness has an influence on utilization of geothermal energy……………………………………………………...

……………………………………………………………………………………………………

SECTION F: Utilization of Direct Geothermal Energy

In this section, you are requested to tick √ **Yes** or **No** in the boxes provided.

	Yes	**No**
Do community members apply geothermal energy in drying of maize?		
Do community members use geothermal energy in fish ponds (Aquaculture)?		
Tomatoes and Fish from GDC pilot project of quality?		
Is there use of geothermal energy in pest control within the community?		

In your own opinion give one reason that shows that there is utilization of direct geothermal

energy……………………………………………………………………………………………….

……………………………………………………………………………………………………

UNIVERSITY OF NAIROBI

COLLEGE OF EDUCATION AND EXTERNAL STUDIES

SCHOOL OF CONTINUING AND DISTANCE EDUCATION

DEPARTMENT OF EXTRA - MURAL STUDIES

Tel 051 - 2210863

P. O Box 1120, Nakuru
30th May 2016

Our Ref: *UoN/CEES/NKUEMC/1/12*

To whom it may concern:

RE: SHARON KAITANO L50/77094/2015

The above named is a student of the University of Nairobi at Nakuru Extra-Mural Centre Pursuing a Masters degree in Project Planning and Management.

Part of the course requirement is that students must undertake a research project during their course of study. She has now been released to undertake the same and has identified your institution for the purpose of data collection on "Factors Influencing Utilization of Direct Geothermal Energy in Kenya: A Case of Menengai Geothermal Project.

The information obtained will strictly be used for the purpose of the study.

I am for that reason writing to request that you please assist her.

Yours Faithfully,

NAKURU EXTRA-MURAL CENTRE
RESIDENT LECTURER
NAKURU
UNIVERSITY OF NAIROBI

Mumo Mueke
Ag. Resident Lecturer
Nakuru Extra-Mural Centre

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY AND INNOVATION

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9th Floor, Utalii House
Uhuru Highway
P.O. Box 30623-00100
NAIROBI-KENYA

Ref: No. **NACOSTI/P/16/23777/12125**

Date:

6th July, 2016

Sharon Rhodah Kaitano
University of Nairobi
P.O. Box 30197-00100
NAIROBI.

RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on "***Factors influencing utilization of direct geothermal energy in Kenya a case of Menengai Geothermal,***" I am pleased to inform you that you have been authorized to undertake research in **Nakuru County** for the period ending **5th July, 2017.**

You are advised to report to **the Chief Executive Officer, Geothermal Development Company, the County Commissioner and the County Director of Education, Nakuru County** before embarking on the research project.

On completion of the research, you are expected to submit **two hard copies and one soft copy in pdf** of the research report/thesis to our office.

BONIFACE WANYAMA
FOR: DIRECTOR-GENERAL/CEO

Copy to:

The Chief Executive Officer,
Geothermal Development Company.

The County Commissioner
Nakuru County.

The County Director of Education
Nakuru County.

THIS IS TO CERTIFY THAT:
MS. SHARON RHODAH KAITANO
of UNIVERSITY OF NAIROBI,
14420-20100 nakuru,has been
permitted to conduct research in
Nakuru County

on the topic: *FACTORS INFLUENCING UTILIZATION OF DIRECT GEOTHERMAL ENERGY IN KENYA A CASE OF MENENGAI GEOTHERMAL.*

for the period ending:
5th July,2017

Permit No : NACOSTI/P/16/23777/12125
Date Of Issue : 6th July,2016
Fee Recieved :Ksh 1000

....
Applicant's Signature

....
Director General
National Commission for Science, Technology & Innovation