DETERMINANTS OF PERFOMANCE OF GEOTHERMAL ENERGY PROJECTS IN KENYA: A CASE OF MENENGAI GEOTHERMAL PROJECT IN NAKURU COUNTY

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ABSTRACT

Infrastructural development is a key aspect for economic growth and has been on focus by the Kenyan Government. There has been a lot of investment on development of geothermal energy mainly being one of the major sources of electricity in Kenya owing most to the unreliability of diesel operated generators and hydro power sources of energy. In lieu of this the Government formed Geothermal Development Company (GDC) to fast track development of geothermal resources in the country. There has been inefficiency in carrying out performance of geothermal energy projects, how capital costs, shortage of local geothermal energy expertise, infrastructure development, existing legal policies and regulatory framework on the exploitation of geothermal power in Kenya. The purpose of this study was to identify determinants of performance of geothermal energy projects in Kenya. The study specifically focused on effect of capital costs, technical expertise, infrastructural development and legal and regulatory framework on performance of geothermal energy projects in Kenya. This study employed cross- sectional survey research method. The study targeted 1130 respondents comprising of supervisory staff members of GDC; purposive sampling was used in selection of respondents. Questionnaires were used for data collection, after obtaining data from the field and coding, Statistical Package for Social Sciences (SPSS software) was used to analyze the information that was presented in terms of findings and recommendations. This study was carried through a descriptive survey design combining both qualitative and quantitative research strategies. The study population consisted; Top level managers, Middle level managers and Lower level managers. The study sought to establish to what extent capital cost determines performance of geothermal power in Kenya. Additionally, the study established how Geothermal Energy Experts determines the performance of geothermal energy projects in Kenya. The study also established to a very great extent, how Legal and Regulatory Framework determines performance of geothermal energy projects in Kenya. From the findings, infrastructural Development determines the performance of geothermal energy projects in Kenya. The study found that the projects costs for covering staff employees and project managers have increased to cost of the projects; drilling fuel costs are too high for the company; and the cost of purchasing the geothermal equipment affects the performance of the geothermal projects. Further, the study found that the project managers are recruited based on the expertise they have on geothermal projects and technical expertise is required to maintain the adopted technology. The study also found that the organization has proper infrastructural knowhow to handle geothermal projects. The study also found that there is efficient adherence to various rules and laws governing implementation of geothermal projects. The study concluded that capital costs had the greatest effect on the performance of geothermal energy projects, followed by infrastructural development then legal and regulatory framework while

technical expertise had the least effect to the performance of geothermal energy projects. The study recommends that funds used for corporate social responsibility, and the procurement costs should be minimized, and the funds diverted to capital intensive areas. This would enhance the recovery of the financial investment from the revenues generated from the systems. In addition, to avoid delays in supply and provision of services, the study recommended for improved infrastructure for easy access to drilling sites, evacuation of steam to power plant.

Key Words: Capital cost, Technical expertise, Infrastructural development, Legal and regulatory environment, Performance of geothermal energy projects

INTRODUCTION

Increasing energy prices, political unrest in the Middle East and climate change are some of few issues that have pushed planning for Sustainable energy development (SED) onto the political horizon. SED is broadly defined as 'the provision of adequate energy services at affordable cost in a secure and environmentally friendly manner, in conformity with social and economic development needs (Grubb, 2014). Planning for SED implies that we need to consider the three dimensions of sustainable development, where such movement should not have negative consequences for the economy, the public (social dimension), nor the environment. Iceland has in the last 40 years gone from being mostly reliant on coal and oil, towards extracting 73% of its primary energy needs from renewable energy, and at the same time achieved impressive economic success. Iceland is planning for a hydrogen economy by 2050. A central question that is asked in this presentation is if Iceland's path is indeed sustainable, if it is unique and if other countries possibly can do the same (Shortall, Davidsdottir & Axelsson, 2015).

The use of geothermal steam to heat houses was first tried in 1908, and successfully executed in 1911. The first hydropower turbine began operating 1904, but widespread electrification of the country did not occur until after the 1940's. Similarly, geothermal power did not become a significant source of energy until after the 1940s, and in 1944 electricity was produced for the first time using geothermal power. Yet, as other countries Iceland needed high quality energy to develop, and as a result fossil fuels were imported that mostly consisted of coal and petroleum products. At the end of WWII geothermal and hydropower provided only about 16% of the country's energy requirements, the remainder fulfilled mostly by coal (Ogola, 2018).

Geothermal energy exploitation in Kenya has been primarily for electricity generation and it constitutes 39.2% of the country's electricity. KenGen generates 89% of this energy from two power plants. Olkaria I power plant was commissioned in the year 1981 has in installed capacity of 185 megawatts while Olkaria II was commissioned in the year 2003 has 105 megawatts. Drilling for a third power plant, Olkaria IV was commissioned in 2014 and has an installed capacity of 140 MW. Olkaria V which is yet to be commissioned generates 165 megawatts. GDC is generating 105 megawatts at Menengai geothermal field in Nakuru County (Mading, 2013).

Kenya is currently generating 48 MW, 12 MW from an Ormat binary plant commissioned in the year 2000 and 36 MW is from a single flash plant commissioned in 2009. Oserian Development Company, (Oserian), constructed a 1.8 MW binary plant Ormat OEC in 2004 and 2MW from a back-pressure turbine commissioned in 2007. Both of these plant use wells leased from KenGen (Mading, 2013). Without access to energy to cook, heat the home, earn a living and fully benefit from health, education and cultural opportunities, whole communities are forced to live on the margins of society. One major challenge for investors has been high upfront risks and enormous capital investment. Hence, there is need for a research that will attempt to determine the challenges influencing the slow exploitation and development of geothermal power in Kenya (Hall, 2014).

The world´s major governments have put their emphasis on renewable energy and a transformation to a low carbon economy. At the same time, this could be seen as a significant contribution when it comes to fighting climate change. Moreover, renewable energy sources have been used as an alternative to these limited resources and add to the sustainability of future energy supply. Geothermal energy is no exception in this regard. In light of growing demand for fossil fuels, concerns were raised over future supply, which in turn caused their Policies, Legal & Regulatory environments to increase substantially (Geothermal Development Company, 2015).

This development was reflected in the share performance of publicly listed renewable energy companies, where investors saw potential for high growth as the renewable energy was the fastest growing sector producing energy. When the financial crisis struck the world economy in 2008, equity markets worldwide suffered a huge loss, but have since then recovered most of what they lost. This recovery does not seem to have passed through to the renewable energy stocks, which reached a high in the first part of 2008. The geothermal energy sector seemed to be recovering as it outperformed wind and solar stocks in 2009, but ever since, geothermal energy stocks have been rapidly declining. Since the start of 2009, geothermal stocks have lost value of around 60 percent on average, while the wind and solar stocks are down 22 percent and 44 percent respectively (Kaptuya, 2014; Ndung'u, 2014).

Through the Kenya Vision 2030 policy, economic transformation is envisioned with plans to expand the energy sector through clean renewable options such as geothermal energy in bid to meet the current and future energy demand (Devine-Wright, 2011). Geothermal prospects in the

country occur mainly within the Rift Valley where widespread volcanic activity and geothermal manifestations signify the existence of geothermal resources, with an estimated potential of between 7000MW to 10,000MW (Simiyu, 2010). Kenya is the first country in Sub-Sahara Africa to significantly exploit geothermal energy; it has also the highest level of geothermal installed capacity of 121 MW (Michael, 2016).

The Geothermal Development Company (GDC) is a 100% state-owned company, formed by the Government of Kenya as a Special Purpose Vehicle (SPV) to fast track the development of geothermal resources in the country. Geothermal energy is an indigenous, abundant, reliable and environmentally- friendly source of electricity. The creation of GDC was based on the government's policy on energy - Sessional paper No. 4 of 2004, and the energy Act No.12 of 2006 which un-bundled the key players in the electricity sector to ensure efficiency. GDC will drill 1400 steam wells to provide steam for the generation of 5,000MW of geothermal power by 2030 (Jennejohn, 2010).

GDC offers the following services to a range of clients which include: geothermal drilling; well testing and logging; geothermal reservoir assessment and management; geothermal resource exploration; provision of steam for electricity generation; promotion of alternative uses of geothermal energy other than electricity generation; and consultancy on geothermal development. More than 14 high temperature potential sites occur along the Kenyan Rift Valley with an estimated potential of more than 15,000 MW. Other locations include: Homa Hills in Nyanza, Mwananyamala at the Coast and Nyambene Ridges. These prospects are at different stages of development (Jennejohn, 2010).

Statement of the Problem

Energy use is a vital component of economic and social development, but the use of energy also significantly contributes to environmental degradation. Energy is an important driver of economic and social development because it provides basic services such as heat, illumination, refrigeration, communication, and power for agricultural processes, industry and transportation, just to name a few (Smith, 2012). Consequently, the development of sustainable energy systems has emerged as one of the priority issues in the move towards global sustainability' (Mangi, 2018). The world´s major governments have put their emphasis on renewable energy and a transformation to a low carbon economy. However, most of projects for generation of electricity haven't been performing well.

In Kenya, despite the advantages associated with the use of the geothermal energy across the world, diverse challenge still faces geothermal energy production efforts. Some of the difficulties facing geothermal projects include high operational costs, inadequate technical expertise and weak legal and regulatory framework. This has led to poor performance of the geothermal projects.

Considering growing demand for fossil fuels, concerns were raised over future supply, which in turn caused their Policies, Legal & Regulatory environments to increase substantially. Geothermal resource development, like many other renewable energy sources is not devoid of its own challenges. These challenges range from environmental and social, policy and legislative, technological and financial (Mbuthi, 2014).

Despite huge funding of Menengai geothermal project in Nakuru County, the electricity generation is still not enough for all the county residents. There are still cases of power shortages and few households have been connected to the power grid (Lepatei, 2017). Other challenges include financial, technical and human capacity, environmental and socio-economic and policy and legislative challenges. In addition, lack of maintenance funding, inadequate skilled work force, political interruptions and poor infrastructure have made geothermal energy projects in Menengai to stall in some instances. These challenges have slowed down the utilization of geothermal resources and hence led to poor performance of the project (Simiyu, 2010).

Various studies have been done in relation to performance of geothermal energy projects. These include Coskun, Oktay and Dincer (2011) who examined Performance evaluations of a geothermal power plant, Lepatei (2017) examined the factor influencing the performance of geothermal energy projects in Kenya and Ndirangu (2014) conducted a study on determinants of power projects performance in the Kenya Power and Lighting Company limited. However, none of the studies focused on determinants such as capital costs, technical expertise, infrastructural development and existing legal and regulatory framework of performance of geothermal energy projects. To address this gap in knowledge and address the time variance there was indeed a need for a study on the same. This prompted this study on the determinants of performance of geothermal energy projects in Kenya based on Menengai geothermal project in Nakuru County.

Objectives of the Study

This study was guided by the following objectives:

i. To establish how capital costs, determine the performance of Menengai geothermal project in Nakuru County.
ii. To establish how technical expertise, determine the performance of Menengai geothermal project in Nakuru County.
iii. To determine how infrastructural development, determine the performance of Menengai geothermal project in Nakuru County.
iv. To evaluate how existing legal and regulatory framework determine the performance of Menengai geothermal project in Nakuru County.

THEORETICAL REVIEW

This is the structure that can hold or support a theory of a research study. The theoretical framework introduces and describes the theory that explains why the research problem under study

exists and the relevance of each theory to this study. The study was hinged on logistics theory. This was further supported by the Transaction cost economics theory, Diffusion of Innovation (DOI) Theory and the contingency theory.

Transaction Cost Economics Theory

Transaction cost economics theory was postulated by Ronald H. Coase, in 1937, was the first to highlight the importance of understanding the costs of transacting, but TCE as a formal theory started in earnest in the late 1960s and early 1970s as an attempt to understand and to make empirical predictions about vertical integration. This can be understood through the lens of transaction cost economics (TCE). Explicitly recognizing the costs of coordination among economic entities in markets, TCE stresses that a firm's central task is to coordinate transactions efficiently (Wafula, 2016). Adoption of IT in geothermal projects can lower coordination costs and substantially improve transactional efficiencies through increased information sharing and communications capabilities (Siapei, 2011). To improve performance or even survive in competitive environments, a firm needs to adapt its businesses to respond quickly to competitive actions.

If a project's operation is frequently affected by policies and legal & regulatory environment change it may face greater needs to coordinate with operational costs. For example, a project that needs to modify the design of its product, because of market entry or new products launched by competitors, also needs to modify the design of upstream components that constitute the product; it may also need to rearrange downstream channels for new product distribution (Wafula, 2016). Accordingly, technologies that help reduce coordination costs are more valuable in geothermal projects. This theory is relevant to the study as it helps in establishing how capital costs determine the performance of geothermal energy projects in Kenya.

Logistics Theory

The logistics theory was postulated by Peter Nyhuis in 1957. Logistics is defined as the planning, organization, and control of all activities in the material flow, from raw material until final consumption and reverse flows of the manufactured product, with the aim of satisfying the customer's and other interest party's needs and wishes i.e., to provide a good customer service, low cost, low tied-up capital and small environmental consequences (Kiptoo, 2012). Logistics is also defined as those activities that relate to receiving the right product or service in the right quantity, in the right quality, in the right place, at the right time, delivering to the right customer, and doing this at the right cost.

In most of the cases logistics is seen from the perspective of an operative way of transporting or moving materials from one point to another or producing service. The credibility of this operation

is based on how good is the design of the system that leads to this kind of logistics. Logistics systems encompass operative responsibilities, which include administration, operation and purchase and constructive duties as well as detailed design (Lumsden, 2003). These systems need a lot of skilled employees in order to get it right. In order for the project to move swiftly these employees need to have a lot of knowledge on their responsibilities and meet the objectives of the project. This theory is relevant to the study as it highlights the importance of how technical expertise in determining the performance of geothermal energy projects in Kenya.

Innovation Diffusion Theory

Diffusion of Innovation (DOI) Theory, developed by E.M. Rogers in 1962, is one of the oldest social science theories. Diffusion of innovations is a theory that seeks to explain how, why, and at what rate new ideas and technology spread. Within the rate of adoption, there is a point at which an innovation reaches critical mass. The categories of adopters are innovators, early adopters, early majority, late majority, and laggards. The Innovation diffusion theory is a model grounded in business study. Since 1940's the social scientists coined the terms diffusion and diffusion theory (Dean, 2004). This theory provides a framework with which we can make predictions for the time period that is necessary for a technology to be accepted.

Constructs are the characteristics of the new technology, the communication networks and the characteristics of the adopters. We can see innovation diffusion as a set of four basic elements: the innovation, the time, the communication process and the social system. Here, the concept of a new idea is passed from one member of a social system to another. Clemons, (1992) redefined several constructs for use to examine individual technology acceptance such as relative advantage, ease of use, image, compatibility and results demonstrability. In relation to the study, this theory is relevant in that it shows the importance of developing infrastructure to better the performance of projects. The advantage of an improved infrastructural system is that it has allowed for better communication and efficiency between the project team. This theory highlights how infrastructural development determines the performance of geothermal energy projects in Kenya.

Contingency Theory

The contingency theory of leadership was proposed by the Austrian psychologist Fred Edward Fiedler in his landmark 1964 article, "A Contingency Model of Leadership Effectiveness." The contingency theory emphasizes the importance of both the leader's personality and the situation in which that leader operates. Classical and neoclassical theorists viewed conflict as something to be avoided because it interfered with equilibrium. Contingency theorists view conflict as inescapable, but manageable. Chandler (1962) studied four large United States corporations and proposed that an organization would naturally evolve to meet the needs of its strategy -- that form follows function.

Implicit in Chandler's ideas was that organizations would act in a rational, sequential, and linear manner to adapt to changes in the environment. Effectiveness was a function of management's ability to adapt to environmental changes. Lawrence and Lorsch (1969) also studied how organizations adjusted to fit their environment. In projects, it was noted that there is a need to have frameworks at all levels the authority which will assist in making decisions in the institution. This theory is relevant in determining how existing legal and regulatory framework determines the performance of geothermal energy projects in Kenya.

RESEARCH METHODOLOGY

Research Design

This study employed descriptive survey research method. This particular design was ideal since the research entailed collecting and comparing data from the phenomenon at the same time of study. Wang (2015) argued that survey research design involves the selection of a sample of respondents and administering questionnaires or conducting interviews to gather information on variables of interest. The design was ideal since it seeks to describe the characteristics of certain groups, estimate the proportion with certain characteristics and make predictions. This design involved the collection of quantitative data for carrying out inferential analysis and qualitative data for describing and explaining themes of behavior discerned about the determinants of performance of geothermal energy projects in Kenya: A case of Menengai geothermal project in Nakuru County.

Target Population

A population or universe is defined as aggregate of all elements (Upagade & Shende, 2012). The population must be defined in terms of elements. The study was conducted at GDC Nakuru offices and Menengai Geothermal Power Project in Nakuru County. The target population for the study included all GDC supervisory staff members at the Headquarters, Central, South Rift and North Rift Geothermal areas. According to the GDC Human Resources records the total staff population is 1130.

Sample Size and Sampling Procedure

Ideally, it would have been preferable to collect data from all the 1,130 staff members, from 16 departments however, only supervisory staff members be purposively involved and assumed to provide information on the concerns affecting their respective departments and therefore the entire population. A representative sample size of the supervisory staffs drawn from the 16 departments, the study adopted a formula by Kathuri and Pals (1993) for estimating a sample size, n, from a known population size, N.

A sample is a representative portion of the population of interest which is randomly chosen (Wang, 2015). The Yamane (1967) formula was used to compute the size of the sample as shown in the formula below;

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

Where; n is the sample size
N is the population size and
e is the margin of error.

N =1130
e = 0.05
n = $1130/ (1+1130 (0.05)^2)$
= 295

The sample size was 295. To determine how the sample is distributed among the targeted respondents including project beneficiaries, project managers, monitoring and evaluation staff and community leaders, the sampling ration was calculated and then multiplied with target population for targeted group. The ratio was 295/1130= 0.261, which was used as shown in Table 1.

Table 1: Sampling Frame

Department	Target population	Ratio	Percent
Geothermal Resource Management	96	0.261	25
Reservoir Management Department	84	0.261	22
Project Management	30	0.261	8
Drilling Department	225	0.261	59
Environment Department	34	0.261	9
Safety Department	38	0.261	10
Infrastructure Department	195	0.261	51
Legal Affairs Department	20	0.261	5
Supply Chain Department	56	0.261	15
Finance Department	62	0.261	16
Administration Department	99	0.261	26
Human Resources Department	52	0.261	14
Planning Department	28	0.261	7
ICT Department	45	0.261	12
Audit Department	31	0.261	8
Communications Department	35	0.261	9
Total	**1130**		**295**

Sampling Procedures

Sampling is concerned with the choosing of a portion of individuals from within an entire group to estimate the characteristics of the population. The study selected the respondents using stratified proportionate random sampling technique. Stratified random sampling is unbiased sampling

method of grouping heterogeneous population into homogenous subsets then making a selection within the individual subset to ensure representativeness. The goal of stratified random sampling is to achieve the desired representation from various sub-groups in the population. In stratified random sampling subjects are selected in such a way that the existing sub-groups in the population are more or less represented in the sample (Yin, 2017). The study used simple random sampling to pick the respondents in each stratum.

Research Instruments

The study collected data from primary data source. The data was collected by use of questionnaires which was semi-structured and self-administered to the sample chosen from the survey organizations. This is because the questionnaire provided high degree of data standardization and implementation of generalized information amongst any population as supported by Creswell and Clark (2017). Bloomquist (2012) asserts that matrix questions share the same set of response categories and the most commonly used form of the category is the Likert type scale. This convenienced and better analysis, a five-point Likert Scale was used for the closed- ended questions. A self-administered questionnaire was constructed based on the above-mentioned instruments. The first and the second section of the questionnaire contained questions relating to respondent background information and the research general overview respectively. The third and fourth section, contained propositions on a Likert scale and structured questions on each research objective and measurement of performance respectively.

Pilot Testing

Pilot study is the measurement of a dependent variable among subjects. Its purpose is to ensure that items in the instrument are stated clearly and have the same meaning to all respondents. The purpose of pre-testing the data instrument is to ensure that the items in the instrument are stated clearly and have the same meaning to all respondents. In this study this involved checking whether the questions are clear and revoking any positive or negative response (Wang, 2015). Pilot testing of the research instruments were conducted where 13 questionnaires were administered to the pilot survey respondents who were chosen at random representing 10% of the sample size. The pilot study was done at Ol Karia geothermal project which is also in Nakuru County. After one day the same participants were requested to respond to the same questionnaires but without prior notification in order to ascertain any variation in responses of the first and the second test. This is very important in the research process because it assists in identification and correction of vague questions and unclear instructions. It is also a great opportunity to capture the important comments and suggestions from the participants. This helped to improve on the efficiency of the instrument. This process was repeated until the researcher is satisfied that the instrument does not have variations or vagueness.

Validity of the Research Instrument

According to Creswell and Creswell (2017), validity is the accuracy and meaningfulness of inferences, based on the research results. Validity is the degree by which the sample of test items represents the content the test is designed to measure. Content validity which was employed by this study is a measure of the degree to which data collected using a particular instrument represents a specific domain or content of a particular concept. One of the main reasons for conducting the pilot study is to ascertain the validity of the questionnaire. The study used content validity which draws an inference from test scores to a large domain of items similar to those on the test. Content validity is concerned with sample-population representativeness. Gorard (2013) stated that the knowledge and skills covered by the test items should be representative to the larger domain of knowledge and skills. Expert opinion was requested to comment on the representativeness and suitability of questions and give suggestions of corrections to be made to the structure of the research tools. This helped to improve the content validity of the data that was collected. Content validity was obtained by asking for the opinion of the supervisor, lecturers and other professionals on whether the questionnaire was adequate.

Reliability of Research Instrument

Reliability of a measure indicates the extent to which it is without bias (error free) and hence ensures consistent measurement across time and across the various items in the instrument. It is an indication of the stability and consistency with which the instrument measures the concept and helps to assess the "goodness" of measure. Reliability is concerned with the question of whether the results of a study are repeatable. The questionnaire was administered to a pilot group of 13 randomly selected respondents from the target population and their responses used to check the reliability of the tool. Reliability of the data collection instrument was done using the split half method then be calculated using Spearman Brown correlation formulae to get the whole test reliability. If the sum scale is perfectly reliable, were expected that the two halves are perfectly correlated. A construct composite reliability co-efficient of 0.7 or above, for all the constructs, is considered to be adequate for this study (Rousson, Gasser & Seifer, 2012).

Data Collection Procedures

The study used primary data which was collected by use of questionnaires; use of questionnaires is based on the fact that they are suitable for a descriptive study given that they are easy to administer, ensure fast delivery and the respondent can answer at their convenience. The questionnaires were self- administered through drop and pick later method. The researcher delivered the questionnaire and gave the selected respondent a maximum of 3 days after which the researcher collected the completed questionnaire for analysis. The researcher also assured the participants that the information they give was treated with strict confidentiality. An envelope

marked questionnaire and thesis topic was provided so that once the employee completes the questionnaire, they sealed it to ensure confidentiality is maintained within the organization and guarded against potential victimization by the human resource division or the person designated by the company to co-ordinate the process. The researcher then proceeded to administer the questionnaires through the designated officers and co-ordinate with them to ensure respondents have adequate time to complete them. This enabled create a conducive environment for the distribution and administration of the questionnaire. Administration of the questionnaire followed the agreed schedule.

Data Analysis Techniques

Data was analyzed using Statistical Package for Social Sciences (SPSS Version 25.0). All the questionnaires received was referenced and items in the questionnaire was coded to facilitate data entry. After data cleaning which entailed checking for errors in entry, descriptive statistics such as frequencies, percentages, mean score and standard deviation was estimated for all the quantitative variables and information presented inform of tables. The qualitative data from the open-ended questions were analyzed using thematic content analysis and presented in narrative form.

Inferential data analysis was done using multiple regression analysis. Multiple regression analysis was used to establish the relations between the independent and dependent variables. The multiple regression model is chosen because it is useful in establishing the relative importance of independent variables to the dependent variable (Wang, 2015). Such importance is deduced from standardized regression coefficients (beta-weights), whose magnitudes show how much relative impact the independent variables have on the dependent variable, while the negative and positive signs associated with the coefficients show negative and positive impacts respectively (Wang, 2015). Also, it is ideal for the dependent variable to be recorded at a continuous level of measurement**.** This study the multiple regression model generally assumes the following equation;

$$\boldsymbol{Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \varepsilon}$$

Where: -Y= Performance of geothermal energy projects

β_0=constant

$\beta_1, \beta_2, \beta_3 \beta_4$ = regression coefficients

X_1= Capital costs

X_2= Technical expertise

X_3= Infrastructural development

X_4= Legal and regulatory framework

ε=Error Term

RESULTS AND DISCUSSIONS

Reliability Analysis

Reliability analysis was subsequently done using Cronbach's Alpha which measures the internal consistency by establishing if certain items within a scale measure the same construct. Malhotra (2015) established the Alpha value threshold at 0.7, thus forming the study's benchmark. Table 2 shows the results.

Table 1: Reliability Analysis

	Alpha value	Comments
Capital costs	0.712	Reliable
Technical expertise	0.883	Reliable
Infrastructural development	0.767	Reliable
Legal and regulatory framework	0.788	Reliable
Performance of geothermal energy projects	0.778	Reliable

Cronbach Alpha was established for every objective which formed a scale. The capital costs had a coefficient of 0.712, technical expertise had a coefficient of 0.883, infrastructural development had a coefficient of 0.767, legal and regulatory framework had a coefficient of 0.788 and performance of geothermal energy projects had a coefficient of 0.778. The findings in Table 2 illustrates that all the five variables were reliable as their reliability values exceeded the prescribed threshold of 0.7 (Malhotra, 2015). This, therefore, depicts that the research instrument was reliable and therefore required no amendments.

Multiple Regression Analysis

Multiple regression analysis was carried out to establish determinants of performance of geothermal energy projects in Kenya: A case of Menengai geothermal project in Nakuru County. The findings were presented in Table 3, 4 and 5.

Table 3: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.868	0.753	0.749	1.238

The findings of Table 3 found that adjusted R-Square value (coefficient of determination) is 0.749, which indicates that the independent variables (capital costs, technical expertise, infrastructural development, legal and regulatory framework) explain 74.9% of the variation in the dependent variable (performance of geothermal energy projects). This implies that there are other factors that affect the performance of geothermal energy projects attributed to 25.1% unexplained. In line with this Grubb (2014) argues that increasing energy prices, political unrest in the Middle East and climate change are some of few issues that have pushed planning for Sustainable Energy Development (SED) onto the political horizon.

Table 4: Analysis of Variance Results

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	982.31	4	245.578	157.994	9.82E-62
	Residual	321.75	207	1.554		
	Total	**1304.06**	**211**			

The results shown in Table 4 revealed that p-value was 0.000 and F calculated was 157.994. Since the p-value was less than 0.05 and F-calculated was greater than F-critical (2.4153), and then the overall model was statistically significant.

Model coefficients provide unstandardized and standardized coefficients to explain the direction of the regression model and to establish the level of significance of the study variables. The results are captured in Table 5.

Table 5: Regression Coefficients

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	0.987	0.217		4.548	.000
Capital costs	0.923	0.372	0.901	2.481	.014
Technical expertise	0.653	0.251	0.704	2.602	.010
Infrastructural development	0.834	0.199	0.821	4.191	.000
Legal and regulatory framework	0.751	0.213	0.723	3.526	.000

As per the SPSS generated table above, the equation ($Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \varepsilon$) becomes:

$Y = 0.987 + 0.923X_1 + 0.653X_2 + 0.834X_3 + 0.751X_4$

The findings showed that if all factors (capital costs, technical expertise, infrastructural development, legal and regulatory framework) were held constant at zero performance of geothermal energy projects will be 0.987. The findings presented also show that taking all other independent variables at zero, a unit increase in the capital costs would lead to a 0.923 increase in performance of geothermal energy projects. This variable was significant since the p-value 0.014 was less than 0.05. The findings correlate with Geothermal Development Company (2015) who noted that the world´s major governments have put their emphasis on renewable energy and a transformation to a low carbon economy. At the same time, this could be seen as a significant contribution when it comes to fighting climate change. Moreover, renewable energy sources have been used as an alternative to these limited resources and add to the sustainability of future energy supply.

The findings also show that a unit increase in technical expertise would lead to a 0.653 increase of performance of geothermal energy projects. This variable was significant since 0.010<0.05. Further, the findings show that a unit increase of infrastructural development would lead to a 0.834

significant increase of performance of geothermal energy projects since p-value (0.000) was less than 0.05. The study also found that a unit increase of legal and regulatory framework would significantly lead to a 0.751 increase of performance of geothermal energy projects since p-value (0.000) was less than 0.05. This relates to Hall (2014) who states that one major challenge for investors has been high upfront risks and enormous capital investment.

Overall, it was established that capital costs had the greatest effect on the performance of geothermal energy projects, followed by infrastructural development then legal and regulatory framework while technical expertise had the least effect to the performance of geothermal energy projects.

Conclusion

This study concluded that capital cost positively and significantly affects performance of geothermal energy projects in Kenya. The study concluded that the capital cost for geothermal power plants include both exploration costs, cost of land, drilling and the construction of the physical plant, and is thus a fixed cost.

The study also concluded that technical expertise affects performance of geothermal energy projects in Kenya significantly. The findings further concluded that it is paramount to invest in training so as to acquire highly skilled manpower, particularly of scientists and engineers, because geothermal development requires a unique set of knowledge and skills.

The study concluded that infrastructural development has a positive and significant effect on the performance of geothermal energy projects in Kenya. The study deduced that infrastructural development increases productivity, reduces cost of production, facilitates the easy and wider diffusion of information and technology, enlarges markets and promotes more innovations. It affects the location decisions of the investors and firms. This helps more industrialization and provision of more employment opportunities and thus high GDP.

The study concluded that legal and regulatory framework has a positive and significant effect on the performance of geothermal energy projects in Kenya. The study concluded that based on experience from other natural resources, when access is unregulated the environment suffers hence the importance of regulations in geothermal development. Further, the importance of regulations cannot be overemphasized as they ensure sustainable utilisation of resources and a healthy environment.

Recommendations

The study recommends that funds used for corporate social responsibility, and the procurement costs should be minimized and the funds diverted to capital intensive areas. This will enhance the recovery of the financial investment from the revenues generated from the systems. Additionally, arising challenges in project execution should be mitigated and solutions to the challenges found fast. This will improve on the timelines of project delivery and reduce costs of project delivery. 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

In addition, to avoid delays in supply and provision of services, the study recommended for improved infrastructure for easy access to drilling sites, evacuation of steam to power plant. Further the study recommended for any stable economic and energy regulation environment, a rapid, transparent and fair decision-making processes are basic principles that have to be put in place so as to encouraged investors for development and capacity building

From the findings, this study recommends that skilled and competent top managers should be recruited in undertaking the wind power projects given their big role. Top level managers with great passion for work, and who are visionary be recruited to be in charge of geothermal energy projects. The government should expedite the setting up of Geothermal Centre of excellence so to bridge the gap in the local human capacity/expertise as well as significantly minimize reliance on foreign experts.

This study recommends that government through regulations should ensure that there is adequate monitoring throughout the entire implementation period to prevent any unnecessary and/or avoidable delays or disruptions to implementation schedules. Lastly the governments should through regulations make sure that the implementing agencies keep detailed records of data throughout the period of the project. This kind of detailed reporting would help policy makers and other researchers to evaluate the projects and make appropriate recommendations to governments. There needs to be a clear way of handling geothermal resource host communities, particularly when it comes to land and compensation. The government needs to provide a clear direction in the form of policy and guidelines in order to minimize the cost of compensation and subsequently avoid losing valuable time and money, as there is no properly defined way of handling government projects that fall in/within community owned land.

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