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## FACTORS INFLUENCING PERFORMANCE OF PRIVATE ELECTRICITY MINI GRID PROJECTS IN KENYA: A CASE OF KIRINYAGA COUNTY

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**Abstract:** *Rural electrification rates in Kenya lag stated government goals, in part due to the inability of the national utility, Kenya Power to fund national grid expansion. Private electricity mini grids can offer an alternative immediate pathway to rural electrification in Kenya and the region. Existing private mini grids are struggling with frequent technical faults, a situation that is worsened by the projects' unsustainable revenue generation models. This study sought to analyze the factors influencing performance of private electricity mini grids in Kenya, with specific focus on aspects of staff training, participation of users, household incomes, and planning, and how they influence performance. The research established that development of mini grid schemes in the country is not anchored on proper planning, a situation that gets worsened by the inadequate capacity to operate and maintain the schemes during operation. The study concludes - quality project planning and enrolment of well trained and qualified staff, who should be allowed access to regular training to enhance and maintain quality service delivery consistent with evolving technologies and best customer service approaches. The study further recommends targeted promotion of productive use of electricity alongside project implementation to enhance local economic development that will in turn increase incomes thereby enhancing consumption and payment for electricity.*

**Keywords:** *Commercialization, Energy access, Mini grid, Renewable energy, Rural electrification, Off-grid*

### INTRODUCTION

The issue of electrification has been on top of the global agenda ever since the United Nations (UN) declared 2012 "The international year of sustainable energy for all" (UNDP,2012). Many studies attribute access to quality energy as being vital to attaining the global goals of eradicating poverty and ensuring sustainable development (IRENA, 2013).

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Despite this, an estimated 1.2 billion people worldwide, representing close to one fifth of the world's population, have no access to electricity, a number that is likely to grow if there is no targeted effort at increasing access especially in Sub-Saharan Africa and South Asia (IEA, 2014). In Sub-Saharan Africa, successes recorded elsewhere have prompted governments and international development partners to focus more on promoting electrification through mini grids as a way of increasing electricity access. In West Africa, the ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREE) reckons that it will require construction of approximately 230,000 new mini grid schemes by 2030 to electrify the population currently having no access to energy (Sawin et al. 2014). The PERACOD program in Senegal for instance partnered with the Rural Electrification Agency (ASER) to provide technical assistance to private developers of electricity mini grids to establish sustainable models for developing and operating private isolated mini grids (Franz, 2013). So far, a total of 18 mini grids have been developed with another 50 under implementation. The approach used included incorporated use of smart metering devices which made it much simpler and effective for billing and collecting revenue. Mini grid projects have been in use in remote places in Kenya for the last three decades. Currently, there are 21 public mini grids in Kenya, of which 19 are fully operated by Kenya Power and 2 are operated by both Kengen and Kenya Power. Ten more are under construction at different stages of development (IED, 2013). Just over a dozen mini grid projects owned and operated by private sector entities exist in the country. Most of these are small, un-licensed and vertically integrated mini-grids which serve between 100 – 1000 households (ECA, 2014). Central Kenya, Lamu, Mandera and Lake Victoria Islands are some of the areas currently with installed private mini-grids (IED, 2013). In Kirinyaga County where potential for small hydropower is high, mini-grid projects have in the past been promoted to help in post-harvest processing of farm produce and generally to spur economic development. There are 3 mini-grids in the area owned and operated by private entities; Thiba, Kathamba and Thima. The mini-grids are based on small hydropower systems of capacities between 100-250kW and serve households and businesses most belonging to power user associations who also constitute ownership for the schemes. The Government of Kenya (GoK) in its effort to eradicate poverty by year 2030 as contained in the country's economic blueprint, Kenya Vision 2030, has intensified efforts at increasing access to electricity in rural areas. This has been through several projects



aimed at increasing the generation capacity and expanding the transmission and distribution infrastructure throughout the country.

## **STATEMENT OF THE PROBLEM**

Kenya's rural electrification level, at 15% is one of the lowest in Sub-Saharan Africa (SREP, 2011). The Government of Kenya (GoK) projects a required investment of over 13.7 billion US Dollars in expansion of generation facilities alone if universal electrification is to be achieved by year 2030 (Power Sector MTP, 2015). This, is clearly a monumental challenge to the government, but presents an immense opportunity for private investment in electrification using mini grids. Yet, private sector investment in mini grid projects has been virtually absent. Existing private mini grids were established with significant levels of donor assistance and have registered mixed performances, generally a potentially unattractive scenario for private funding. This has curtailed the much-required capital injection from private sources, which is vital for spurring sector growth and increasing the pace of rural electrification. There have been several private mini grid projects in Kenya, especially in Central Kenya, though most operate on unsustainable models, resulting in low confidence among users. EUEI PDF (2013) cites a struggle of existing and planned private mini grids to gain popularity with users, attract private capital and expand beyond piloting and demonstration. Regular technical problems resulting in frequent breakdowns with long downtimes are common. Revenue generation is low resulting in schemes struggling to finance operations. Financial challenges experienced by the schemes make it difficult to access services of qualified professionals to carry out maintenance. In the past, high up-front capital costs, low capacity factors, often higher tariffs compared to national grid consumers, technology failures, lack of policy framework, and uncertainty in the face of possible future central grid extension have been cited as main sector challenges (Deshmukh, Carvallo & Gambir, 2013). It's clear that private sector investment in isolated mini grids will be instrumental to the government's target of achieving 70% and 100% electrification levels by years 2020 and 2030 respectively. Performance issues in existing mini grids have however deterred investment in the sector with only 15 privately developed and operated mini grids existing in Kenya by 2014, serving less than 1,000 households (ECA, 2014). It is clear there is a shortage of past studies conducted on private electricity mini grid projects specific to Kenya that examine the performance issues exhibited in existing schemes. Past



research dwells more on general challenges related to policy and financing, relegating specific aspects influencing performance during, both development and operation of schemes. Further, these analyses have taken regional approaches, therefore, providing a rather generalized view that is not unique to Kenya. This study therefore sought to fill in the gaps by identifying and analyzing specific factors that influence both technical and financial performance of electricity mini grids in Kenya. The study focused more on the challenges in planning and management of the projects and how these affect their performance. The general objective of this study was to examine the factors influencing performance of private electricity mini grid projects in Kenya.

### **SPECIFIC OBJECTIVES OF THE STUDY**

1. To assess the extent to which staff training affects performance of private electricity mini grid projects in Kenya
2. To analyse how user involvement influences performance of private electricity mini grid projects in Kenya
3. To determine how household income, influences performance of private electricity mini grid projects in Kenya
4. To find out how project planning contributes to performance of private electricity mini grid projects in Kenya

### **RESEARCH QUESTIONS**

1. What is the effect of staff training on performance of private electricity mini grid projects in Kenya?
2. How does user involvement influence performance of private electricity mini grid projects in Kenya?
3. How does household income affect performance of private electricity mini grid projects in Kenya?
4. How does project planning contribute towards performance of private electricity mini grid projects in Ken

### **LITERATURE REVIEW**

#### **Theoretical Framework**

The purpose of this section is to lay down the theoretical framework adopted for study of the subject matter of this research.



### **Human Capital Theory**

Human Capital Theory refers to the aggregate stock of competencies, knowledge, social, and personality attributes, including creativity, embodied in the ability to create economic value (Meghna, 2013). The theory distinguishes between training in general-usage and firm-specific skills necessary for accomplishing specific functions and activities of the organization. Kessler and Lulfessmann (2006) found that for employers to draw maximum benefits from training of their staff when labor markets are competitive, they should invest in specific training, as opposed to general training. They argue that there exists an incentive complementarity between employer-sponsored specific training. Human capital theory has practical implication for determining the value of training and education in an organization (Makkar, 2007). For mini grid projects, the expectation is that widespread investment in human capital would create in the labor-force, the skill-base required for seamless operation and maintenance of the grid infrastructure, thus boosting performance.

### **Social Cognitive Theory**

Albert Bandura developed the Social Cognitive Theory based on the concept that learning is affected by cognitive, behavioral, and environmental factors (iSALT Team, 2014). The theory states that portions of an individual's knowledge acquisition can be directly related to observing others within the context of social interactions, experiences, and outside media influences. It is based on the understanding that human beings learn from observing the behavior of others and how that is rewarded or punished. Individuals' interaction with the environment involves beliefs and cognitive competencies developed and modified by social influences. This interaction involves a person's behavior determining their environment, which in turn affects their behavior. The relevance of the theory to the development process of mini grid projects is drawn from its assertion that human beings are the agents or managers of their own behaviors (iSALT Team, 2014). Stakeholders' participation in planning, design and management of mini grid projects will generally affect how they relate to the project during operation. Goldin and Lawrence (2008) reckon that human beings are more apt to initiate, exert effort in, and persist at activities in which they have high interaction with.



### **Theory of Consumer Choice**

The theory of consumer choice is the branch of microeconomics that relates preferences to consumption expenditures and to consumer demand curves. It analyzes how consumers achieve equilibrium between preferences and expenditures by maximizing utility as subject to consumer budget constraints. Consumer choice theory tries to explain from an outsider's point of view how individuals are likely to spend their income given a set of choices and prevailing conditions. Findings by Levin and Milgrom (2004) show that a relationship can be derived from the consumer choice theory because the consumer's choice sets are assumed to be defined by certain prices and the consumer's income or wealth. The idea is that the consumer chooses a vector of goods  $x = (x_1, x_2, \dots, x_n)$  to maximize her utility subject to a budget constraint that says she cannot spend more than her total wealth. In the case of mini grids which come in to substitute other energy forms such as kerosene lanterns, the theory postulates that the principle of marginal rate of substitution (MRS) which is the maximum quantity of good  $y$  a consumer is willing to give up to get an additional unit of good  $x$ , applies. MRS in other words is the value of a unit of good  $x$  measured in units of good  $y$ . This presents a challenge as it will always be difficult to change mindsets of communities from the use of the perceived cheaper alternative fuels (wood, kerosene, candles etc.) and instead hook onto the perceived costly electricity supply offered by mini grids (ECA, 2014). To keep tariffs within the bounds of what consumers would be willing to pay requires substantial capital subsidies to be provided in innovative delivery models.

### **Project Management Theory**

According to Koskela and Howell (2002), it's possible to precisely point out the underlying theoretical foundation of project management as espoused in the PMBOK despite the general view that there is no explicit theory of project management. This foundation can be divided into a theory of project and a theory of management. They contend that understanding of management is based on three theories: management-as-planning, the dispatching model and the thermostat model. In management-as-planning, management at the operations level is seen to consist of the creation, revision and implementation of plans. This approach to management views a strong causal connection between the actions of management and outcomes of the organization.



## Conceptual Framework

The conceptual framework illustrated in Figure 1 shows the relationship between variables in mini grid projects that affect performance of private electricity mini grid projects.

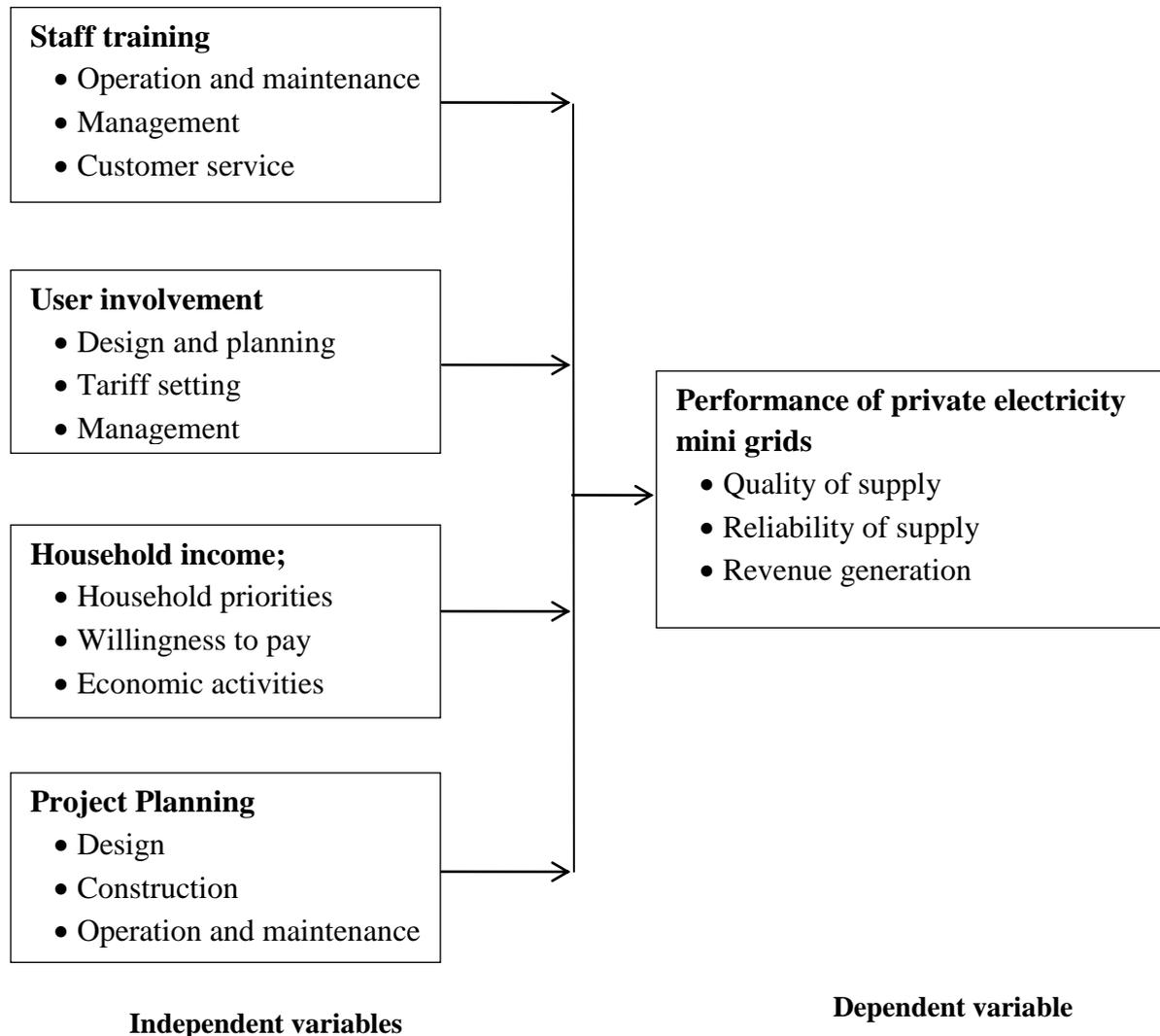


Figure 1: Conceptual framework

## RESEARCH METHODOLOGY

### Research Design

Descriptive survey was used to gather information, summarize, interpret and present data for clarification. Good description provokes the 'why' questions of research. It determines and reports the way things are and helps in establishing the status of the population under study by describing, explaining or exploring the existing status of two or more variables (Mugenda & Mugenda, 2003).

### Target Population



The population of interest for this study comprised customers of mini grid projects in Kenya. The target population was drawn from households and businesses within the study area, comprising the customers of three mini grid projects, namely, Kathamba, Thiba and Thima within Kirinyaga County. The target population for the study was made up of 65 customers from Kathamba, 48 from Thiba and 137 from Thima, representing 26%, 19% and 55% of the total population, respectively.

**Table 1: Target population**

<b>Cadre</b>	<b>Population size</b>	<b>Percentage (%)</b>
Kathamba	65	26
Thiba	48	19
Thima	137	55
<b>Total</b>	<b>250</b>	<b>100</b>

Source: Ministry of Water, Environment and Natural Resources office; Kirinyaga County Government (2016)

### **Sample and Sampling Procedure**

The study applied stratified random sampling procedure to obtain the respondents for the survey. Stratified sampling was chosen because it allows the researcher to obtain estimates of known precision for certain subgroups of the population by treating each subgroup as a stratum which in turn is treated as a population (Kothari, 2004). The sample size selected depends on the subject of inquiry, purpose of the inquiry, its significance, what was useful, what had credibility and what can be done with available time and resources. According to Mugenda and Mugenda (2003), for stratified sampling, at least 30% individuals per group are required for research with a general guide of at a sample total of 384 for populations greater than 10,000. Mugenda and Mugenda (2003) suggest the following formula for determining appropriate sample size for population sizes less than 10,000:

$$n_f = \frac{n}{1 + \frac{n}{N}}$$

Where;

$n_f$  = desired sample size when the population is less than 10,000

$n$  = desired sample when the population is more than 10,000

$N$  = estimate of the population size



Therefore, with an estimated population size of 250, a sample size of 151 respondents which corresponds to approximately 60% of the population was selected using a stratified random sampling technique as shown in Table 2.

**Table 2: Sample size**

<b>Cadre</b>	<b>Population size</b>	<b>Percentage (%)</b>	<b>Sample size</b>
Kathamba	65	60	39
Thiba	48	60	29
Thima	137	60	83
<b>Total</b>	<b>250</b>	<b>60</b>	<b>151</b>

### **Data Collection Procedure**

The study used both primary and secondary data collection approaches. Secondary data was sought to obtain further insight into the background knowledge about issues relevant to mini grid policy, finance and tariffs in developing countries. These included past studies, publications and presentations by renowned persons, organizations and institutions. The researcher obtained an introduction letter from the University prior to commencement of primary data collection. A meeting with the local authorities in the study region helped clarify the purpose of the study to local government while explanation of the nature of the exercise to respondents was done while distributing the questionnaires. Primary data collection was conducted through use of questionnaires. The questionnaires were administered to respondents from the research area composed of owners, staff and customers of mini grid projects. The questionnaires were predominantly composed of closed-ended questions.

### **Data Analysis and Presentation**

Both quantitative and qualitative approaches were used for data analysis. Quantitative data from the questionnaire was coded and fed into the computer for computation of descriptive statistics including frequencies, percentages, means and standard deviations. The Statistical Package for Social Sciences (SPSS v.22) was used to run descriptive statistics.

Multiple linear regression analysis was used to estimate the relationships among variables. The technique was used to establish the relationship between the dependent variable (performance of private electricity mini grid projects) and the various independent variables. The analysis helps estimate how the dependent variable changes when any one of



the independent variables is varied, while the other independent variables are held fixed per the formula;

$$y_i = \beta_0 + \beta_1 x_1 + \beta_2 x_2^2 + \dots + \beta_n x_n^n, i = 1, 2, \dots, n, \text{ where,}$$

$y_i$  - dependent variable

$\beta_0$  - A constant (coefficient of intercept)

$\beta_1, \beta_2, \dots, \beta_n$  - Regression coefficients of the independent variables

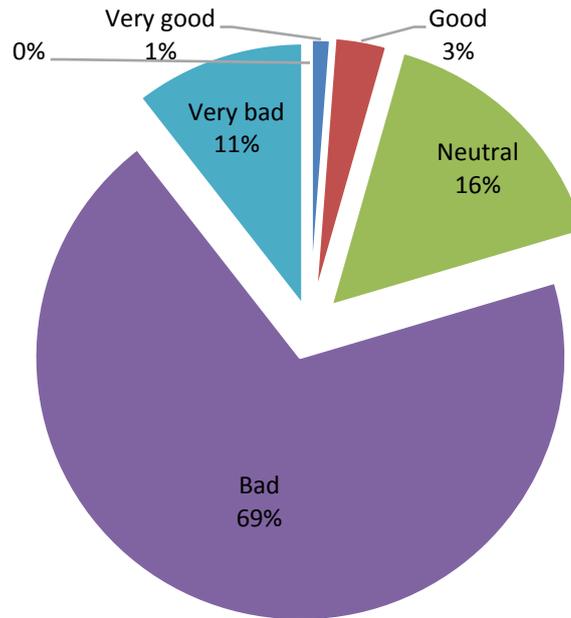
$x_1, x_2, \dots, x_n$  - Independent variables

Correlation analysis was also used to analyze data through estimation of the Pearson Product Moment correlation coefficient,  $r$  which ranges between -1 and +1 and is used to quantify the direction and strength of the linear association between two variables. The relationship between two variables is considered positive if higher levels of one variable are associated with higher levels of the other and negative if higher levels of one variable are associated with lower levels of the other. Analysis of variance (ANOVA) was used to test the significance of the overall model at 95% level of significance. Further, quantitative data is presented in form of tables and graphs while qualitative data generated from open ended questions is reported in narrative form to reinforce the quantitative data.

## RESEARCH FINDINGS AND DISCUSSION

### Staff Training

The study sought to find out if customers of the mini grid schemes thought the performance of staff as demonstrated by the level of service they received was satisfactory and from the response 80% of the respondents rate the performance of the staff as unsatisfactory as shown in Figure 2. This shows that service delivery of the mini grid schemes was not aligned with customer expectations. The findings collaborate the study by Rolland and Glania (2011) which concluded that the quality of service in most mini grid schemes in Eastern Africa was wanting which in most cases resulted in low customer confidence.



**Figure 2: Respondents view of staff performance**

Further, respondents had unfavorable views on adequacy of relevant specific skill sets of the staff for the mini grids with only 10%, 23% and 7% feeling that the staff's technical, customer relationship and managerial skills, respectively, were sufficient as shown in Table 3. Particularly, a strong majority, 86.1% thought the managerial skills of the staff for the mini grids were inadequate. Only 16% of respondents thought adequate training of mini grid staff had been undertaken before commissioning of the projects and none of the respondents thought any form of training had been undertaken for the staff afterwards, within the previous 12 months. The study findings also reinforce IED's recommendations for capacity building targeting staff of existing mini grids and extending to institutions of higher learning should be carried out in order to improve knowledge for operation and maintenance in private mini grids. Almost all the respondents in the study, 99%, thought staff training would contribute to improved service delivery. However, study findings found that respondents were not confident of the existence of a quality training institution for electrical technicians within a 30km radius of their village, with most respondents, 43.3%, being uncertain, while 39% disagreed such an institution existed. This indicates the difficult of mini grid staff to access quality training service with potential low availability of trained staff from the community to hire as mini grid staff. Rolland and Glania (2011) highlight the need for



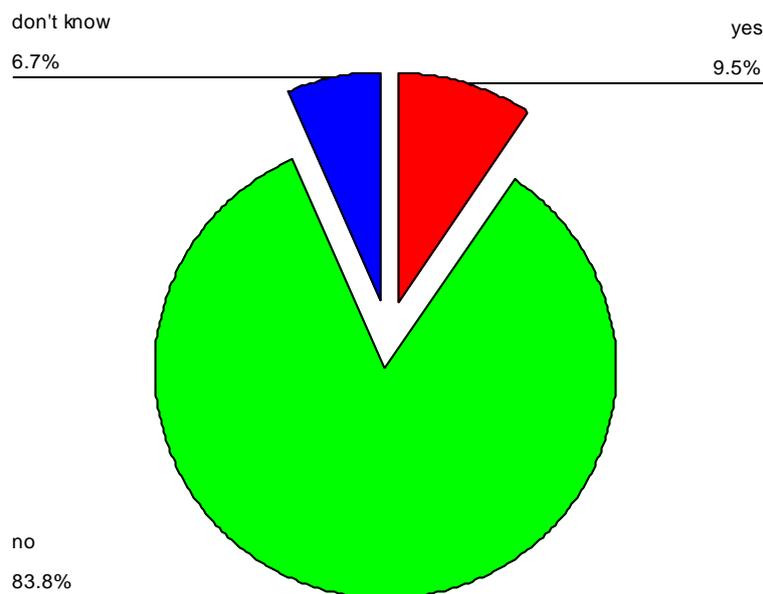
capacity building in local tertiary institutions to offer quality training relevant to operation and maintenance of mini grids.

**Table 3. State of staff training in mini grid projects**

Statement	Strongly Disagree	Disagree	Neutral	Agree	Strongly agree	Mean	Std Dev
Staff have adequate technical skills for O&M of scheme	70.5%	18.5%	1.0%	10.0%	0%	1.5	0.93
The staff's customer relationship skills are satisfactory	30.5%	13.3%	32.9%	13.3%	10.0%	2.6	1.31
The staff's management skills are adequate	86.1%	2.7%	4.0%	5.4%	1.8%	1.2	0.97
Staff training was done at start of project	47.6%	10.0%	25.7%	11.9%	4.8%	2.2	1.27
Additional staff training has been done at least once in the last 12 months	72.4%	22.9%	4.7%	0%	0%	1.3	0.56
A quality training center for technicians is within a 30km radius	7.1%	31.9%	43.4%	9.0%	8.6%	2.8	1.00
Regular staff training will improve performance of the scheme	15.2%	83.8%	0.5%	0.5%	0%	1.7	0.40

### User Involvement

Social, political and economic issues are believed to have a bearing on the development process, particularly, in rural development projects. The level of engagement with users and the approaches used in engaging users in private mini grid projects was researched and analyzed herein. Feedback received from the respondents regarding the level and form of consultation within the community during initiation, planning and development of the mini grid schemes, as shown in Figure 3. clearly shows that there was minimal consultation. Only 9.5% acknowledged having been consulted during the planning phase of the project with an overwhelming 84% indicating that they or any member of their household were not consulted during initiation and planning for the schemes. This indicates that the users of the schemes were not involved in its planning and design which could potentially result in discontent among users.



**Figure 3: Level of consultation during planning**

The low level of consultation of users of private mini grids by their management is illustrated further by the findings from the research as shown in Table 4. where more than 90% of the respondents either disagreed or strongly disagreed when asked whether the mini grids' management regularly consulted them before making major decisions governing the management of the schemes. Only 4% agreed that they were consulted. The study further finds no form of representation of the users exists as no respondent indicated the existence of user representatives to pass their opinions. This is, although over 90% feel they would be inclined to cooperate with management on new proposals if they participated in formulating the proposals. Further, on a more specific note, slightly over 85% feel they would be more comfortable paying electricity bills if they were involved in setting of the electricity tariffs. These results indicate a high willingness of mini grid users to support mini grid management decisions if they are involved in making those decisions. It concurs with Manetsgruber, Wagemann, Kondev and Dziergwa (2015) study which found that customers were rarely consulted by mini grid management especially in matters relating to tariff setting which contributed to high levels of non-compliance with mini grid decisions.



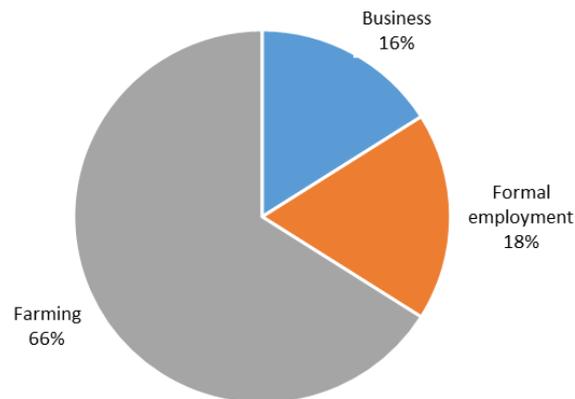
**Table 4: User involvement in mini grid scheme's management**

Statement	Strongly Disagree	Disagree	Neutral	Agree	Strongly agree	Mean	Std dev
Users are consulted by the scheme's management on key decisions	63.8%	27.0%	4.8%	4.4%	0.0%	1.8	1.20
Users have representatives who pass across their opinions on running of the mini grid	88.1%	9.0%	2.9%	0.0%	0.0%	1.2	0.70
My participation in decision making affects my cooperation on scheme's new proposals	1.9%	7.1%	2.9%	51.9%	36.2%	1.9	0.91
I feel more comfortable paying electricity bills if I am involved in tariff-setting	3.3%	11.0%	0.0%	50.0%	35.7%	4.0	1.04
There is regular communication to users on matters relating the scheme's operations	87.6%	4.8%	4.8%	2.8%	0.0%	1.2	0.67

In their study, they show the need to cultivate a sense of ownership in the projects across the target users and the community at large right from project initiation, through employment of a participatory approach to mini grid development.

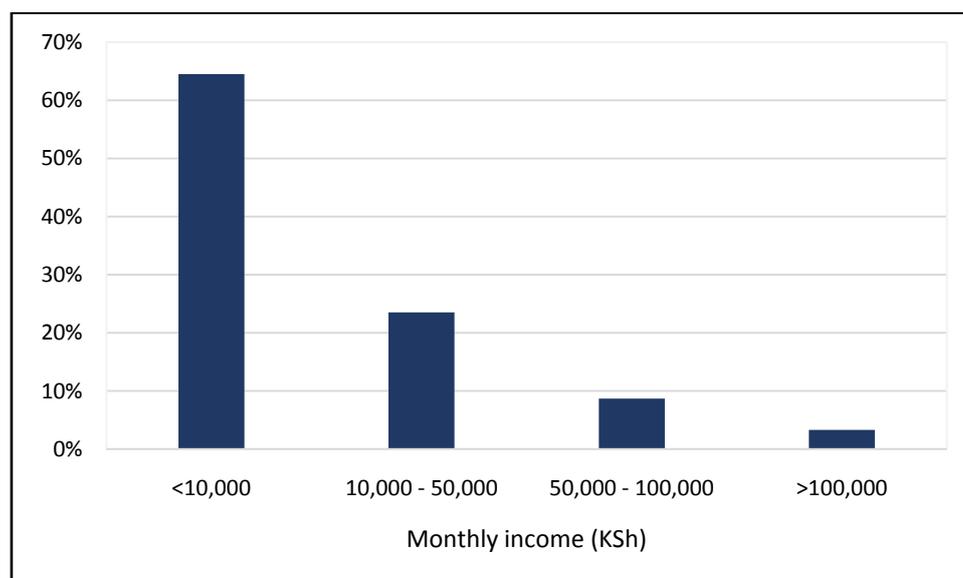
### Household Income

Majority of the household heads among respondents, as illustrated in Figure 4 were farmers at 66% with those doing businesses and in formal employment accounting for 16% and 18% of the respondents respectively. This shows a potential for high agricultural yield in the study area with the accompanying demand for electricity to power preservation and processing technologies of the produce from farms. This agrees with UNDP (2012) whose findings revealed that over 80% of Kenya's population in rural areas was involved in some form of agricultural activity.



**Figure 4: Occupation of household heads**

In response to how much income the household generated monthly, as shown in Figure 5, 65% indicated they made less than 10,000 shillings, 24% made between 10,000 and 50,000 while 9% made between 50,000 and 100,000. Only 3% of the respondents indicated they made over 100,000 per month. This shows that majority of the households' average monthly income is just above the gazetted national average minimum monthly wage of 7,700 for the agricultural industry. This agrees with Franz, Peterschmidt, Rohrer and Kondev (2014) who found that households in rural communities have relatively low incomes with little or no surplus to comfortably pay for electricity services after taking care of their basic needs such as food and education.

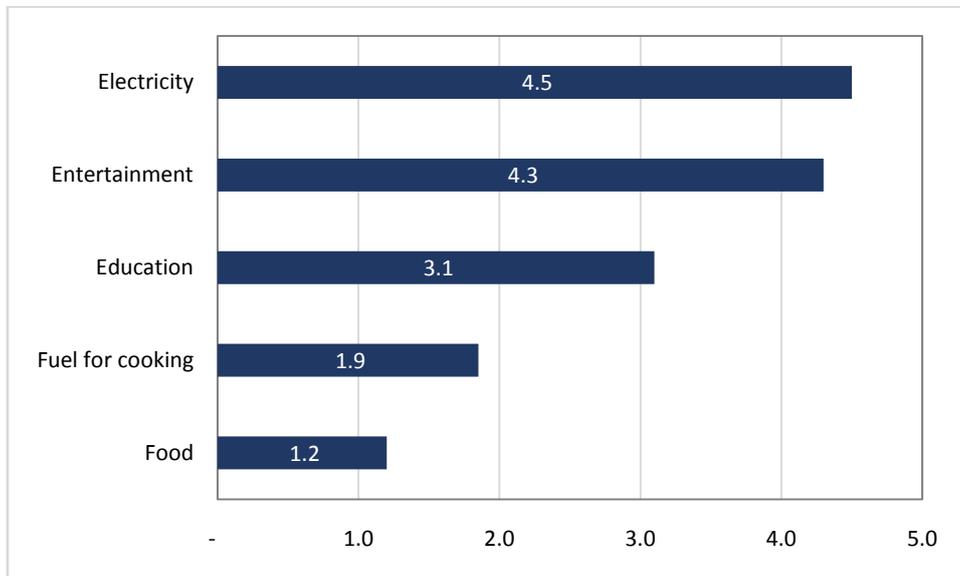


**Figure 5: Average monthly income of household head**

From findings on statements related to spending priorities, the research found that all the respondents ranked food as highest on their spending priorities as shown in Figure 6, where food is shown to have the lowest statistical rank of 1.2. Cooking fuel and energy for lighting

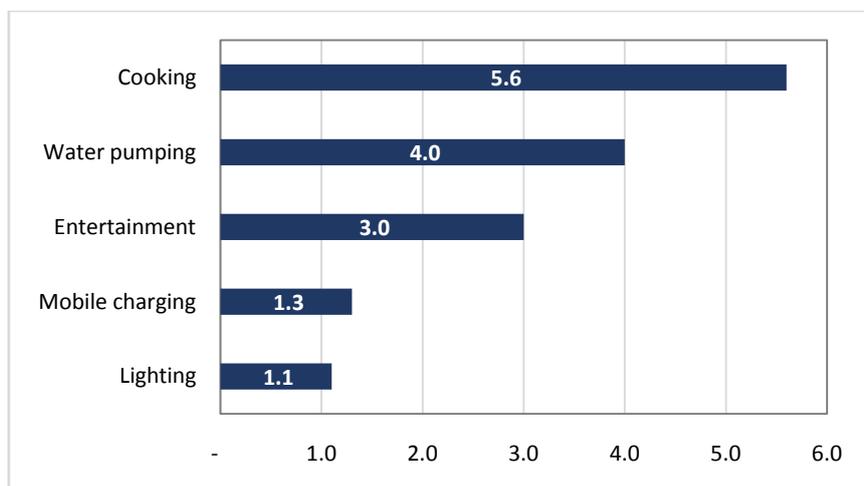


were ranked second and third respectively, while Education and entertainment were ranked fourth and fifth respectively in order of spending priority. This shows that households will first seek to satisfy their basic needs before spending on other needs such as electricity services thus relegating the need to pay electricity bills.



**Figure 6: Ranking of spending priorities for households**

On prioritization of electricity uses, lighting had, statistically, the lowest rank followed by mobile phone charging, entertainment, water pumping and cooking, in that order, as shown in Figure 7. In this case, lighting was ranked as the most important use for electricity among respondents with cooking ranked as the least important attribute. These findings show that communities in rural areas do not value the use of electricity for productive use and makes the case for promoting productive uses within rural communities alongside electricity access programs even more necessary.

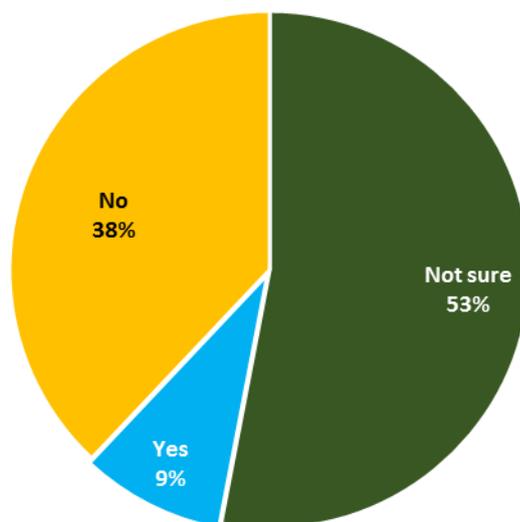




**Figure 7: Ranking of electricity uses among customers**

### Project Planning

The research sought to find out if professional feasibility studies inclusive of a socio-economic analysis were conducted during planning of the three mini grid schemes and how the users thought this influenced the performance of the projects. Only 9% of the sampled population thought exhaustive and quality feasibility studies and socio-economic assessments were carried out for the schemes while 38% felt the studies were not adequate and 53% were not certain if any studies were carried out. This response indicates a likelihood that the studies were either not conducted by professional consultants or they lacked a key facet of adequate technical feasibility studies – the socio-economic element.



**Figure 8: Response on quality of designs carried out**

When asked on whether they felt a proper design was carried out which could be attributed to lowering frequency of break-downs in the infrastructure, 87% disagreed while only about 9.5% agreed. Similarly, most felt the mini grid schemes did not have clear operation and maintenance plans in place as shown in Table 4.6. These findings show a correlation between the regular technical hitches experienced by the plant and the low quality of design coupled with absence of clear operation and maintenance plans for the schemes. This tallies with the findings by Deshmukh, Carvallo and Gambir which showed a lack of standard operation and maintenance plans for mini grid schemes which resulted in haphazard plant maintenance schedules that did not cater for the requirement for regular servicing of plant components and general grid infrastructure.

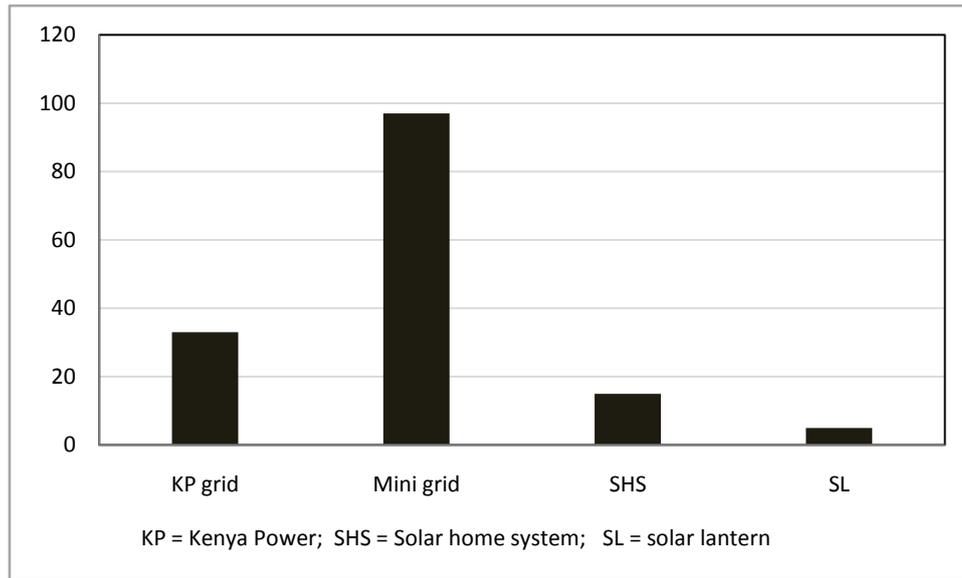


**Table 5: Relationship between quality of technical studies and performance**

Statement	Strongly Disagree	Disagree	Neutral	Agree	Strongly agree	Mean	Std dev
System was designed well resulting in low frequency of break-downs	32.1%	54.8%	3.6%	8.3%	1.2%	2.22	1.02
Project planning would have enhanced proper participation of all stakeholders	1.9%	12.9%	33.3%	21.9%	30.0%	1.08	0.47
The project has an O&M plan that ensures efficient operation	97.1%	1%	1.9%	0%	0%	1.43	1.20
The scheme's performance issues are because of poor design and O&M planning	8.5%	0%	0%	2.9%	88.6%	4.67	0.98

### Performance of Private Electricity Mini Grid Projects

The research sought to find out from the respondents their opinion on the level service they expected and received from their respective electricity mini grid operators within the study area. This segment of the research focused on alternative primary energy sources within households, electricity tariffs, supply quality, reliability and convenience of use. To establish the variations in monthly energy charges with respect to common energy sources, respondents were asked to indicate what their primary source of electricity in the household had been in the past year and on average how much this cost per month. As illustrated in Figure 9, over 65% had used the mini grid as their primary source of electricity, 22% had used the Kenya Power grid, while 10% used solar home systems. Only 5% of respondents used solar lanterns. This shows that most the respondents used the mini grid as their primary source of electricity.



**Figure 9: Primary sources of electricity for households and businesses**

On average, respondents who had the mini grid as their primary source of electricity spent 200 Shillings monthly on electricity bills as compared to those primarily using electricity from Kenya Power who spent on average 500 shillings. Solar home systems' and solar lantern users had no monthly costs. This result, summarized in Table 6, shows private mini grids within the study area charging a flat tariff of KSh. 200 for monthly consumption below 50kWh as compared to Kenya Power who charge a minimum of KSh. 400 inclusive of a fixed monthly charge of KSh. 175. This relatively low tariff for private mini grid users has been linked to the relatively common poor financial performance of mini grids in Africa (IED, 2013).

**Table 6: Cross tabulation of primary electricity source and monthly bill**

Primary Source of Electricity	Average Monthly Bill								Total
	200	500	700	600	0	600	800	1100	
Kenya power	0	55	5	5	0	1	1	1	68
Mini grid	133	3	0	0	0	0	0	0	136
Solar lantern	0	0	0	0	3	0	0	0	3
Solar home system	0	0	0	0	3	0	0	0	3
Total	133	54	5	5	6	1	1	1	210

Respondents were asked to indicate their opinions on the level of performance of the mini grid scheme as measured using different criteria relating to quality, safety and reliability of service. The results are summarized in Table 7. A significant majority of the respondents, 90%, indicated that voltage fluctuations occur regularly resulting in damage to electrical



equipment. Further, respondents indicated that there were regular unpredicted interruptions in electricity supply. This shows that operational glitches were frequent a result of either, low technical capacity of staff or poor design and planning, or both. This corresponds to Rolland and Glania's (2011) conclusions that attributed prevalence of supply reliability issues in existing mini grid schemes to capacity issues of the staff responsible for the operation and maintenance of the plants..

On the other hand, respondents feel that the schemes' payment system is both convenient and flexible allowing them to pay remotely via mobile money transfers and for proportions they need and can afford at any one time. Further, most feel they would readily recommend their family and friends within the project area to join the scheme. This shows that given the available energy service alternatives, mini grid schemes are still considered as useful to customers.

These findings agree with GVEP (2011), who found that despite their many shortcomings, mini grids' popularity was still expanding due to their potential to provide a more reliable source of cheap power in remote locations with greater functionality than that provided by stand-alone systems such as solar home systems.

**Table 7: Performance levels of various aspects of the mini grid operation**

Statement	Strongly Disagree	Disagree	Neutral	Agree	Strongly agree	Mean	Std dev
voltage fluctuations occur regularly resulting in damage to household electrical appliances	1.4%	2.1%	6.3%	49.2%	41.0%	3.70	1.29
unpredictable interruptions of electricity supply are common within the scheme	0.0%	2.9%	0.0%	0.0%	97.1%	4.91	0.50
It takes too long to restore normal supply whenever interruptions occur	0.5%	3.8%	1.9%	1.4%	92.4%	4.81	0.69
The scheme experiences over one major downtime in a period of 12 months	0.5%	5.7%	2.4%	2.4%	89.0%	4.74	0.80
The scheme's billing and payment method is easy and convenient to use	3.3%	28.1%	4.3%	61.0%	3.3%	3.33	1.03



I would readily recommend to my friends and family to connect to the mini grid scheme

0.0%	0.0%	0.0%	19.5%	80.5%	4.80	0.40
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### Regression Analysis

Multiple regression analysis was used to establish the statistical relationship between the influencing factors in private electricity mini grid projects and the performance of the schemes. The research used Statistical Package for Social Sciences (SPSS v.22) to code, enter and compute the measurements of the multiple regressions. The value of the adjusted R Square of the model is 0.715 as shown in Table 8 and indication that there is a variation of 71.5% on Performance of private mini grid projects due to changes in training of mini grid staff, household income, user involvement and planning in mini grid projects at 95% confidence level.

**Table 8: Multiple regression model summary**

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.849(a)	.721	.715	.27160

From the Anova analysis in Table 9, independent variables statistically significantly predict the behavior of the dependent variable. This is illustrated by the significance value, (p – value) which is less than 5%, a measure that indicates that the regression model is a good fit for the data.

**Table 9: Anova analysis**

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	39.015	4	9.754	132.221	.000(a)
	Residual	15.123	205	.074		
	Total	54.138	209			

Further, from table 11, it's clear that when all the independent variables are regressed against the dependent variable the constant gives a positive result meaning there is a strong relationship and each variable influences the dependent variable. A unit change in staff training would lead to a .043 effect on performance of mini grid projects; while a unit change in household income would have an effect of .060 change in performance of mini



grid projects. Similarly, a unit change in user participation approaches would have an effect of .043 change in performance of mini grid projects while a unit change in project planning practices would have an effect of .108 change on performance of mini grid projects. The study shows project planning to have more influence on performance of private electricity mini grid projects than other factors. The findings of Deshmukh et al. (2013) found that the level of project planning during development and operation of mini grid projects is an important precursor for provision of quality services by mini grid projects that enhances performance of the schemes.

**Table 1: Coefficients**

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.104	.139		7.911	.000
	Staff training	.043	.006	.337	7.726	.000
	Household income	.060	.008	.335	7.869	.000
	User involvement	.043	.007	.252	6.213	.000
	Project planning	.108	.014	.297	7.503	.000

The resulting regression equation was

$$Y = 1.104 + 0.043X_1 + 0.060X_2 + 0.043X_3 + 0.108X_4$$

The significance value for all the independent variables was found to be less than 5% indicating that they were all statistically significant. Pearson correlation was conducted among the four constructs of performance of private electricity mini grid projects; staff training, user participation, household income and project planning as shown in Table 12. The analysis yielded positive correlations for all the constructs which showed that staff training, user participation, household income and project planning were all positive antecedents to performance of private electricity mini grid projects.

**Table 2: Pearson correlation coefficients**

		X11	X22	X33	X44	Y11
X11	Training of personnel	1				
X22	User involvement	.424(**)	1			
		.000	.			
X33	Household income	.320(**)	.378(**)	1		
		.000	.000	.		
X44	Project planning	.357(**)	.186(**)	.143(*)	1	
		.000	.007	.038	.	



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Y11	Performance of mini grids	.665(**)	.628(**)	.529(**)	.515(**)	1
		.000	.000	.000	.000	.

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## CONCLUSION

The study concludes that there is a substantial need for capacity building in system design and feasibility studies as well as training in operation and maintenance and assistance in management support during the lifetime of the projects, for developers, owners and staff of private mini grid projects in the county. Lack of a quality training institution within the project area for training of mini grid practitioners is partly to blame for the inadequate training of staff experienced in the mini grid projects. The study concludes that if user involvement is applied correctly, the impact on project success can be large, as users embrace the projects as theirs. The study concludes that developers of private mini grids rely on informal and unqualified professionals in planning and designing mini grid projects. Resources for power generation, once identified by local community members, are not properly analyzed to compute proper estimates of capacity and availability. This creates uncertainty in availability of power generation plants due to factors such as competing uses and seasonal variations. Projects currently lack firm operation and maintenance plans and utilize a fire-fighting approach to maintenance, resulting in frequent technical challenges that create reliability issues.

## RECOMMENDATION

The study recommends integration of local environments during design through encouraging participation from local communities who would comprise the schemes' customers. Proper communication and targeted involvement will help tailor the projects to meet the unique needs of the communities in which they are located besides creating buy-in from the users which is a key driver of the mini grid's sustainability. The planners are encouraged to incorporate in the design parallel activities to trigger utilization of the new-found electricity by households and businesses for productive use. Productive use of electricity generated will spur local economic development creating surplus incomes for households that will enable them to utilize more electricity and pay for it comfortably. To mini grid developers and operators, the study recommends incorporation of good quality planning during development and operation of projects to ensure an all-round consideration



of all the factors that affect their success. Proper feasibility studies should be carried out using knowledgeable and experienced consultants and this should incorporate development of a solid scheme-specific O&M plan for the project. Developers should ensure staff capacity is regularly improved through provision of regular, relevant training. To the government, the study recommends capacity development focusing on local institutions offering relevant training courses to build the capacity of learning institutions to properly train students for the mini grid market.

## REFERENCES

1. Ahlborg, H., & Sjöstedt M. (2014). *Small-scale hydropower in Africa: Socio-technical designs for renewable energy in Tanzanian villages*. Göteborg, Sweden: Energy, Research & Social Science.
2. Asmus, P. (2011). Why microgrids are inevitable: And why smart utilities should plan accordingly. *Distributed Energy*, 1547, (44-47)
3. Barnes, F.D., & Halpern, J. (2000). *Subsidies and sustainable rural energy services: Can we create incentives without distorting markets* (ESMAP Technical Paper No. 010). Washington, DC: World Bank.
4. Batool, A., & Batool, B. (2012). Effects of employees training on the organizational competitive advantage: Empirical study of Private Sector of Islamabad, Pakistan. *Far East Journal of Psychology and Business*, 6(1).
5. Bazilian, M., Nussbaumer, P., Cabraal, A., Centurelli, R., Detchon, R., Gielen, D., ... Rogner, H. (2010). *Measuring energy access: Supporting a global target*. New York: Earth Institute, Columbia University.
6. Becker, G.S. (1993). *Human capital: A theoretical and empirical analysis with special reference to education (3rd Ed.)*. Chicago: University of Chicago Press.
7. Bhattacharyya, S.C. (2012). *Energy access programmes and sustainable development: A critical re-view and analysis*. *Energy Sustain Dev* 2012; 16:260–71.
8. Bryman, A. (2012). *Social research methods*. London: Oxford University Press, Oxford
9. Bryman, A., & Bell, E. (2007). *Planning a research project and formulating research questions*. In: *Business Research Methods*. New York: Oxford University Press
10. Chowdhury, A., & Mavrotas, G. (2005): FDI and Growth: A Causal Relationship. *UNU-WIDER Research*, 2005/25.



11. Cornwall, A. (2002). *Beneficiary, consumer, citizen: Perspectives on participation for poverty reduction*. Gothenburg, Sweden: SIDA Studies
12. Creswell, J.W. (2003). *Research design: Qualitative, quantitative, and mixed methods*. London: SAGE Publications
13. Cronbach, L.J. (1951). *Coefficient alpha and the internal structure of tests*. Illinois: University of Illinois
14. Berkeley National Laboratory
15. Economic Consulting Associates. (2014). *Renewable energy development for offgrid power supply in rural regions of Kenya*. London: Economic Consulting Associates
16. European Union Energy Initiative - Partnership Dialogue Facility. (2013). *Mini-grids: Opportunities for Rural Development in Africa. Workshop Report, EU Energy Initiative Partnership Dialogue Facility*. Eschborn, Germany
17. Energy Sector Management Assistance Program. (2001). *Peru: Rural electrification*. Washington D.C: World Bank.
18. Energy Sector Management Assistance Program, (2000). *Reducing the cost of grid extension for rural electrification*. Washington, DC: World Bank.
19. Goertz, G. & Mahoney, J. (2012). *A Tale of Two Cultures: Qualitative and Quantitative Research in the Social Sciences*. Princeton, Princeton University Press
20. Goldin, C., & Lawrence F.K. (2008). *The Race between Education and Technology*. Cambridge, MA, Belknap Press
21. Hankins, M., (2013). *Mini grid policy toolkit: Mini-grids opportunities for rural development in Africa. AEI Workshop Arusha 5 September 2013*.
22. Hartwick, J., & Barki, H. (2012) *Measuring user participation, user involvement and user attitude*. MIS Quarterly, 18(1):59–82, 2002
23. Her Majesty's Treasury. (2006): *Stern review on the economics of climate change*. London: Project Guttenberg.
24. International Energy Agency.(2002). *Renewable energy into the mainstream*. The Netherlands: IEA Renewable Energy Working Party.
25. International Energy Agency. (2009). *World energy outlook 2009*. Paris, France: International Energy Agency.



26. International Energy Agency. (2011). *World energy outlook 2011*. Paris, France: International Energy Agency.
27. International Energy Agency. (2014). *World energy outlook 2012*. Paris, France: International Energy Agency
28. International Renewable Energy Agency. (2013). Note of the director-general on IRENA's role in the sustainable energy for all initiative. *Third meeting of the Assembly Abu Dhabi, 13–14 January 2013*.
29. Ingrid, F. (2004). An index method for measurement of performance of private electricity mini grid projects. *TQM Magazine*, 16,1/57-66
30. SALT Team. (2014). "*Social Cognitive Theory*": *Theories, Concepts, and Measures*. Paper 4. Minnesota State University.
31. J.D. Power. (2014). *Electric Utility Residential Performance of private electricity mini grid projects Study*. Westlake Village, Ca.: McGraw Hill financial.
32. Karim, M.R., Huda, K.N., & Khan, R.S. (2012). Significance of training and post training evaluation for employee effectiveness: An empirical study on Sainsbury's supermarket Ltd, UK. *International Journal of Business and Management*, 7(18), 141-148.
33. Kessler, A.S. & Lulfesmann, C. (2006). *The theory of Human Capital Revisited: On the Interaction of General and Specific Investments*. Burnaby, Canada.
34. Khandker, S.R., Samad, A.H., Ali, R., & Barnes, D.F (2012). Who benefits most from rural electrification? Evidence in India. *Policy Research Working Paper*, 6095.
35. Koskela, L., & Howell, G. (2002). *The underlying theory of project management is obsolete*. Finland: Project Management Institute.
36. Kothari, C.R. (2004). *Research methodology: Methods and techniques*. Delhi: New Age International.
37. Lee K., Brewer E., Christiano C., Meyo F., Miguel E., Podolsky M., Wolfram, C. (2014). Barriers to electrification for "under grid" households in rural Kenya. *NBER Working Paper*, 20327.
38. Levin, J., & Milgrom P. (2004). *Consumer theory*. California: Stanford University.
39. Lewis J.P. (2006). *Project Planning, Scheduling and Control: A Hands-On Guide to bringing projects in on time and on budget*. McGraw-Hill Professional.



40. Liu, H., Masera, D., & Esser, L.(Eds.). (2013). *World small hydropower development report, 2013*. Hangzhou, China: ICSHP.
41. Luse, A., Mennecke, B., & Townsend, A. (2012). *Selecting a research topic: A framework for*
42. Meghna, G.M. (2013). *Human Capital Theory*. Power Plus Cables Co. LLC. Fujairah, U.A.E.
43. Merwe V.D., (2014). Policy, regulation and legislation of mini grids. *Aurecon presentation, Malawi*.
44. Ministry of Energy and Petroleum – Kenya. (2015). *Draft national energy bill – 2015*. Nairobi, Kenya: MoEP
45. Mohammad, M.J. (2013). *Practical guidelines for conducting research: Summarizing good research practice in line with the DCED standard*. London: The Donor Committee for Enterprise Development
46. Mohan, Giles (2001). Participatory development. In: Desai, Vandana and Potter, Rob eds. *The Arnold companion to development studies*, 49–54.
47. Mugenda, A.G.,& Mugenda, O. (2003). *Research methods: Quantitative and qualitative approaches*. Nairobi, Kenya: Africa Centre for Technology Press.
48. Navigant Research. (2013). Micro grids: Global market analysis and forecasts. *Navigant Research, 13*
49. Niez, A. (2010). *Comparative Study on Rural Electrification Policies in Emerging Economies: Keys to Successful Policies*. Paris, France: IEA, Energy Technology Policy Division
50. Ogbadu, E.E. (2009). Profitability through effective management of materials. *Journal of Economics and International Finance*, 1(4), 99-105.
51. Orodho, A.J. (2003). *Essentials of educational and social science research methods: Qualitative and quantitative approaches*. Nairobi, Kenya: Acts Press.
52. Osawa, B., & Telep, P. (2015). *How do we licence it? A guide to licensing a mini-grid energy service company in Kenya*. Nairobi, Kenya: GIZ ProSolar.
53. Parshall, L., Pillai, D., Mohan, S., Sanoh, A.,& Modi, V. (2009). *National electricity planning in settings with low pre-existing grid coverage: Development of a spatial*



- model and case study of Kenya*. NY, USA: Center for Energy, Marine Transportation and Public Policy.
54. Rolland, S., & Glania, G. (2011). *Hybrid mini-grids for rural electrification: Lessons learned*. Brussels, Belgium: Alliance for Rural Electrification.
55. Sawin, J. L., Freyr, S., Chawla K., Lins C., McCrone A., Musolino E., ... Skin, J. (2014). *Renewables 2014: Global status report*. Paris, France: REN21 Secretariat.
56. SE4All, & OFID.(2014). *The mini-grid option: Lessons learned and factors of success*. Vienna, Austria: SE4ALL.
57. Samantha, o., Ralph, S., & Nicolai K. (2007). *Contribution of renewables to energy security*. Paris, France: International Energy Agency.
58. Sekaran, U. (2010). *Research methods for business: A skill building approach (5th Ed.)*. California, USA: John Wiley & Sons.
59. United Nations Development Program. (2012). *Sustainable energy for all - A brief guide to advocacy planning*. NY, USA: UNDP.
60. United Nations Development Program, & World Bank. (2001). *Best practice manual: Promoting decentralized electrification investment*. Washington, DC: The World Bank.
61. Zarakas, W.P., Hanser, P.Q., & Diep, K. (2013). *Rates, reliability and region – Performance of private electricity mini grid projects and electric utilities*. Isaac Newton Sq. VA: Public Utilities Fortnightly.