CHALLENGES OF ACCESSING ELECTRICITY FOR ICT USE IN KENYAN SECONDARY SCHOOLS: A CASE OF NANDI COUNTY

BY

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2014

DECLARATION

DECLARATION BY THE CANDIDATE

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This thesis has been submitted with our approval as the university supervisors.

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DEDICATION

To my dear wife Dorcas,

Thank you for the sacrifice and support.

ABSTRACT

The use of ICT in the teaching and learning in local secondary schools in Nandi County has not been realized because of challenges arising from accessing electricity. This study focused on the electric power accessibility challenges facing the use of ICT equipment in secondary schools in Nandi County. The specific objectives of the study included; the determination of the use of alternative sources of energy in schools, the investigation of factors affecting the use of the alternative sources of energy in the powering of ICT equipment in schools, and the assessment of the schools principals' attitudes towards the use of alternative sources of energy in local secondary schools. The study was conducted through a survey research design. Purposive sampling techniques were used to select the sample for the study. The data was analyzed by the use of the Statistical Package for Social Sciences (SPSS) computer program. The findings of the study revealed that there was lack of electricity supply to many secondary schools; there were frequent power outages in the schools supplied with electricity; the cost of electric power use was high; the use of generators to generate electricity was expensive, and renewable sources of energy were not used to power ICT equipment in many secondary schools. The conclusions arrived at were that it was difficult to use ICT equipment in secondary schools in Nandi County because many secondary schools lacked access to electricity; there were frequent power outages in the schools supplied with electricity; cost of electricity was high; the cost of running generators were also high and there was lack of use of cost-effective alternative sources of energy. This study recommends that the government should supply electricity to all secondary schools, initiate renewable sources of energy projects to cater for the electricity deficit and the power distribution companies to use modern distribution methods to help reduce the power outages.

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LIST OF ABBREVIATIONS

AC:	Alternating Current
AMORE:	Alliance for Mindano Off-grid Renewable Energy
CISCO:	Computer Information System Company
CLS:	Complete Laboratory Solutions
DC:	Direct Current
DGS:	Distributed Generation Systems
EPA:	Environmental Protection Agency
EST:	Energy Saving Trust
GSR:	Global Status Report
ICT:	Information and Communication Technology
IDRC:	International Development Research Centre
IP:	Internet Protocol
IREC:	Interstate Renewable Energy Council
IT:	Information Technology
K.P.L.C:	Kenya Power and Lighting Company

KWh:	Kilo Watt-hour
MDGs:	Millennium Development Goals
MPD:	Micro Planning Directorate
MOEST:	Ministry of Education Science and Technology
MW:	Mega Watt
NTT:	Nippon Telegraph and Telephone
PC:	Personal Computer
PV:	Photovoltaic
SD:	Standard Deviation
SREP:	Scaling Renewable Energy Program
TANESCO:	Tanzania Electricity Supply Company
UNDP:	United Nations Development Programme
UNESCO:	United Nations Educational, Scientific, and Cultural Organization
USAID:	United States Agency for International Development
USDA:	US Department of Agriculture
WFS:	Wind Flower Society

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CHAPTER ONE

INTRODUCTION

1.0 Background to the Study

The ever increasing advancement in technology has greatly enhanced the integration of ICT in the teaching and learning in secondary schools. Over the past two decades, government's ICT policies have rested on claims that ICT can change the nature and raise the quality of teaching and learning (Reynold et al, 2003). The internet, the current effective communication method mainly relies on the use of ICT equipment. This is in agreement with Ajegbomogun (2007) who emphasizes that the internet has become an effective communication method of our time.

There is every reason for schools to integrate ICT into the classroom since it is beneficial to the teaching and learning of students (Mwangi, 2011). According to the Kenya Ministry of Education, provision of the necessary infrastructure as well as e-learning materials is an urgent need which should go hand in hand with adequate training of teachers in the use of ICT (Lime, 2011).

Educational institutions acknowledge that they must move in pace with the technology driven changes in the society. In today's knowledge society, the schools must equip learners with the critical and analytic tools necessary to live and flourish in an information-saturated environment (Victoria, 2002). Although the use of ICT boosts teaching and learning, many schools in remote areas have not utilized it. Organizations in Africa have been concerned with the problem of poor implementation of ICT in schools (Yusufu, 2007). In Kenya, ICT has penetrated many sectors including banking, transportation, communications, and medical services, but it seems to lag behind in the educational system (Mungai, 2012). In a paper investigating the outstanding challenges facing primary schools' computerization in rural Kenya, Ogembo et al. (2012) reported that the use of ICT in teaching and learning is low in Kenya.

The use of traditional ways of teaching coupled with lack of ICT infrastructure make the integration of ICT in teaching and learning difficult. For instance, the Association of African Universities (2000) examined the major obstacles affecting the use of ICT in African universities and categorized them as being technical, non-technical, human, organizational and financial (Yusufu, 2007). According to Hennessy (2009), a number of physical, cultural, socioeconomic and pedagogical factors hinder the use of ICT by teachers and students in sub-Saharan Africa. These factors include low living standards, lack of electricity and frequent power outages, inadequate ways of using ICT to optimize the impact on teaching and learning, lack of technical support, bad policies imposed on the usage of the computer laboratories, poor technology infrastructure, overcrowded computer labs, low bandwidth, high costs of (mainly satellite) internet connectivity, software licenses, insufficient and inappropriate software, and poor equipment maintenance.

In Rongo District of Kenya, the use of ICT in teaching and learning is affected by the lack of electricity (Ombese, 2011). In his assessment of the challenges facing computer education in Nandi County of Kenya, Mungai (2012) found out that the obstacle to the use of ICT in teaching and learning in many schools was lack of electricity connection in the schools.

The availability of electricity is a key factor in the successful use of ICT in teaching and learning but it is a scarce resource in remote areas in Kenya. In rural schools, electricity is required to enable teachers to integrate ICT in the teaching and learning (Vaccaro, et al, 2010). According to Wangombe and Ikara (2009), there is a challenge in accessing electricity in Kenya. During the signing of the Ngong Hills Wind Turbine Electricity Generation Project phase 1, Githae, the Kenya Government Finance Minister, testified that there is scarcity of electricity in Kenya (Anyanzwa, 2012). Electricity access in Kenya is low despite the government's ambitious target to increase electricity connectivity from the current 15% to at least 65% by the year 2022 (EnergyPedia, 2012).

A study by Boit et al. (2012) on the implementation of ICT to support learning, teaching, school administration and use of E-communication between cooperating rural secondary schools in Western Kenya revealed that many schools in Nandi County were not supplied with electricity from the National Grid. Another study by Ogembo et al. (2012) on information systems in developing countries showed that only a few schools had electricity in Nandi County.

Many schools in Nandi County do not use computers to facilitate the teaching and learning because they are not supplied with electricity from the Kenya Power Company. Hennessy (2009) reported that lack of electricity is one of the main factors hindering the use of ICT in schools. Kenya, like other third world countries, has not done much to generate electricity from renewable sources of energy. Despite the fact that the developed world has advanced so much in the utilization of renewable energy sources, Kenya has not done much to benefit from the cheapest sources of power (Munguti, 2009).

Kenya does not only suffer from the scarcity of electricity, but it also experiences power outages. In his assessment of the provision of information to users at the United Nations Environmental Programme Headquarters, Nairobi, Macharia (2010) revealed that electricity interruption was a constraint to the use of ICT in Kenya. In support of Macharia, Hennessy et al. (2010) confirmed that Kenya experiences frequent power outages. He argued further that breakdown of ICT equipment due to multiple power outages in Kenya has increased the cost of owning ICT infrastructure and made it almost difficult for schools in the rural areas to integrate ICT in teaching and learning. The efforts to arrest the power outages by use of standby generators are thwarted by the ever increasing prices of fuel (Karambu, 2011)

Every nation is on its toes in the harnessing of its resources to ensure that it has enough energy to sustain its development projects. This is as a result of the recognition that without energy, most development objectives including the Millennium Development Goals (MDGs) cannot be achieved. Energy issues have moved higher in the development agenda of policy-makers (Yumkella, 2007). The developed world has utilized its resources to generate electricity, but the third world countries with unexploited energy resources continue experiencing the scarcity of electricity. The developed world has extensive electricity grid supplying power to nearly 100% of the population, but in the developing world, many rural areas have unreliable grids forcing its residents to use expensive diesel generated electricity (Zervos and Teske, 2009).

Many nations and organizations have put large sums of money on research and development of renewable energy sources. Globally, many governments and industries are chalking out strategies to acquire renewable energy technologies to reduce global warming (Baburajan, 2011). The use of renewable energy sources can help reduce the climate-change impacts associated with the electricity industry (Watt and Outhred, 2011). For instance, European electricity consumption is projected to increase at an average annual rate of 1.4% up to 2030 and the share of renewable energy in Europe's electricity generation will double; from 13% now to 26% in 2030 (Potocnic, 2006).

In regions which receive abundance of sunshine, solar power generated electricity can be used to power ICT equipment. U Win Khaing, a managing director of Myanmar Solar Energy System, a subsidiary of United Engineering foresaw the use of alternative sources of energy as a great potential in the generation of electricity in the United States (Naing, and Times, 2003). Lynn (2010) in his study of generation of electricity from sunlight indicates that people living in tropical countries will increasingly live in solar homes and power school ICT equipment from large PV power plants. By generating electricity from solar power, the problem of scarcity of electricity can be alleviated. Energy efficient ICT equipment paired with appropriate solar panels, PCs can be introduced in areas where there is lack of or limited supply of electricity (Mash et al., 2011).

The developed countries have made a substantial use of solar power. For instance, in the fiscal year 2010, Netherland installed solar power systems that generate a total of 530 KW of electricity (NTT, 2010). This shows that Kenya, a country that enjoys abundance of sunshine than Netherland has a higher potential of utilizing solar power to generate electricity to power ICT equipment in schools. Schools around the country are being offered the opportunity to partner with governmental agencies, community foundations, utilities, business, and corporations to install PV systems (IREC, 2007).

Kenya is situated at the equator enabling it to enjoy high sunshine intensity for long hours. This puts it at the advantage of utilizing the available solar energy to generate electricity that can solve problems related to energy crisis. Solar energy is a great potential source of energy in regions where sunshine is available for longer hours per day and in great intensity (Singh, 2008). The Solar Electric Power Association states that bringing solar to schools is an important step to increasing the use of solar energy in the community (IREC, 2007). U Win Khaing cited in Naing and Times (2003), said that solar power could help raise socio-economic standards for people living in remote areas, where it is difficult and costly to install overhead power lines. A modern laptop or ipad can provide a rich experience with consuming 90% less power of a typical desktop system of just a few years ago (Mash et al., 2011).

Mobile networks are making greater use of renewable solar and wind energy sources (Green Touch, 2012). Singh (2008), while assessing the viability of using various alternative sources of energy, found out that solar is the most secure of all sources of energy, since it is abundantly available. Theoretically, if a small fraction of the total incident solar energy is captured effectively, it can meet electrical power requirements.

The sun provides an immerse source of energy that is not fully utilized. The largest renewable energy source is direct from the sun, with the total energy reaching the surface of the Earth in a day being equivalent to about 30 years of current global commercial energy use (Dodds and Venables, 2010).

In order to cut down the cost of electricity, the government of Kenya has put policies which will force the owners of big estates to utilize solar energy to generate electricity. In a bid to cut down high energy costs and supplement the Kenya national electricity grid, all premises with hot water requirements of capacity exceeding 100 liters per day will be required to install solar water heating equipment along with solar power panels (Olingo, 2011). According to Muthika (2011), the government, through the Energy Regulatory Commission, has also passed a legislation requiring all developers to install solar powered water heating and electricity generating systems by 2014.

The use of solar energy to generate electricity in schools located in remote areas is a viable project. Solar power is already in widespread use in some remote locations where access to other power sources is limited (Madson, 2011). According to Beumann et al (2009), the installation of solar power in schools is an important step towards facilitating the use of ICT equipment in the teaching and learning. In total, the renewable sources of energy have the technical potential to meet a greatly increased global demand for energy with significantly reduced environmental impact, particularly atmospheric pollution (Dodds and Venables, 2010).

In rural areas that have not been connected to the National Power Grid, wind powered generators and solar power modules are essential infrastructures that will help in the generation of electricity to power ICT equipment in the schools. Studies by KenGen show that wind speeds at Marsabit and Ngong Hills are good enough for wind power electricity generation (Karambu, 2012). Kenya has good wind regimes, but the exploitation of wind energy currently stands at 0.3 GWH or 0.01 percent (Anyanzwa, 2012). This shows that Kenya has good wind regimes that can be utilized to generate electricity. A good wind regime lies between 5meters per second to 10 meters per second (Abramowski and Posorski, 2000). The figures 1.1 to 1.3 shows wind speeds for Ngong, Knangop and Turkana sites in Kenya for the duration of October 2011 to March 2012. (Barasa, 2010).

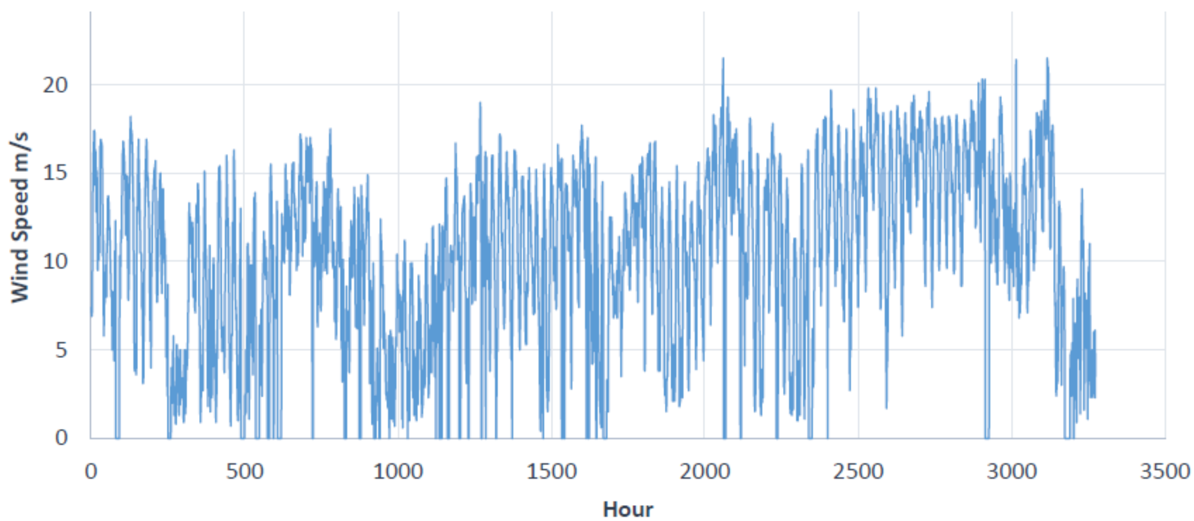


Figure 1.1 Wind speeds from Ngong from October 2011 to March 2012

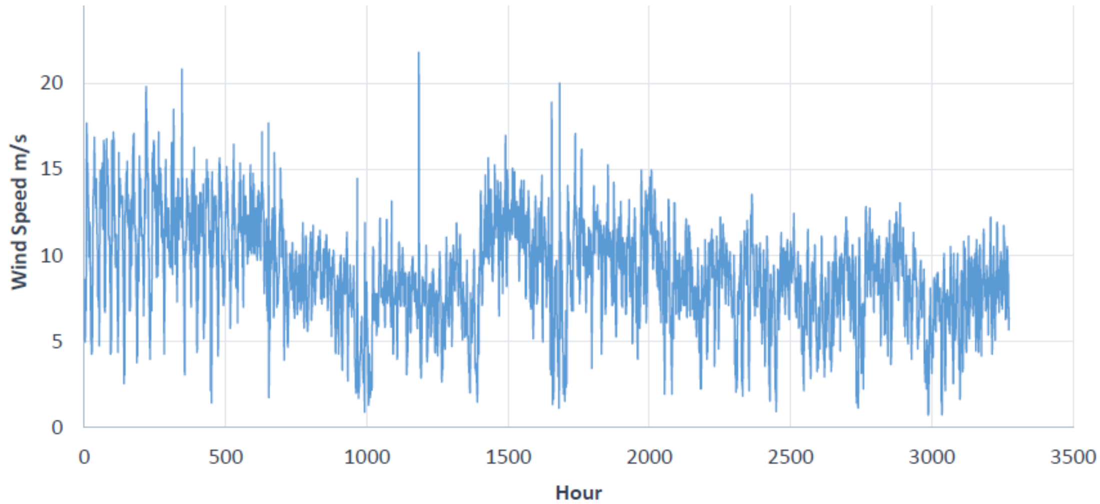


Figure 1.2 Wind speeds from Kinangop from October 2011 to March 2012

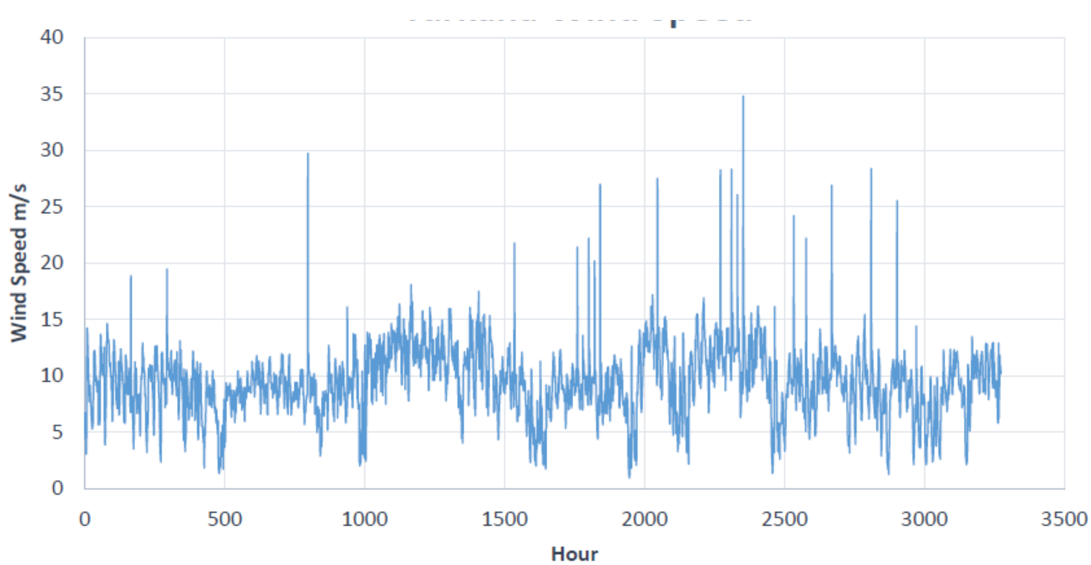


Figure 1.3 Wind speeds from Turkana from October 2011 to March 2012

The above graphs show that the general wind pattern in the three sites is predominantly random, Ngong depict more zero with no spikes, Kinangop depicts fewer spikes with no zeros and Turkana depicts more spikes but no zeros. Nandi County has a number of physical features which share characteristics like those of Turkana County. Also many schools in Nandi County are built on higher altitudes which receive good wind regimes.

The generation of electricity from wind power and solar power face some challenges. The wind generated electricity may be intermittent due to variations in wind speed and solar power may be affected by bad weather. A study conducted by Lal and Raturi (2012) which investigated the feasibility of a wind/solar photovoltaic/diesel generator-based hybrid power system in a remote location in Fiji islands revealed that one of the major challenges in using renewable energy sources for electricity generation is their intermittent and weather dependent nature. These challenges have been arrested by the use of modern technologies. Wind power generation intermittency is subdued by use of Plug-in Hybrid Electric Vehicles (PHEVs which are able to compensate the wind intermittency through utilizing V2G capability (Ehsan et al., 2013).

The political systems and governments in many counties that do not give a humble room for sustainable development projects is a great barrier to the use of ICT infrastructure in schools. There is a trend among the politicians of sabotaging or opposing the new technologies initiated or suggested by their opponents as a means of strengthening their political grip (Leo van der and Lars, 2010).

Kenya also lacks technicians in the ICT installation related fields, a factor that has adversely affected the implementation of ICT in schools. Ajegbomogun (2009) reported that lack of technical skills is a major drawback to the setting up of ICT laboratories. Yusufu (2009) supports Ajegbomogun by noting that poor technologies are a barrier to the implementation of ICT in schools. Many young people in Kenya do not pursue technical courses because they regard them as being involving and the job market is less assured. This is testified by Daamani (2008) who says that despite the various interventions to ensure that technical institute graduates are well equipped with the requisite practical skills for the job market and the campaign about the benefits of technical and vocational education, it has not attracted the youth in the region to move into technical and vocational training at all because most technical graduates have not been able to enter into employment in their respective fields of training. Many of them prefer to do business and managerial courses which do not offer technical skills. This has contributed greatly to the scarcity of technical staff needed to support the integration of ICT in teaching and learning in schools. There is a great disparity between male and female enrollment in engineering courses. According to MOEST (2004) many female students (52.4 percent) are enrolled in business studies compared to less than 5 percent registered in engineering courses (MOEST, 2004).

Attitude towards the use of alternative sources of energy is also a barrier to the use of ICT equipment in schools. A negative attitude towards the use of alternative sources of energy to power ICT equipment is a drawback to the implementation of the use of ICT in schools in the developing countries (Ajegbomogun, 2007). According to Snow (2011), ignorance on the use of renewable sources of energy is also a barrier to implementation of ICT equipment in the schools.

1.2 Statement of the Problem

The use of ICT is a key factor in the teaching and learning in schools today, but it has not been realized in many local schools. According to Parliamentary office of science and technology (2006), the benefits of ICT have not been fully realized in Kenya. In Kenya, ICT integration in education is considerably new, small scale and experimental in nature

(MOEST, 2005). The lack of reliable and affordable electricity is one of the greatest barriers to the adoption of information and communication technologies across Africa (Vota, 2012). In Kenya, the integration of ICT in teaching and learning in secondary schools is hindered by shortage of electricity (Hennessy, et al., 2010). The current electricity supply / demand balance in Kenya is tight, with an installed electricity generation capacity of around 1,650 MW under average hydrological conditions. Almost three quarters of KENGEN's electricity output is currently hydropower, with 14% of electricity generated by geothermal plants (Reegle, 2014).

A large fraction of the population in poor countries is unable to access modern energy services at all, while the remaining fraction that access it often pay high electricity bills (McDame et al., 2005). This revelation shows that there is a need to investigate the energy related factors that affect the use of ICT equipment in schools in Kenya. According to Chigona et al (2010), further research is needed to gain a deeper understanding of the challenges and steps that may be used to address the use of ICT in schools. This situation has prompted the researcher to investigate the power challenges facing the use of ICT in secondary schools in Nandi County of Kenya.

1.3 Purpose

The purpose of this study was to assess the challenges of accessing electricity for ICT use in Kenyan secondary schools using a cross-sectional survey design with view of improving the integration of ICT in teaching and learning. The challenges are characterized by shortage of electricity, cost of electricity, power outages and lack of use of alternative sources of energy to generate electricity for ICT use.

1.4 Objectives

This study focused on the following objectives:

1. To determine the alternative sources of energy used to power ICT in Nandi County schools.
2. To investigate the challenges facing the use of alternative sources of energy in schools in Nandi County.
3. To find out the school principals' opinions on the acquisition of alternative sources of energy for use in local secondary schools in Nandi County.
4. To find out whether solar energy is used to power ICT equipment in Nandi County secondary schools.
5. To explore the cons and pros of using solar energy to power ICT in Nandi County secondary schools.

1.4 Research Questions

This study addressed the following research questions:

1. What are the alternative sources of energy that are used to power ICT in Nandi County schools?
2. What are the challenges facing the use of alternative sources of energy in schools in Nandi County?
3. What are the school principals' opinions on the acquisition of alternative sources of energy for use in Nandi County local secondary schools?
4. Is solar energy used to power ICT equipment in Nandi County secondary schools?

5. What are the cons and pros of using solar energy to power ICT in Nandi County secondary schools?

1.5 Justification of the Study

In Kenya, many studies pertaining to the variables affecting the use of ICT in teaching and learning in secondary schools have been done. Apart from the work of Lime (2011) who assessed the hindrance of using ICT in schools in rural areas and the Sessional paper No.1 of 2005 (MOEST, 2006), the subject of challenges of accessing electricity for ICT use in secondary schools is one that is largely unexplored especially in Nandi County.

1.6 Significance of the Study

This study will bring awareness in the use of alternative sources of energy for ICT use in Kenyan secondary schools. This study is useful in many ways. First, the study will advance knowledge in campaign for the use of alternative sources of energy in Nandi County secondary schools. Second, it will contribute to the solution of challenges of electricity for ICT use in Kenyan Secondary schools. Third, it will demonstrate an alternative use of source of electricity to power ICT equipment in secondary schools. In addition to all these uses, the findings of this study will assist:

1. Curriculum developers and schools policy makers to make adequate arrangements to enhance the use of ICT in the teaching and learning in Nandi County.
2. To change school administrators' attitude towards the use of alternative sources of energy to power ICT equipment in schools.

3. Contribute towards generating information which will be used by school policy-makers to foster domestication of the ICT technology into schools in the disadvantaged areas.

1.7 Research Assumptions

This study was based on the following assumptions:

1. All respondents were honest in providing the solicited information.
2. All the respondents who participated in the study shared similar experiences.

1.8 Scope of the Study

This study on electric power challenges facing the use of ICT equipment in local secondary schools in Nandi County was conducted between April 2010 and July 2012 by use of a survey research design of a constructed cohort of principals of the sampled local secondary schools in Nandi County. The study was conducted in one hundred and ten (110) local secondary schools that were supplied and those that were not supplied with electricity by the Kenya Power Company in Nandi County. The data was collected by the researcher using questionnaires and interviews. This study specifically sought to determine the availability of alternative sources of energy in schools, investigate the factors affecting the use of the alternative sources of energy in the powering of ICT equipment in schools, find out whether the schools used solar power to power ICT equipment and assess the schools principals' attitudes towards the use of alternative sources of energy in local secondary schools.

1.9 Limitations and Delimitations of the Study

The study was limited to the information that was availed by the respondents, available financial resources and amount of time specified for the study. By means of stratified and purposive sampling techniques, one hundred and ten (110) principals who participated in this study were selected from secondary schools that were supplied and those that were not supplied with electricity from the KPLC.

1.10 Theoretical Framework

The theoretical framework adopted in this study was the Power Quality Theory derived from Berry, W. Kennedy in 2000. This theory first emerged as a system of assessing the quality of power to solve power quality problems (Kennedy, 2000). The theory states that the quality of power is influenced by power system events, nonlinear loads, power wiring and grounding. The term 'power quality' refers to purity of the voltage and current waveform and power quality disturbance is a deviation from the pure sinusoidal form(Bayless and Hardy, 2007). Sankaran (2002) defines power quality as "a set of electrical boundaries that allows equipment to function in its intended manner without significant loss of performance or life expectancy. He further says that when the quality of electrical power supplied to equipment is deficient the equipment's performance degrades. The subject power quality covers all aspects of power systems engineering, from transmission and distribution level analysis to end-user problems (Fuchs and Masoum, 2008).

The power quality is a field that has attracted special interest recently due to the continuous industrial growth, the rise of electric power demands, and the proliferation of "polluting" electrical loads. Cardenas and Gonzales (2008) reported that power quality is a topic in the area of engineering that emerged in the 1970 with the aim of providing a clean sinusoidal, stable, reliable, regulated, and uninterrupted supply voltage to electrical systems. Khalid and Dwivwdi (2011) concur with Cardenas and Gonzales that electric power quality is gaining importance because a small power outage has a great economic impact on the power consumers; a longer power interruption harms practically all operations of a modern society; new electrical equipment are more sensitive to power quality variations; and the advent of variable speed drives and switched mode power supplies has brought new disturbances into the supply system. Recently, the increasing number of nonlinear loads and power electronic devices for utility and customers are becoming sources of degradation of electric power quality via the generation of disturbances, e.g., impulsive transients, transient oscillations, interruptions, sag, harmonic distortion, interharmonics, etc (Shin et al, 2006).

Afonso et al. (2003) used the power quality theory to as a tool to control active power filters and analyze three-phase power systems in order to detect problems related to harmonics, reactive power and unbalance. In his study of power quality improvement using active power filters, Kiran (2014) used the power quality theory to analyze a hybrid power filter which he used to monitor the load current constantly and continuously and adapted a power system to adapt to the changes in load harmonics. Also Kim (2000) used power quality theory to assess generalized power quality improvements such as reactive power compensation, harmonic elimination and unbalance compensation.

This framework was used to help conceptualize the generation, transmission and distribution of electricity as key factors affecting the use of ICT in Nandi County secondary schools. It clarifies different aspects that affect the availability of quality of electricity. More so, it attempts to identify the key components that can be improved to ensure that there is enough and quality electricity to be used to power ICT equipment.

The framework is useful in the identification of factors affecting the quality of electricity generated from various alternative sources of energy. This framework can be modified to suit the different contexts such as power systems. It also brings out a clear picture of causes of electric power challenges facing the use of ICT in schools.

The framework further indicates that power system events such as the increasing number of nonlinear loads and power electronic devices for utility and customers are cause of electric power quality deterioration because they generate disturbances, e.g., impulsive transients, transient oscillations, interruptions, sag, harmonic distortion, and interharmonics (Shin et al, 2006). Power quality indices include; Total harmonic distortion (THD), power factor (PF), C message factor, IT product, VT product, K factor, Crest factor and flicker factor (Heydt, 2000). This is important to this study as it shows how shortfalls in power generation, transmission, and distribution make it difficult to the use of electricity to power ICT equipment in the schools. The framework is important in regard to power supplies whereby the systems power generation, the used of nonlinear loads and the power wiring systems affects the quality of power that is used to power ICT equipment in schools. Bayless and Hardy (2007) say that power quality problems result from unpredictable events, the electric utility, the customer and manufacturer. The continue to say that more than 60% of power quality problems are generated by natural an unpredictable events such as faults, lightening surge propagation, resonance, ferrosonance and geomagnetically induced currents. They add on that the three main sources of poor power quality related to utilities include the point of supply generation, transmission system and distribution systems. Furchs and Masoum (2008) indicate that the power quality problems originating at generation plants are mainly due to maintenance activity, scheduling, events leading to forced outages and transferring from one substation to another. They continue to say that power problems originating in transmission are galloping (under high-wind conditions resulting in supply interruption and or random voltage dips (due to faults), interruption due to planned outages by utility, transient over-voltages (generated by capacitor and / or inductor switching, and lightening), transformer energizing (resulting in inrush currents that are rich in harmonic components), improper operation of voltage regulation devices (which can lead to long durations voltage variations). They add on that distribution system power quality problems are voltage dips, spikes, interruptions, transient voltage variation, power line carrier signals, BPL and EMFs. They further report that the customer and manufacturer related problems are harmonics (generated by nonlinear loads such as power electric devices and equipment, renewable energy sources, FACTS devices, adjustable speed drives, uninterruptible power supplies, fax machines, laser printers, computers, and fluorescent lights), poor power factor (due to highly inductive loads such as induction motors and air conditioning units) flicker (generated by arc furnaces), transients (mostly generated inside a device to device switching, electrostatic discharge, and arcing) improper grounding (causing most reported customer problems), frequency variations (when secondary and backup power sources, such as diesel engine and turbines generators are used), misapplication of technology, wiring regulations, and other relevant standards.

The framework uses a checklist to conceptualize how different electric power challenges affect the use of ICT equipment. The quality of power generated may be affected by harmonics due to poor power conversion methods. Power transients may be realized because of poor synchronization of generators or alternators (Thompson, 2010). Bad weather may reduce the amount of generated power which can quite affect the quality of power. The wiring cables used in the distribution of the generated power system may result to power losses due to resistance or power fault due to loose connections. Also lack of the proper power factor correction devices in the electrical network can lead to poor power factor. The accumulation of dust or dirty on the solar panel can greatly reduce the amount of power generated by the solar electricity generating system.

In this study, the Power Quality Theory is superior over the Fourier and instantaneous d-q theory because the Fourier theory is used to analyze harmonics but does not fit in the analysis of transients owing to the nonstationary property of its signals in both time and frequency domains (Oyedoja and Obiyemi, 2013) while the instantaneous d-q theory also is not able to give very clear analysis of the quality of power because it generates a disturbing component − based control algorithm (Czarnecki, L. S. (2008). The power quality theory enabled the researcher to break down the power quality problem into three parts: sources (initiating events), causes and effects of power problems (Ibid, 2000).

However, in adopting this theory, the researcher is aware of its wide range of applications, but this has been solved by the researcher in limiting the study to an assessment of challenges of accessing electricity for ICT in Nandi County.

1.11 Conceptual Framework

Figure 1.4 represents a research framework constructed from these preliminary studies. The framework specifies the area of research interest. It shows the challenges of accessing electricity for ICT use in secondary schools. The integration of ICT in teaching and learning in secondary schools is hindered by shortage of electricity, high cost of electricity, power outage, challenges of using standby generators, challenges of using solar power generated electricity and challenges of using wind power generated electricity.

The independent and intervening variables can therefore be addressed in the implementation of the use of ICT in the schools.

The conceptual framework has the independent variables, intervening variables and a dependent variable. The independent variables include the shortage of electricity, cost of electricity, power outages, challenges of using solar power generated electricity, challenges of using wind power generated electricity, and challenges of using standby generators. The intervening variables are use of solar and use of wind generated electricity. The dependent variable is the use of ICT. The idea in this study is that, there are challenges of accessing electricity for ICT use in Kenyan secondary schools. These challenges include lack of electricity, power outages, high electricity bills, and the high cost of using standby generators. These factors help demonstrate how the use of ICT is weighed down. The use of solar and wind generated electricity are the options of lessening these challenges affecting the use of ICT in Nandi County Secondary schools.

The effectiveness of using ICT in teaching and learning in secondary schools depends upon the availability of electricity, low cost of electricity, use of solar and wind power to generate electricity and elimination of power outages. The use of wind power and solar power to generate electricity will reduce the shortage and cost of electricity. Availability of enough electricity in schools will facilitate the integration of ICT in teaching and learning. The elimination of power outages will protect the ICT equipment from being damaged and this will also help in the integration of ICT in teaching and learning. The success of integrating ICT in teaching in secondary schools is perceived to be achieved by making use of solar and wind power generated electricity.

It is important that the policies appertaining to overcoming these challenges are put in place to facilitate the use of ICT in secondary schools. The following theoretical framework gives a vivid picture of the conceptual framework of this study.

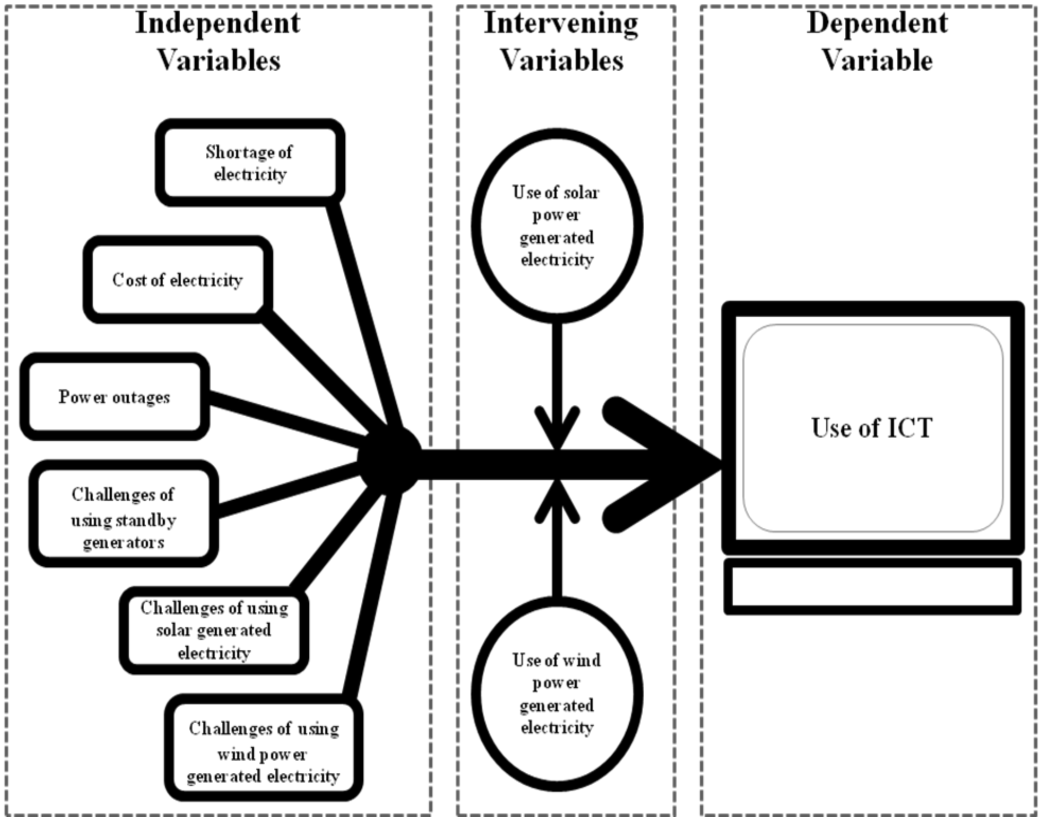


Figure 1. 4 Electric Power Challenges and the Use of ICT (Source : Author, 2013)

1.12 Definition of Terms

1. **ICT:** this acronym stands for Information and Communication Technologies and is defined for the purpose of this study as a "diverse set of technological tools and resources used to communicate, and to create, disseminate, store, and manage information." These technologies include computers, the Internet, broadcasting technologies (radio and television), and telephone.
2. **Alternative Sources of Energy:** this refers to solar power, standby generator, and wind power.

3. **Small-Scale Power Systems:** this refers to standalone power systems such as standby generators, solar PV systems and small wind systems.
4. **Insolation:** this is the rate at which solar energy is received over a period of time; it is measured by the number of peak sun hours (PSH) per day: i.e. Wind energy α (wind speed)^3 x (Radius of turbine)^2 x time.
5. **Socio-technical factors:** these are factors that affect the peoples' relationship with themselves and the established or establishment of school ICT systems.
6. **Equipment**: this refers to an integrated system of facilities used to provide one or more ICT services.
7. **Principal:** the head teacher of a secondary school as an official administrator.
8. **Outages:** a cessation of the normal operation of one or more items of power system equipment due to a fault or scheduled maintenance that can lead to an interruption of electricity supply (a blackout).
9. **Renewable energy:** energy sources derived directly or indirectly from the energy of the sun, the Earth's core, or from lunar and solar gravitational forces, and which are therefore renewable over time. These include solar, wind, biomass, tidal, wave, hydro, and geothermal energy.
10. **Greenhouse gas emissions:** emissions of gases that collect in the atmosphere and contribute to the Earth's "greenhouse" effect. Increasing concentrations of gases, such as carbon dioxide, methane, and nitrous oxide are currently producing an enhanced greenhouse effect, because they are accumulating at a rate faster than they can be dispersed. The combustion of fossil fuels is thought to be a major

cause of this enhanced effect, which in turn is expected to contribute to higher average global temperatures over the next century.

11. **Power:** this refers to electricity supplied to a system.
12. **Inverter**: this refers to a device that takes a Direct Current (DC) input and produces a sinusoidal Alternating Current (AC) output.
13. **Standalone generator**: refers to a drive-prime backup system consisting of a permanent installed fuel driven engine that takes over the generation of electricity in case of power failure.
14. **Standby generator**: refers to a generator that is installed in a remote area (where there is no grid electricity) to generate electricity to power electric systems in that location.

1.13 Summary

In today's knowledge society, schools must equip learners with the critical and analytical tools necessary to live and flourish in information saturated environment. The ever advancing technology has greatly improved the integration of ICT in the teaching and learning in secondary schools. The internet, the current effective communication method majorly relies on the use of ICT equipment. The developed world has extensive electricity grid supplying electricity to nearly all the population as compared to the developing world, where many rural areas have unreliable grids. The availability of electricity is a key factor in the successful use of ICT in teaching and learning, but it is scarce in remote areas. Although the use of ICT boosts teaching and learning, many schools in remote areas have not utilized it. A number of physical, cultural, social and pedagogical factors hinder the use of ICT to optimize the teaching and learning. The use of ICT in teaching and learning is affected by the scarcity of electricity, frequent power outages, high electricity bills and lack of use of other alternative sources of energy. Many secondary schools do not use computers to facilitate the teaching and learning because they are not supplied with electricity. Attitude towards the use of alternative sources of energy is also a barrier to the use of ICT equipment in schools. In regions which receive abundance of sunshine, solar power generated electricity can be used to power ICT equipment. Energy efficient ICT equipment paired up by appropriate solar panels and PCs can be introduced in area where there is lack of or limited supply of electricity. The quality of power is influenced by power system events, nonlinear loads, power wiring and grounding.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This chapter discusses the literature related to the challenges of accessing electricity for ICT use in schools. The literature reviewed includes the use of ICT in Kenya secondary schools, the availability of electricity, the cost of electricity, power outages, solar power, wind power and use of standby generators.

2.1 The Use of ICT

ICT is increasingly used and viewed as central in teaching and learning in schools (Makewa 2013). In the developed world teachers and learners are no longer solely dependent on physical media such as printed textbooks which are often times outdated, they live in a world that has seen an ICT explosion (InvenoDev, 2010). In India, various ICTs which include radio, satellite based, interactive television and the Internet have been employed over the years to promote primary and secondary education (Inveno, 2010). A survey by UNESCO (2013) on ICT in education in five Arab states (Egypt, Jordan, Oman, Palestine and Qartar) revealed that national network upgrades, teledensity improvements, enhanced national connectivity, and the gradual introduction of new Internet Provider (IP) delivery technologies have created a favorable environment for the integration of ICT in teaching and learning in schools. This findings show that developed nations have achieved a greater use of ICT in teaching and learning.

However, an assessment of ICT in Secondary school education by InveneoDev (2010) revealed that there have been enormous geographic and demographic disparities in the use of ICT in teaching and learning.

Although ICT has contributed greatly to advancement of education in schools worldwide, Kenyan schools teachers rarely integrates ICT in teaching and learning (Mingaine 2013). According to MOEST (2005), the integration of ICT in education is considerably new, small scale and experimental in nature. After several years of effort, Kenya promulgated a National ICT Policy in January 2006 that aims to "improve the livelihoods of Kenyans by ensuring the availability of accessible, efficient, reliable and affordable ICT services (Farrell, 2009). Eight years now, Kenya still seems to have not made many strides in the use of ICT in secondary schools. In an e-learning survey conducted in 2011, Lime (2011) reveals that Kenya has not integrated ICT in teaching and learning in schools located in rural areas. Like many counties in Kenya, the integration of ICT in the teaching and learning in schools has not been realized in Nandi County (Menjo & Boit, 2005). In his speech in "Educa" eLearning conference in Berlin, Germany, Siele (2006) indicated that Kenya lags behind many countries in ICT technology. In a study entitled "Use of ICT in Enhancing Teaching and Curriculum Delivery in Marginalised Secondary Schools in Kenya", Williams (2009) reported that the use of ICT in marginalized schools was limited and outdated. In a study undertaken to evaluate the implementation of ICT to support learning, teaching, school administration and use of E-communication between cooperating rural secondary schools in Western Kenya (Boit et al.,2012), it is revealed that the application of ICT to support instruction and learning was very limited. Ombese (2011) conducted a study assessing the variables associated with the principals' performances in implementations of computer studies in Rongo District of Kenya and found out that many secondary schools had not implemented computer studies because they lacked electricity. According to Mwangi (2011), technology is revolutionizing the way people communicate and conduct business, yet it has been slow to penetrate our school curriculum. Galava (2009) while assessing the factors associated with integration of computer technology as an instruction resource in selected secondary schools in Uasin Gishu District (now Uasin Gishu County), found out that the integration of computer technology as an instruction resource was very inadequate. In his study of skill challenges in adoption and use of ICT in publics secondary schools in Kenya, MPND (2013) indicated that limited and unreliable supply of electricity, 125 (56.82%) was one of the challenges encountered in the use of ICT in secondary schools in Kenya.

2.2 Electricity

Availability of electricity, cost of electricity and power outages are the main factors that influences the use of ICT in secondary schools.

2.2.1 Availability of Electricity

Globally, there is a shortage of electricity. Atur and Kennedy (2000), indicate that forecast electricity production growth rates are lower than those for electricity consumption. According to the United Nations Development Programme (UNDP), at present, 2 billion people have no electricity at all, 1 billion people use electricity from uneconomic sources (dry cell batteries, kerosene) and 2.5 billion people in rural areas have little access to commercial energy services (Hubbert, 2003). Veccaro et al. (2010)

agree with Hubbert and adds on that almost 1.6 billion people in developing countries do not have access to electricity.

The shortage of electricity in Africa has made it difficult to implement the use of ICT in schools. According to Afrosocialmedia (2011), African rural communities don't usually have electricity and this has been the major drawback to implementation of ICT in local schools. The little electricity available is sparingly supplied. Energy has been supplied in insufficient quantity and quality that has limited its consumption by the majority of Africa's population, making the continent the lowest per capita consumer of modern energy of all regions of the world (Yumkella, 2007).

According to International Monetary Fund (2008) Sub-Saharan Africa has endemic electricity shortages to the extent that meeting the subcontinent's infrastructure is challenging. Energy Initiative Partnership Dialogue Facility reported that as many as 25 African countries are faced with power shortages (EUEI PDF, 2007). According to ICS (2011) most of African countries have inadequate electricity generation capacity and limited electrification.

The problem of power shortage has become a problem in the whole of East Africa with dire consequences being recorded mostly in Uganda, Kenya and Rwanda (Akanga, 2006). This power shortage is one of the barriers to the use of ICT equipment in many schools. Although the government of Kenya through Sessional Paper No. 4 of 2004, Energy Act of 2006 and the Feed-in-Tariff (FiT) policy indicates that it is committed to promoting electricity generation from renewable energy sources, not much has been done towards achieving a sustainable electricity supply (SREP, 2011). Power shortages are also a major problem and force many organisations to buy back-up generators (Bridges.org, 2003).

The lack of electricity has posed a great challenge to the integration of ICT in teaching and learning in many schools (Amedzo, 2007). Modi (2010) agree with Amedzo by saying that delivery of electricity for ICT use is challenging. Many regions in remote areas have no access to the grid and grid extension is expensive (Pandey and Acharya, 2004).

There is a serious shortage of electricity in Kenya (Chabari, 2009). According to MPD (2008), electric power supply in Kenya falls far below the demand. The national electricity grid is limited to commercially viable areas missing out most of the schools in the rural areas (Hennessy (2009). According to the K.P.L.C. (2006), the consumption of electricity has risen sharply to the extent that there is need to expand energy generation sources. It is estimated that seventy-five percent (75%) of the Kenyan households have no access to the national grid electricity due to high connectivity costs, expensive electricity bills and maintenance (Olingo, 2011). According to SREP (2011) the current electricity demand in Kenya is one million four hundred and twenty-nine megawatts (1,429 MW) while the effective installed capacity under normal hydrology is one million one hundred and ninety-one megawatts (1,191MW).

During the initiation of an ambitious Olkaria Geothermal Project that is intended to increase power generation by forty percent (40%) and cut down Kenya’s dependence on rivers to generate electricity, President Kibaki reported that Kenya does not have enough power reserves to cater for the ever increasing demand for electricity (Wachira and Kimani (2012).

Ken Gen Director, Eddy Njoroge, on his tour around Olkaria power plant in Naivasha, noted that generated hydropower in Kenya drops greatly due to drought which reduce the water levels at the major production dams (Gitonga, 2012). A recent spot check around the country established that there is an acute shortage of electricity in Kenya (Ombati, 2012). A report on the effect of lack of infrastructure on e-learning indicate that, schools in rural areas in Kenya lack electricity to power electrical gadgets needed for e-learning. A large part of the country is still not connected to electricity distribution services (Barbier, 2011). Ongwae (2012) while assessing the shortage of electricity in Kenya revealed that 1,326 secondary schools have not yet connected to electricity. Nandi County is one of the regions sparingly supplied with electricity. There is lack of electricity connection from the Mains power supply to some of the schools in Nandi County (Menjo & Boit, 2005). Cheison (2012) agrees with Menjo and Boit that many of the secondary schools in Nandi County are not supplied with electricity.

There is lack of electricity in many secondary schools in Nandi County. This makes it difficult for these schools to integrate ICT in teaching and learning. This shortage is due to lack of use of alternative sources of energy like solar power and wind power to generate electricity. Kenya also relies on hydropower electricity generating plants situated in the few rivers which are greatly affected by dry season.

Much research has been done on the use of ICT in secondary schools. Most of these researches touch on socioeconomic, psychological, cultural, intellectual, and literacy issues. No comprehensive research has been done on electric factors affecting the use of ICT in secondary schools. Therefore this study focuses on the challenges of accessing electricity for ICT use in Kenyan secondary schools: A case of Nandi County.

ICT is itself a learning resource and its use will boost the teaching and learning in secondary schools. Availability of reliable electricity is the key factor in the integration of ICT in teaching and learning in secondary schools. Therefore, shortage of electricity is a major drawback to the use of ICT in local secondary schools. Most of the schools in Kenya are not connected to the electrical power from the National Grid. This is because the demand for electricity outstrips its availability from the convectional sources and the little available is unreliable. Besides this, there is no generation of electricity from the renewable sources of energy.

2.2.2 The Cost of Electricity

The cost of electricity all over the world keeps on skyrocketing now and again (Frede et al., 2005). According to Hubbert (2003), electricity in the developing countries is costly in economic terms. A comparative study of electricity tariffs used in Africa by UPDEA (2009) reveals that the cost of electricity in Kenya is high (see Appendix VII). Due to ever increasing prices of the imported crude oil, the use of diesel to generate electricity has led to increase in the cost of electricity. Jirani (2009) indicates that generation of electricity by diesel generators by KenGen has increased the production cost of electricity. In support of Jiran, Muiri (2012) adds on that the cost of petroleum has gone up across the board leading to an increase of the cost of electricity. Fifty percent (50%) of electricity in Kenya is generated from rivers which the water levels drop drastically during the dry seasons. The reduction of water levels in dams, which account for nearly half of the country's electricity, forces power companies to partly use fossil fuels to cover for the deficit, which are more expensive (Wahome and Mwaniki, 2012). The transmission and distribution of power from the central generating station to the consumers requires significant investment (Borenstein, 2008). The government reforms on the tariff grid which allows the electricity distributor Kenya Power Company to directly pass on the variations of the cost of fuel and exchange rates to the consumers has led to unchecked in increasing of the cost of electricity (Barbier, 2011).

2.2.3 Power Outages

Many electricity consumers experience frequent power outages (Barbier, 2011). Power outages seriously interfere with the use of ICT equipment. Ajegbomogun (2007) indicated that erratic power supply is a constraint to the development of ICT in developing countries. Chigona et al. (2010) adds on that it is difficult for the regular running of ICT facilities in regions experiencing frequent power outages. The problem of power outages is very rampant. They are now becoming common in many parts of the United States (Heid, 2011). In Africa, the situation is worse. In 2007 alone, nearly two-third of the countries in sub-Saharan Africa experienced frequent and extended electricity outages (International Monetary Fund, 2008). The frequent power outages have made the consumers to cast doubts on the reliability of electricity supplying companies. For instance, the Kenya Power Company and Tanzania's Electricity Supply Company (TANESCO) are often derisively referred to as Paraffin Lanterns and Candles companies because of frequent power outages and low power episodes (Lyakurwa, 2007). Generally African countries have a shortage of electricity and experience power outage as shown in figure 1.5 and 1.6 (Eberhard et al., 2011). The utilization of the scarce electricity is also flawed by outages because of unreliable transmit and delivering technologies used (Cary, 2010). In many of the schools, the regularity of power service remains an issue because almost one third of the schools experience power outages at least once a month with the extreme cases being ten power outages in a month (Victoria, 2002).

Erratic electricity supply is a disrupting factor for eLearning in school (Bridges.org, 2003). It causes schools ICT equipment to fail. In a study conducted by Ndume et al. (2010) in Tanzania, 45% of respondents agreed that during the learning period, learners were so much affected by electric power cuts, 32% disagreed, while 23% were undecided.

Buyeyo University (2002) concurs with Brides.org by saying that unreliable electricity is a major challenge to the use of ICT. In an assessment of the reliability of using electricity from Kenya Power Company, Joseph (2011) revealed that Kenya experience a lot of power outages. Electricity supply from the National Grid to the consumer has been erratic in Kenya, leading to poor plant performance and damage of equipment (Wahome, 2010). Ombese (2011) reported that few schools that had implemented computers studies in Rongo District suffered from frequent power outages.

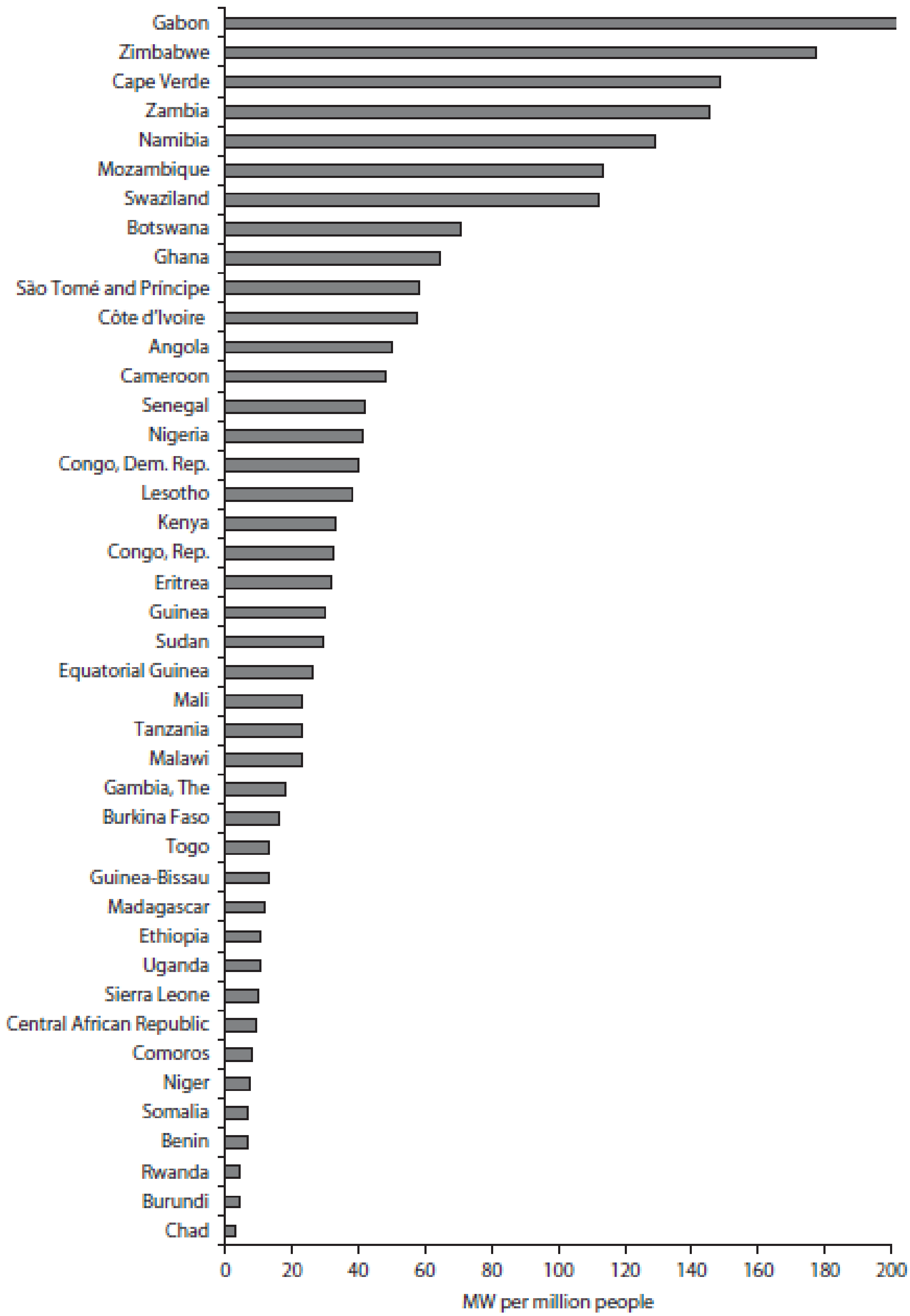


Figure 1.5 Power generation capacities in African Countries, 2011.

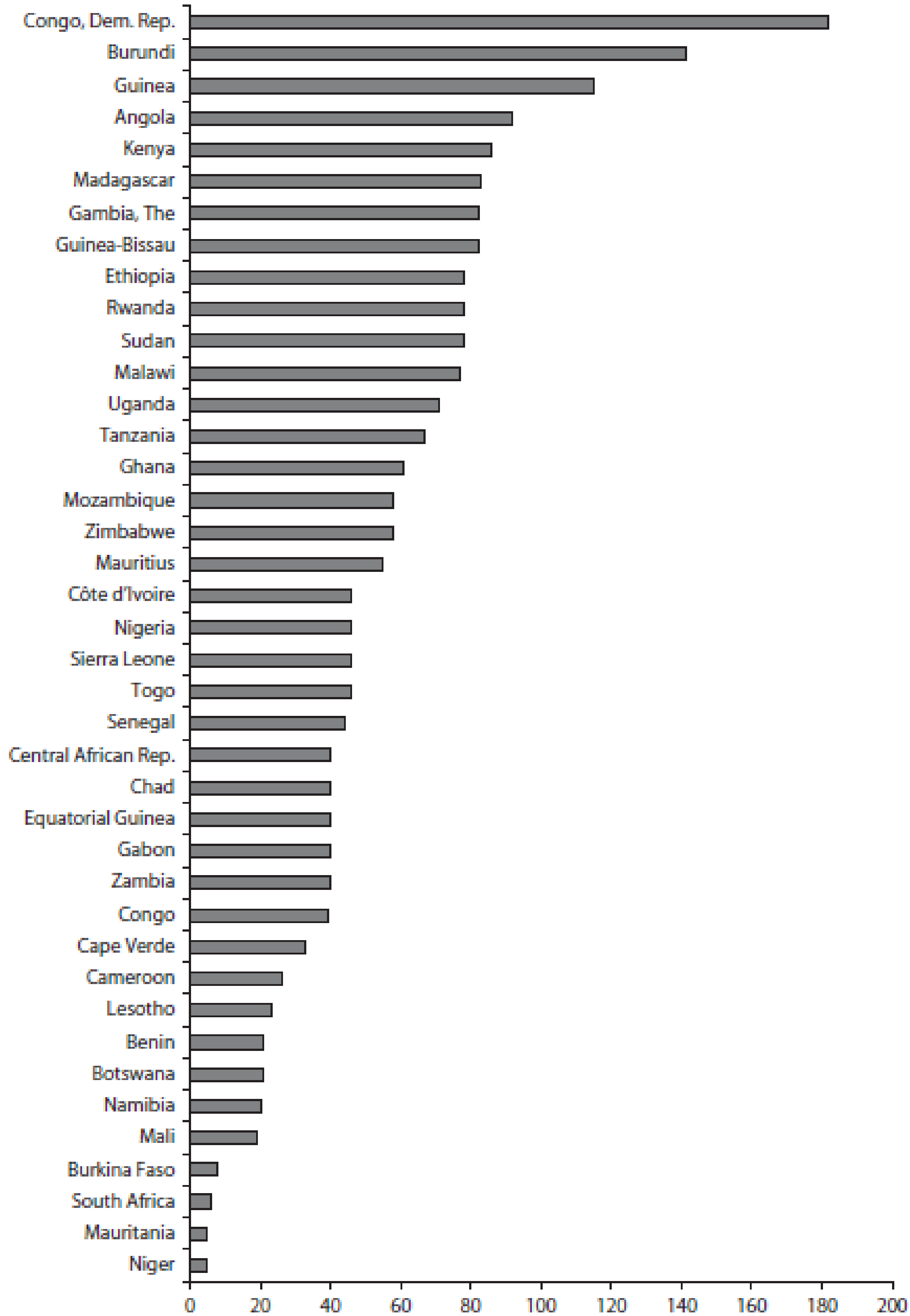


Figure 1.6 Power outages in African Countries, days per year 2007 – 2011

2.3 Renewable Energy

The use of renewable energy is a major way of reducing the shortage of electricity since it is achieved from the utilization of naturally sustained sources (Yumkella, 2007). A renewable energy source constantly renews its energy, and will therefore never run out (Casci et al., 2005). On-site renewable energy generation can produce significant energy, reduce local government costs, reduce environment pollution, and foster economic benefits for a local government and the community (U.S. EPA, 2008). In many circumstances, renewable energy sources such as solar and wind have an important role to play, alongside fossil fuels, in an energy portfolio that supports achievement of the MDGs (Flavin and Aeck, 2005).

Many countries and states in both developing and developed world have directed most of their resources towards the generation of electricity from renewable energy sources (Backburn and Cunninggham, 2010). Real estate developers are now resorting to renewable energy to capture the market, which is keen on saving and having eco-friendly homes (Olingo, 2011). The World Bank's solar initiative believes that the time has come for many renewable energy systems to be considered seriously in investment project, not only because of their economic or environmental objectives but also because of their economic and social merits (Foley, 1995). Since 2001, concern over energy prices and availability has intensified and focused governments local to world- wide on developing renewable energy sources (Liebrand and Ing, 2009).

The developed world has made several strides towards the utilization of renewable sources of energy to generate electricity. Fifty per cent of Australians say they would prefer to get their electricity from solar power, thirteen percent (13%) wind power, eight percent (8%) hydro power, six percent (6%) natural gas, five percent (5%) geothermal and two percent (2%) biofuels or biomass (Macintosh and Hamilton, 2007). Renewable energy sources such as solar energy and wind energy are not well-known and have not been exploited yet, but are considered potential sources to supplement hydro power generation and have been discussed (Akakpo, 2008). This indicates that countries near the Equator like Kenya can reap more benefits from the utilization of solar energy. According to Kaboutis and Hatziargyrious (2010), renewable energy forms have both advantages and disadvantages compared to non-renewable energy. Some of these advantages include the following:

1. The environmental impacts associated with renewable energy forms, including greenhouse gas emissions, are often less severe than for non-renewable energy forms.
2. Resource depletion is not an issue for renewable energy forms, if used within their sustainable yields.
3. There are many opportunities to develop new renewable energy products and systems that may prove to be commercially successful.

Some of the disadvantages include the following:

1. Time-varying renewable energy fluxes may not match desired patterns of end-use, for example artificial lighting substituting for a lack of solar energy.
2. Capital costs may be higher than for some non-renewable energy forms, although investment lead times are usually short and operating costs low.

2.3.1 Solar Power

The use of solar technology has been known to exist for many years. Technology for converting solar energy to electricity was first introduced over 130 years ago, and it has been used to power PCs for more than 20 years (Nordhausen, 2011). Since 1966 when the first solar power generator was designed, technological advancements have made it easier to make a small solar power generator for $250 to $300 (Solar Solutions & Systems, 2010). In a study conducted among the Aboriginal communities by McLaughlin et al. (2010), it was found that solar photovoltaic (PV) technology can provide communities with an opportunity to (i) weaken the cycle of poverty; (ii) directly counteract climate change by producing renewable energy; and (iii) become more self-sufficient. As technology advances, the use of solar power to generate electricity will greatly increase. According to Madson (2011), many experts believe that solar power may one day be a much more practical and widely used resource. Ezine (2009) indicates that solar energy is renewable, flexible, expandable, non-pollution, virtually an unlimited supply source of energy and is the best way to supply electricity to isolated places in the world where the cost associated with installing power distribution lines makes it impractical or impossible.

In a recent research, it was found that while solar panels can produce 50% of a home's electricity, the surplus of it is supplied to the main grid (Jenny, 2011). The improvement in Photovoltaic technology has greatly improved the reliability of the use of solar energy to generate electricity. Photovoltaic power offers a proven and reliable source of electrical power for remote, small-scale ICT facilities (USAID, 2004). Solar energy is quickly proving to be one of the better options across the country due to its availability and cost effectiveness (Olingo, 2011). The use of solar power is not only used in lighting homes but has also penetrated into the medical field. Currently, solar energy is being used to power medical electronic equipments in regions which experience frequent power outages. Systems that are charged by use of in built solar panels enable medics to address night time emergencies, have proper lighting for medical procedures, and use electric medical devices and laptop computers (Flavin and Aeck, 2005).

Increased use of solar energy for industrial and domestic use will promote use of environmentally friendly technologies which will help in water conservation and protection of water catchment areas (MPD, 2008). There is now a completely portable (and ultra-high efficient) solar power panel which produces up to 1800 Watts of household electricity on demand when you need it most (Heid, 2011). When the sun is shining, every square metre of area that is at right angles to the rays of the sun receives about 1000 W of solar power (Casci et al., 2005).

2.3.1.1 Use of Solar Power

The use of solar power in the schools can reduce the schools expenditure on electricity. According to IREC (2007), the installation of the PV system in schools can help to reduce the cost of energy. Schools in some regions of the world which have used Photovoltaic to generate electricity have ripped a substantial amount of benefit from (IREC, 2007).

Recent studies have shown that a number of schools have successfully used solar energy to power ICT equipment. For example, Haines City High School in Florida is currently celebrating a newly installed solar power system that powers its ICT equipments from a 10,000 watt solar electric system (Shields, 2013). The Hilston View Elementary school 80-foot collection of solar panels installation harness energy that provides a learning resource for students and teachers (Castle, 2013). Currently, solar power is supplying electricity to a rural school, Tenua High School, a semi government high school in Netrokana, Bangladesh (Mash et al., 2011). In Tanzania, extensive preparations have been made, such as the installation of solar power equipment to power the ICT equipment in some schools (Ericsson, 2011). In March 2011, the Complete Laboratory Solutions (CLS) completed the installation of all 52 labs with solar powered computers in local schools located in area not supplied with the power grid (Inveneo, 2010). Individual in some schools have been able to utilizing solar-chargeable laptops since they are low power consumers (Hosman, 2011).

Schools that are located in regions with limited or non-existent electricity sorely rely on solar power to supply computers with electricity (Vota, 2012). According to Mash et al. (2011), energy efficient ICT equipment paired with appropriate solar panels, PCs and related devices can be introduced in areas where there is lack of or where there is limited supply of electricity.

Solar power can be used to power low power consumption computers in a computer lab and therefore enable the school to meet their energy needs (Hosman, 2011). A part from powering ICT equipment, solar energy is used for lighting and running small machines and appliances. Solar power can be utilized for lighting, small appliances, machinery and computers for schools in places where they don't have regular electricity (Iwasaki, 2011).

Fewer base stations per school, with low power consumption per base station, enables schools to save power using on-grid topology, or to power their online access using solar power when installed off-grid (Wavion, 2008). Currently the costs of some solar panels have slightly reduced as compared to the past decades. According the World Nuclear Association (2011), the thin film PV modules using silicon or cadmium telluride are at least 20% less costly than crystalline silicon-based ones. A 4.5 kWatts solar power system which comprises 18 -250 Watts solar panels, 10-24 Volts batteries and 1-power-one PVI-42-OUTD-AU 4000Watts inverter at an estimated cost of $5,814 (Kshs. 500,000) is capable of powering ICT equipment in a secondary school (Inveneo, 2010).

2.3.1.2 Challenges of Using Solar Power

The PVs and associated fittings have a high initial cost (Modi, 2010). Solar and wind (2009) supports Modi by saying that solar energy installation front costs are high and many places in the world don't have enough constant and intense sunshine to make commercial use of solar energy practical. Use of solar power involves a high level of administrative, architectural, communication, marketing and environmental issues that are costly (Prasa and Snow, 2011). Many people keep off from using solar power because of high initial costs of solar fittings. The high cost of power from solar photovoltaic (PV) panels has been a major deterrent to the technology's market penetration. Large-scale production of energy in the form of electricity from renewable energy sources is a great challenge (Imamura et. al, 1992). Solar and wind (2009) revealed that cloud cover and rainy seasons are other drawbacks in the use of solar power to generate electricity. It continues to say that areas experiencing heavy rainfall will not allow the sun to shine on the solar panels for enough hours that can sustain the solar panel to generate enough electricity. Madson (2011) agrees with Solar and Wind that parts of the world that don't receive large amounts of sunlight are not well suited to the generation of electricity from energy.

The ever changing direction of the sun's rays and weather conditions also greatly affect the output of solar power (Ehow (2011). Even when solar panels are installed on your roof, they can become dirty due to pollution, traffic dust and bird droppings leading to reduction of their efficiency (Ndume et al, 2010). In his study, Madson (2011) reported that a large number of panels may be necessary to produce sufficient amounts of heat or electricity requiring a significant financial investment. Large-scale commercial energy projects require potentially large areas of land (Solar & Wind energy, 2009). IN case of installing many solar panel that can't fit on a roof top, one may the option of using the piece of land for solar panels installation which would have been used for a more viable projects that can be carried out on the same piece of land.

The quantity of energy delivered to an area by the sun depends on the location on earth (Casci et al., 2005). Areas far away from the equator receive less sunshine than regions near the equator. Table 2.3.1.1.1 shows the Duration of daylight for certain latitudes (ESRSE, 2014).

Table 2.3.1.1.1

Duration of daylight for certain latitudes

LENGTH OF DAY (Northern Hemisphere) (read down)			
Latitudes (in degrees)	MAR. 20 / SEPT. 22	JUNE 21	DEC. 21
0.0	12 hr	12 hr	12 hr
10.0	12 hr	12 hr 35 min	11 hr 25 min
20.0	12 hr	13 hr 12 min	10 hr 48 min
23.5	12 hr	13 hr 35 min	10 hr 41 min
30.0	12 hr	13 hr 56 min	10 hr 4 min
40.0	12 hr	14 hr 52 min	9 hr 8min
50.0	12 hr	16 18 min	7 hr 42 min
60.0	12 hr	18 hr 27 min	5 hr 33 min
66.5	12 hr	24 hr	0 hr
70.0	12 hr	24 hr	0 hr
80.0	12 hr	24 hr	0 hr
90.0	12 hr	24 hr	0 hr
LATITUDE	MAR. 20 /SEPT.22	DEC. 21	JUNE 21
LENGTH OF DAY (Southern Hemisphere) (read out)			

SREP (2011) also chips in that low awareness of the potential opportunities and economic benefits offered by solar technologies, and lack of adherence to system standards by suppliers are some of the barriers affecting the exploitation of solar energy resource.

Some computers consume more energy making it difficult to run them on insufficient solar generated electricity. Old computer design simply put too much demand on the limited generation capabilities of the solar panels (Nordhausen, 2011). However new computer designs consume far much less power making them capable of being powered solar generated electricity.

2.3.2 Wind Power

Wind energy is among the world's fastest-growing sources of energy and during the last decade, its energy growth rates worldwide averaged about 30 percent annually (Combs, 2011). Manwell et al. (2009) in their assessment of wind energy as a source of electric power indicated that wind energy if harnessed properly can generate a substantial amount of electricity. Wind energy is a potential source of energy for electrical power in rural and remote areas (USAID, 2004).

Wind energy systems tap into a natural source of energy, have a long lifespan, do not require fuel, and save communities time and work (Harper and Oglethorpe, 2009). Wind power electricity generation has a high advantage in that it is a free source of power (Theraja and Theraja, 2010).

The increasingly lower cost of wind generated electricity – due in part to a movement toward larger, more efficient turbines, and facilitated by federal tax incentives – is now an important driver for new wind installations (McLaughlin et al., 2010). Kenya has a great potential of generating electricity from wind power. Preliminary wind resource assessment shows that wind regimes in certain parts of Kenya (such as Marsabit, Ngong and the Coastal region) can support commercial electricity generation as they enjoy wind speeds ranging from 8 to 14 metres per second (MPD, 2008). Simple technologies can be used to tarp energy from the wind power. Wind energy does not have to be high-tech (the most advanced technology available): in many developing countries simple windmills are used for pumping water (Casci et al., 2005). Research has shown that it is cheaper to generate electricity from wind energy than from solar energy. Wind systems are generally cheaper than solar systems on the international market (Akakpo, 2008). The following are the statistics showing that wind systems are cheaper than solar system (Komor, 2009).

Table 2.3.2.1
Comparison of the cost of generating electricity from wind power, solar power, and natural gas.

Technology	First cost ($/kW)	Operational maintenance cost (₵/kWh)	Fuel Cost (₵/kWh)	Capacity factor	Resulting LCOE(₵/kWh)
Wind(> 1 MW	1900-2400	1	0	0.32	9-12
Concentrating solar power (CSP)	3800-4800	3	0	0.26	24-29
Utility-scale photovoltaic (>10 MW)	5000-7500	1	0	0.26	28-42
Distributed photovoltaic (>10 kW)	7000-9000	1	0	0.22	46-59
Natural Gas	800	0.5	2.8-8.3	0.70	5-10

2.3.2.1 The Use of Wind Power Generated Electricity to Power ICT in Secondary Schools

An attempt by a number of schools has shown that wind power generated electricity can be used to power ICT equipment in secondary schools. For example, an overview of the energy consumption and behaviour of Currie Community High School in England by Jenkins (2010) revealed that the school has recently installed a small-scale 11 kW wind turbine that generates electricity for its ICT use. An installed 20 kW wind turbine in Abaarso Tech Secondary School in Hargeisa provides enough electricity that powers the school ICT leaving a surplus of the generated electricity that is sold to the neighbouring villagers (Mckenna, 2013). Spirit Lake Community School in Spirit Lake, Lowa, in the United States of America generates 1,570, 000 KW hours energy from wind power that it uses to power its ICT equipment (Unesco, 2013). A customer case study by CISCO (2013) reveals that Rainha Dona Amelia Secondary school in Lisbon, Portugal is currently powering it ICT equipment from wind power generated electricity.

2.3.2.2 Challenges of Using Wind Power

Although the use of wind energy has proved to be a potential source of energy, there are a number of challenges that affect its use to generate electricity to power ICT. The initial installation of wind generator requires expensive materials and fitting. Wind energy is expensive to install or to maintain (Olingo, 2011). The use of wind energy to generate power has been and is a problem because of low levels of technological advancement and maintenance costs. The construction of wind turbines appears more difficult than expected due to technical problems and high maintenance costs. These technical problems include; lack of proper installation skills, meeting the technical recommendation and safety rules, designing wind turbines that fit the physical properties of the site, and achieving the capacity of the local transmission or distribution grid. (Leo van der Geest and Lars, 2010). In some regions, the speed of wind varies causing the electricity generated by wind generator to be intermittent. The major challenge to using wind as a source of power is that it is intermittent and does not always blow when electricity is needed either can it be stored (although wind-generated electricity can be stored, if batteries are used), and besides this, not all winds can be harnessed to meet the timing of electricity demands(Wind Energy Basics, 2010). In their study of wind power systems, Wang et al. (2010) revealed that generation of electricity from wind power is challenged by the variation in the wind speed leading to intermittent power supply to the system. The intermittent generation of electricity by the wind generator results in poor quality of electricity. The variations in wind speeds causes fluctuations in wind power generator output resulting to poor quality power supply (Watt and Outhred, 2011). According to Combs (2011) the use of wind power challenges are largely related to its variable nature – wind speed or direction can change by the season, day, hour and minute, high wind variations where sometimes too much wind is blowing and at others too little – makes it difficult to integrate wind into a grid that was not designed for fluctuations. Whether constructing a wind turbine is economically viable at your home or farm depends most strongly on the quality of your wind resource and generally, average annual wind speeds of at least 4.0-4.5 m/s (14.4- 16.2 km/h; 9.0-10.2 mph) are needed for a small wind turbine to produce enough electricity to be cost-effective (Ministry of Agriculture, Food and Rural Affairs, Ontario, 2011). Clarke (2014) reports that large wind turbines are those usually installed in clusters called wind farms and can generate large amounts of electricity. He adds on that small wind turbines are generally those producing no more than 100 kW of electricity, are designed to be installed at homes, farms and small businesses either as a source of backup electricity, or to offset use of utility power and reduce electricity bills. Manwell et al (2009) in their assessment of wind energy as a source of electric power generation, reported that the variability of wind speed sometimes vary greatly making the generated power to be intermittent. Grid integration and stability issues are complicated by wind generators' random intermittency (Ruffles, 2004). The energy delivered by a wind turbine depends on the number of hours it can operate each year and this of course depends on the weather conditions, and in practice a wind turbine delivers about 20-30% of its potential energy output averaged over a year (Casci et al., 2005). Wind power is largely affected by wind speed, barometric pressure, altitude, air temperature, high initial investment costs, site specific technology, fluctuations in energy produced, which calls for backup system or battery to store electricity, environmental impacts such as bird and bat mortality, and require a reasonable knowledge of both mechanical and electrical systems maintenance (Harper and Oglethorpe, 2009).

The wind turbine speed adjustment also plays a key role on the performance of the wind energy generation. When the rotor speed is not well adjusted by pitch control, the blades of the turbine can spin too quickly if the wind is too strong, making the wind turbine unstable and eventually sustain catastrophic damage (Demand Media, 2011). The main factor in the generation of wind energy is the site of positioning the wind turbine. Most important is the windiness of the site since the available power or energy is a function of the cube of the wind speed. Therefore, a doubling of the wind speed gives eight times the power output from the turbine (RenewableUK, 2011). The emergence of wind power as a relatively cheap source of electricity has further complicated life for the traditional generating industry due to over-taxation of wind generator fittings (Backburn and Cunninggham, 2010). State over taxing of wind electricity generation fittings can have a negative effect on wind energy development (McLaughlin et al., 2010).

The other barrier of wind power installation is ignorance on the potential of using wind power generated electricity (Kaboutis and Hatziargyriou, 2010).

2.4 Standby Generators

The use of other sources of electricity to supplement the National grid is inevitable in regions which experience frequent power outages (Olingo, 2011). The need for standby power is evident whenever there are prolonged power outages (Lords View, 2011). The use of standby generators has risen due to shortage of electricity in many regions. A survey conducted by Millennium Consolidated Consultancy Services (2010), revealed that there were around 6,000 small standby and 4,000 or more stand-alone generators in use in Namibia. Many companies and businesses are forced to use standby generators to power their machines and equipment during the long periods of power outages.

2.4.1 Challenges of Using Standby Generators

Power generated by standby generators is more expensive because of high cost of fuel. Jirani (2009) indicates that generation of electricity by diesel generators by KenGen has made the electricity bills to sky rocket. Fuel costs represent the largest ongoing cost of operating standby generators (Winrock International, 2004). Individual generators are an uneconomical means of providing power because the cost of fuels is high for small firms (Lyakurwa, 2007). Another challenge of using standby generators is the high cost of spare parts (CTA, 2007). In a recent spotlight, Ongwae (2012) reported that schools not connected to the national grid rely on unpredictable generators that frequently breakdown and leave the learners in total darkness.

Many secondary schools in Nandi County of Kenya lack standby generators because standby generators are perceived as being expensive to purchase and run (Boit and Menjo, 2005). The challenge of using standby generators is compounded by the ever rising price of fuel. The cost of fuel is high because Kenya relies on imported petroleum products.

2.5 Storage Batteries

The use of storage batteries is wide spread used but has its shortcomings. Lead acid batteries are slightly less robust, flooded batteries tend to use up their water, and tend to die early from grid corrosion (Woodbank, 2005). Battery Council International (2005) indicates that Lead acid batteries are very heavy, bulky, are not suitable for fast charging, face a danger of overheating during charging, and may be irreparably damaged if completely discharged. Nickel-cadmium batteries have a relatively low energy density, must be periodically exercised (discharge/charge) to prevent memory effect, and are environmentally unfriendly (PowerStream, 2007). They contain toxic metals, and have a relatively high self-discharge. Some batteries are damaged by overcharging. Isidor (2005) reported that NiMH batteries are damaged from overcharging or by being reversed. They are bulky, have limited service life, have relatively short storage, have limited discharge current, have a reduced cycle life by a heavy load, need more complex charge algorithm, require slightly longer charge times than nickel-cadmium, have high self-discharge, their performance degrades if stored at elevated temperatures, require high-pressure steel canisters and have self-discharge rate of approximately 20 percent month. Lithium-Ion batteries take damage from overcharging and may explode when overcharged (Isidor, 2005). Poor maintenance of batteries makes them to fail earlier than usual. Backup battery packs for solar systems are typically of the lead-acid type, with a five-year life, if properly maintained. However, most do not last that long because of poor maintenance (Vaccaro et al., 2010). Batteries require periodic maintenance which involve cleaning, topping with distilled water and measuring the battery water density with a barometer to ascertain that it is in good working condition.

2.6 DC-AC Power Inverters

Many of the electric devices are designed for AC voltage power outlets. Since solar power is generated in DC form, the DC-AC power inverters come in handy to convert the DC voltage to AC voltage. However, the use of DC-AC power inverters faces a number of challenges. Many of DC-AC power inverters give poor quality electricity. According to Motto (2000), Conventional HVDC DC-AC inverters have been line-commutated thyristor inverters, which have very high power ratings (up to several Gigawatts) but produce poor AC waveforms. A substantial number of inverter topologies that have been designed do not fully and exhaustively address the issue of inverter power consumption. Many DC/AC power inverters at converter level the reactive power consumed may be as much as 50 % of active power rating of a dc link and this pose a problem to their applications (Hahn, 2006).

Few engineering staffs dare to venture further into electrical power conservation (Clark II, 1997). Some DC-AC power inverter designs in the market consume more power as they operate affecting their power efficiency. For example; high switching frequency DC-AC inverters increase losses and lower efficiency (Frank, 2008). Other inverter designs suffer from harmonics distortions. According to Korovesis et al (2004), harmonics distortion causes motor, transformer and wiring overheats and lower operating efficiency of office equipment. Power Nucleus (2005) reveals square wave and modified square wave inverters contains many unwanted higher frequency components that are greater than the fundamental waveform frequency called harmonics which contribute to heating and reduction of the overall power efficiency. If the inverter does not have enough starting capacity, it may be difficult to start up the ICT infrastructure. In some power system components, the use of converters results in energy losses due to inefficiencies. Typical inverter efficiency is 85% (Pandey and Acharya, 2004). Some solar and other power generators have inverters to convert DC power to AC which are generally inefficient (Vaccaro el al., 2010).

Modified sine wave and pure sine waves power inverters provide high power efficiencies making them better in the conversion of solar DC generated power to AC power that can be used to power Ac equipment (Crowley and Leung, 2011).

The following tables 2.6.1.to 2.6.3 show power efficiencies for various modified and pure sine wave power inverters (Crowley and Leung, 2011).

Table 2.6.1:
Comparison of Inverters, Pure Sine vs. Modified Sine of the Same Capacity

Model / **Specification**	Duracell Inverter 300	Duracell Inverter 1000	Samlex PST-30s-12A	Samlex PST-100S-12A
Output type	Modified Sine - 60Hz	Modified Sine-60Hz	Pure sine – 60 Hz	Pure sine – 60 Hz
Rated Output	300W	1000W	300W	1000W
Overload protection	Yes	Yes	Yes	Yes
Maximum output Surge (<1 Sec)	500W	2000W	500W	2000W
Low battery shutdown	Yes	Yes	Yes	Yes
Cooling	Thermostat-Controlled Forced Air			
Outlets	2	2	1	2
Dimensions	152x106x50 mm	305x152x76 mm	214x146x65 mm	395x236x83 mm
Thermal shutdown	Yes	Yes	Yes	Yes
Peak efficiency	90%	90%	85%	85%
THD	Not rated	Not rated	<3%	<3%
Cost	$44	$129	$159	$479

Table 2.6.2

Comparison of power efficiency of modified sine wave inverters

Model	Rated Output	Maximum Output	Outlets	Dimension LxWxH	Efficiency	Cost
Cobra	150W	300W	1	3.25’’x3.25’’x75’’	85%	$25
Voltec	200W	400W	2	6.5’’x4.125’’x2’’	87%	$29
Samlex	250W	500W	1	5.9’’x4.5’’x1.8’’	90%	$25
Black&Decker	400W	800W	2	6’’x5.25’’x2’’	90%	$37
AIMS	800W	1600W	2	10.5’’x5.75’’x2’’	95%	$69
Xantrex	1000W	2000W	2	12’’x6’’x3’’	90%	$129
Wagan	2000W	4000W	2	12.3’’x6.4’’x3’’	90%	$219

Table 2.6.3

Comparison of power efficiency of pure sine wave inverters

Model	**Rated Output**	**Maximum Output**	**Outlets**	**Dimension LxWxH**	**Efficiency**	**Cost**
Samlex	120W	240W	1	7,4’’x4.3’’x1.18’’	88%	$99
Go Power	150W	260W	2	8’’x5.3’’x2;9’’	90%	$150
Samlex	300W	500W	2	8.5’’x5.8’’x2.6’’	90%	$149
AIMS	600W	1200W	2	9’’x3’’x3’’	86%	$189
Xantrex	800W	900W	2	13.4’’x8.7’’x3.5’’	90%	$299
Wagan	1000W	2000W	4	19’’x7.5’’x3.5’’	90%	$499

From table 2.6.2 above it is revealed that AIMS modified sine wave inverter has the highest efficiency (95%) and therefore the best choice to incorporate in solar PV system to convert dc voltage to ac voltage.

Many different approaches to inverter design have been attempted, but all have strong points as well as weaknesses as shown in figure 2.6.3 (Trace engineering, 2014). This means that a “perfect” inverter has yet to be invented and therefore we must continue using the present technology and move forward as semiconductors become better and better.

Table 2.6.4

Comparison of inverter topologies

Topology	Switch type	Switch frequency	Waveform type	Total harmonic distortion	Typical efficiency	Idle power consumption	Surge ability	Interference	DC-AC isolation	Reliability
Vibrator	Mechanical	Low	Square	High (-50%)	60– 80 %	High	Poor	Medium	Yes	Poor
Push-pull	SCR	Low	Square	High (-50%)	80%	High	Good	Low	Yes	Good
Push-pull	MOSFET	Low	Modified square	Medium (-15-35%)	80 - 90%	Low	Very good	Low	Yes	Good
H-Bridge low frequency	MOSFET	Low	Modified square	High (-50%)	85-95%	Low	Very good	Low	Yes	Good
H-Bridge high frequency	MOSFET	High	Modified square	High (-50%)	85-90%	Medium	Poor to Good	High	No	Poor
Dual Xfrmr	MOSFET	Low	Modified square	High (-50%)	80-90%	Medium	Good	Low	Yes	Good
Rotary	Mechanical	Low	Sine wave	Low	50-70%	High	Poor	Low	Yes	Poor
Ferro Resonant	MOSFET	Low	Semi-sine wave	High (-50%)	50-70%	High	Poor	Low	Yes	Good
High frequency	MOSFET	High	Sine wave	Very good (1-5%)	70-90%	High	Poor	High	Yes	Poor
Low frequency multi-step	MOSFET	Medium low	Sine wave	Very good (3-5%)	85-95%	Low	Very good	Low	Yes	Very good
Hybrid High/Low	MOSFET	High	Sine wave	Very good (1-5%)	85-95%	Medium	Good	Low	Yes	Very good

2.7 School principal's Opinions on the Acquisition of Alternative Sources of energy for ICT use in Secondary Schools

School administrators are the main determinants for the desired outcomes and success in schools hence seen as critical stakeholders (Mungaine, 2013). Mungaine (2013) observe that school leadership plays a major role in the implementation of ICT in schools. In a study conducted by Shields (2013) entitled "Solar electric system provides emergency power and teaching tool for Haines High School", the assistant principal at Haines City High School testified that the use of solar power to power ICT in schools will be a tremendous resource. A study by Makewa et al. (2013) on ICT in secondary school administration in rural southern Kenya: An educator's eye opener on its importance and use reveal that both teachers and principals viewed the use of alternative sources of energy to power ICT in secondary schools as a viable project.

The principal of Holston View Elementary School maintains that the use of solar and wind energy generated electricity is the solution to the shortage of electricity for ICT use in schools (Castle, 2013). A study by Mangaine (2013) established that although principals encountered numerous challenges during implementing ICT in schools, they appeared to have positive attitudes towards its implementation. A study Conducted by Makewa et al. (2013), that investigated whether there was a significant difference between teachers' and administrators' perceptions on the importance of ICT in secondary school revealed that school administrators rated the importance of using ICT in teaching and learning more highly.

However, despite emphasis on implementing ICT in schools, several studies reveal that many principals are either not actively participating on ICT implementation or have no considerable knowledge that can aid in its implementation (Laaria, 2013 and Makhanu, 2010). The principals in some schools have a challenge of considering alternative power sources or power backup sources in order to be able to implement ICT (Mingaine, 2013).

2.8 The Pros and Cons of Using Solar Power in Schools

Studies of pros and cons of solar energy have found that solar power electricity generating system give off no pollution (Bratley, 2013), it is a renewable energy source (Maehlum, 2011), it eliminates the need to run long power lines to a home (Durkee, 2013), and once installed, it is easily maintained and monitored (Silvers, 2013). Solar power has the ability of harnessing electricity in remote locations that are not linked to a national grid (Bratley, 2013). A key example of this is in space, where satellites are powered by high efficiency solar cells. Solar power energy meets the needs of the present without compromising the ability of future generations to meet their needs (Maehlum, 2012). Depending on how many panels, storage batteries and/or backup generators one has installed, one can generate exactly the amount of energy for household requirements and not pay a penny to the power company, or one can have enough energy leftover to sell to the power company (Silvers, 2013). The electricity generated by solar panels can be stored in a battery and used at night. Generation of electricity by use of PV system reduces electricity costs and provides electricity when a power outage occurs (Shields, 2013). Governments and a number of federal organizations give incentives to those who decide to install solar panels on their homes (Durkee, 2013). These incentives include tax credits for homes and businesses. However, solar power energy system installation requires a high initial cost of solar cells and currently, prices of highly efficient solar cells are above $1000 per panel, and some households may need more than one (Bratley, 2013). Solar panels can take up a lot of space that would have been used to a more economic viable project (Silvers, 2013). Zhang et al. (2013) in their experimental study of the impact of large-scale wind farms on land-atmosphere exchange found out that large-scale wind farms, covering a significant portion of the land, may affect the transport of momentum, heat, mass and moisture between the atmosphere and the land locally and globally. Also, access to sunlight might be limited at certain times and areas (Maehlum, 2011).

2.9 The Use of Solar energy to Power ICT in Schools

A survey by Intel (2013) on technological changes that have made solar power cost feasible for PC development, and providing an overview of how to design a solar powered PC reveal that the Alliance for Mindano Off-grid Renewable Energy (AMORE) program has provided clean and renewable energy to Philipines schools to power ICT for years. Students and teachers of Haines City School are currently reaping multiple benefits from the new 10,000-watt photovoltaic (PV) system installed in the school. The PV system with battery backup provides emergency power during an outage, reduces daily electricity costs to the school, and serve as a learning resource (Shields, 2013). A study by Marsh et al. (2011) on Solar power for rural PCs, reveal that, in Africa, solar power is being used to power ICT in Jonathan Sims_Chikanta High school in a remote part of Southern Zambia and CEG Komtoega Secondary School in East-Central Burkina Faso. The study also discloses that each school is capable of powering 20 PCs. The Hoston View Elementary school solar energy installation comprises of 200 panels stretching across 83 feet of property with each panel generating 275 watts of electricity converted from sunlight (Castle, 2013). This solar project generates electric power of an average of 65,000 to 75,000 kilowatts. A survey by Ericsson (2013), which compared the use of ICT in the Sub-Sahara Africa with the rest of the world, revealed that the use of solar generated electricity to power ICT can help significantly to improve the use of ICT in local schools.

2.10 Readiness to Adopt a New Technology

Affordability of the technology is an important indicator for their wider use since cost is the major factor in encouraging or discouraging the application of appropriate technology in developing economies (Pyakuryal, 2002). Many people are discouraged to use technologies when they perceive them as being expensive or unaffordable. Naturally, people tend to embrace affordable technologies. There is a need for the government to subsidize technologies related equipment so that they are affordable. The small independent power producers should be encouraged, financed, and facilitated to produce electricity to supplement the electricity supplied from hydro power generating plants. Government legislation of smaller independent power producers to operate under a regulated environment can make it possible for these producers to generate electricity and even sell the surplus electricity to the grid (Modi, 2010).

2.11 Technical Manpower

There is a shortage of technical manpower to maintain and repair modern equipment which supports the ever advancing technologies. The increasing dependence on technology requires a more technologically trained work-force (Ragaller and Dandliker, 2010). Akakpo (2008) agrees with Ragallaer and Dandliker that there is a need to rapidly increase the number of people trained in installing and maintaining the ICT equipment.

2.12 Summary

The use of ICT in secondary schools will enhance teaching and learning. The integration of ICT in teaching and learning in Kenya is low because of because of shortage of electricity, there is no generation of electricity from renewable sources of energy, and the little electricity supplied by the Kenya Power Company is expensive and unreliable. However, it is possible to use alternative sources of energy to power ICT in secondary schools. This research is necessary because no research has been done to find out why such alternative sources are not used to power ICT in Kenya.

CHAPTER THREE

RESEARCH DESIGN AND METHODOLOGY

3.0 Introduction

This chapter describes the research design that was adopted in the study, rationale of the methodology, description of the research area, target population, sampling techniques, data collection procedure, materials and methods, statistical data treatment and finally data analysis.

3.1 Research Design

This study adopted a survey research design. According to Onen and Oso (2005), survey research studies are those that are concerned with providing qualitative and numeric descriptions of some part of the population. This study was concerned with determining challenges of accessing electricity for ICT use in Kenyan secondary schools. It was specifically intended to investigate the availability and barriers of using the Kenya Power Company electricity, standby generators, solar power and wind power to power ICT equipment in Nandi County secondary schools. The survey research design enabled the researcher to consider issues such as economy of the design, rapid data collection and ability to understand populations from a part of it (Igo, 2007). It helped the researcher to carry out an extensive research. Survey research eased the researcher's accessible information and provides unbiased representation of population under the study (Owens, 2002). Both quantitative and qualitative research methods were used in the study. Since the objectives of the study were varied, it made sense to use both methods since they complemented each other in the case of Nandi County.

3.2 Description of the Research Area

This study was carried out in the local secondary schools of Nandi County, in Rift Valley Province of Kenya. The county has population of 725,965 and covers an area of 2884.2 km^2. The county borders Uasin Gishu County to the East, Kericho County to the South East, Kisumu County to the South, Vihiga County to the South West, Kakamega County to the West and Bungoma County to the North (See Appendix VIII).

The region has an altitude that varies from 1300 meters to 2500 meters and is favorable for small and large scale farming with the main activities of growing tea, sugar cane, maize, and wheat (Mbugua, 2004). Maize is grown for consumption and sugar cane, wheat and tea are grown purely as cash crops. The farmers also grow beans, potatoes, pyrethrum and vegetables. Dairy farming also flourishes in the region. Wealthy farmers practice floriculture. The region is accessible by tarmac roads, a railway line and an international airport as means of transport and earth roads which connect the rural areas of the region. Kapsabet town and Nandi Hills town are the major towns and commercial centers in the County where Kapsabet town is the Nandi County’s headquarters, commercial and administrative center. A few regions in the entire county are served with electricity, most of which is confined to a few schools and market centers. Nandi County was selected because it is scarcely supplied with electricity leaving the inhabitants with the challenges of accessing electricity.

3.3 Population and Sampling Techniques

A population is a complete set of individuals, cases or objects with some observation characteristics, and sampling techniques are ways of selecting a sample (Mugenda and Mugenda, 2005).

3.3.1 Target/Accessible Population

The target population consisted of all the 155 Nandi County secondary school principals in Nandi County. Nandi County is one of the largest counties in Kenya and it has almost all categories of secondary schools. It was therefore considered appropriate for providing a focal point for the study of challenges of accessing electricity for ICT use in Kenyan secondary schools.

3.3.2. Sample Size and Sampling Technique

3.3.2.1 Sample Size

The sample size was determined by use of formula for calculating a sample for proportions. In this study the following formula for yielding a representative sample for proportions for populations that are large was used (Mugenda and Mugenda, 2005).

$$n = \frac{Z^2 pq}{d^2}$$

Where: n = the desired sample size (if the target population is greater than 10,000)

Z = the standard normal deviation at the required confidence level.

p = the population in the target population estimated to have characteristics being measured.

q = 1- p

d = the level of statistical significance set.

In this case Z = 1.96

q = 0.5

d = 0.05

$$n = \frac{(1.96)^2(0.50)(0.50)}{(0.05)^2} = 384$$

Since the target population was less than 10,000 people, the sample size was reduced slightly. This was because a given sample size provides a proportionately more information for a small population than for a large populations. The sample size (n_o) was adjusted using the following formula (Israel, 2013).

$$\mathrm{nf} = \frac{n_o}{1 + \frac{n_o - 1}{N}}$$

Where: nf = the desired size or final sample size (where the population is less than 10,000).

n_o = the desired sample size (when the population is more 10,000).

N = the estimate of the population size.

Therefore, the sample size is;

$$\text{Final sample size (nf)} = \frac{385}{1+\frac{385-1}{155}} = 110$$

The sample size consisting of one hundred and ten (110) out of the one hundred and fifty-five (155) secondary schools principals was selected to participate in the study. The one hundred and ten (110) secondary school principals were selected according to calculations above.

3.3.2.2 Sampling Technique

Purposive sampling technique was used in this study. Purposive sampling is a sampling technique which the researcher handpicks cases to be included in his sample on the basis of his judgment of the typicality…(Cohen and Manion, 1992). Purposive sampling technique was used to select the head teachers / principals of the schools under the study. The purposive sampling technique was chosen because it enabled the researcher to get the specific information he was interested in from the respondents who were few in the study area (Mugenda and Mugenda, 2003).

3.4 Research Instruments

This study used one type of questionnaire, an interview schedule and observation method to collect data.

3.4.1. Questionnaire

The questionnaire was for the principals of the local secondary schools that were selected for the study. The researcher developed a questionnaire that was used in the study to collect data after it had been validated. This questionnaire was developed from the literature review to ensure that they covered all required information. The questionnaire was administered to the secondary school principals who were sampled out to evaluate electric power challenges facing the use of ICT in Kenyan schools. The questionnaire was both open and closed ended and was designed to solicit information on the power challenges facing the use of ICT equipment in the selected schools. The questionnaire also solicited information on the availability of alternative sources of energy and the school principals' perceptions on the possibility of using various alternative sources of energy.

3.4.2. The Interview Schedule

The principals' questionnaires were supplemented by an interview in order to get more input and verify the information obtained from the questionnaires. This also helped the researcher to collect information that could not be directly observed or were difficult to put down in writing.

3.4.3 Observation Method

The researcher personally visited the selected schools to observe the availability of electricity, the use of alternative sources of energy and the use of ICT equipment. This method helped the researcher to obtain information by direct observation without soliciting it from the respondents.

3.5 Validity of the Research Instruments

For data collection to be considered valid, the selected instruments must be relevant to the need or gap in the study. The instruments used in the study were examined and validated by professionals in the Department of Technology Education, University of Eldoret. The recommendations given by the professionals were incorporated by the researcher so as to ensure accurate and correct measurements are made.

3.6 Reliability of the Research Instruments

A pilot study was conducted in twenty schools in Uasin Gishu County. Ten principals of schools supplied with electricity from Kenya Power Company and ten principals of schools not supplied with electricity from the Kenya Power Company in Uasin Gishu County participated in the pilot study. The data from the pilot study were used to determine the reliability of the instruments. A minimum Cronbach Alpha Coefficient of 0.95 was obtained. A minimum Cronbach Alpha Coefficient of 0.95 is appropriate for a study (George, and Mallery, 2011). The Cronbach alpha of 0.95 for the set of scores that was obtained indicated that the test was 95 % reliable, and by extension that it was 5 % unreliable (100% - 95% = 5%).

3.7 Data Collection Procedures

The researcher requested from University of Eldoret, Department of Technology Education chairperson, an introduction letter requesting for a permit from the Ministry of Education to facilitate the researcher carry out the study. The researcher personally visited the schools and familiarized himself with the principals and informed them the importance of carrying out the study. The research then administered the questionnaires to the principals of the various secondary schools. The researcher also guided the respondents through the interview as they responded to various questions.

3.8 Ethical Considerations

In this study, consideration was given to complying with ethical measures in the course of conducting the research. To ensure their safety and rights, the respondents were informed about the current ethical consideration, for example, informed consent, rights of the respondents, voluntary participation, anonymity and confidentiality. The researcher obtained informed consent from each respondent. The consent was obtained orally after the participant had the opportunity to carefully consider the risks and benefits and to ask any pertinent questions about the study. Privacy and confidentiality concerns were given the deserved consideration (Chigona et al., 2010). The ethical principle refers to the obligation on the part of the researcher to respect each respondent as a person capable of making an informed decision regarding participation in the research study. The researcher ensured that the participants received full disclosure of the nature of the study, benefits and alternatives, with an extended opportunity to ask questions.

3.9 Statistical Treatment of Data

Descriptive statistics were used to analyze the data that was collected by the questionnaires. The descriptive statistics that were used in the data analysis were frequencies, percentages, and means. The collected data through the questionnaire was analyzed using the Statistical Package for Social Sciences (SPSS). The results that were obtained were presented in form of graphs and tables. The information that was obtained from the analyzed data was used to determine the findings, and from the findings conclusions were drawn and recommendations made.

3.10 Summary

This study adopted a survey research design. It investigated the scarcity of electricity and challenges facing the use of solar generated electricity and wind power generated electricity to power ICT equipment in Nandi County local secondary schools. A questionnaire and interview schedule was used to collect data. The study employed purposive sampling technique. The instruments used in the study were first examined and validated by professionals before they were used in the study. A pilot study was conducted in ten schools in Uasin Gishu County which gave a minimum Cronbach Alpha Coefficient of 0.95 was obtained that was considered appropriate. The Statistical Package for Social Sciences (SPSS) computer software was used to analyze the data collected.

CHAPTER FOUR

DATA PRESENTATION, ANALYSIS AND INTERPRETATION

4.0 Introduction

This chapter presents an analysis of the data gathered for the study using the tools discussed in the previous chapter. This section is divided into four main sub-sections. The first part presents a detailed analysis and interpretation of data on the available alternative energy sources. The second part presents power challenges facing the use of alternative sources of energy to power ICT equipment. The third part gives the principals opinions on the use of alternative sources of energy in the secondary schools. The fourth part gives the principals opinions on the use of alternative sources of energy in the secondary schools. The fifth part assesses the possibility of using solar power, wind power and standby generators to generate electricity to power ICT equipment in the local secondary schools. Finally the last section presents the discussion of the findings.

4.1 The Availability of the Alternative Source of Energy in the Schools

In this section, respondents were asked to indicate their level of agreement with the different statements that described each of the factors using a Yes and No scale. The researcher used the following scale interpretation: Yes (1) and No (2). Analysis of the frequencies, means and percentages of the Yes and No responses provided a clear picture of what respondents perceive about the availability of alternative sources of energy in local secondary schools in Nandi County.

Table 4.1
Availability of the Alternative Sources of Energy in Secondary Schools

Item	Response	Frequency	Percentage
Our school has installed solar power generated electricity	No	110	100
Our school has installed wind power generators	No	110	100
Our school has a standalone generator power to power ICT equipment	No	110	100

Table 4.1 shows that all 110 respondents (100%) indicated that there was no solar power installed in all the sampled secondary schools in Nandi County. This indicates that the secondary schools were not using solar power to power ICT equipment. In their study of factor affecting the use of ICT in teaching and learning in Nandi County secondary schools, Menjo and Boit (2005) reported that although there was sufficient sunshine, there were no installed solar power systems in the schools. Muwanga_Zake (2007) agrees with Menjo and Boit that local schools have not installed solar power systems. This shows that the schools administration was not aware of the potential of using solar power to generate electricity. Lack of the use of solar power to generate electricity in regions where there is enough sunshine is attributed to higher level of ignorance and awareness of the use of solar energy (Chandak, 2011).

All 110 respondents (100%) indicated that they had no installed wind power generator. This indicates that the local secondary schools had no wind power generator installed in the institution. Menjo and Boit (2005) in their assessment of factors affecting the use of ICT in teaching and learning in Nandi County found out that there were no installed wind power generators that could be used to generate electricity despite the fact that the region has good wind regimes. This reveals that wind power was not utilized to generate electricity to power ICT equipment in Nandi County schools. Lack of utilization of wind power to generate electricity in regions having good wind regimes is a revelation that the school stake holders were not aware of the potential of utilizing wind power to generate electricity. Chandak (2011) affirms this by asserting that poor level of awareness is one of the reasons why many local schools do not utilize wind power to generate electricity to power ICT equipment.

All 110 respondents (100%) indicated that the sampled secondary schools had no standalone generators. This shows that all the sampled secondary schools in the study had no standby generators. Many secondary schools in Nandi County do not have standalone generators to help light or power computers (Cheison, 2012). Menjo and Boit (2005) supports Cheison that most of the schools in Nandi County do not have standalone generators.

The above findings show that solar and wind power generated electricity were not used at all in Nandi County secondary schools. This is attributed to the stake holder's lack of awareness of the potential of using alternative sources of energy to power ICT equipments.

4.2 Challenges Facing the Use of Alternative Sources of Energy to Power ICT Equipment in Local Secondary Schools

In this section, respondents were asked to indicate their level of agreement with the different statements that described each of the factors using a five-point Likert scale. The researcher used the following five-point Likert scale interpretation: strongly agree (5), agree (4), not sure (3), disagree (2), and strongly disagree (1). Analysis of the frequencies and percentages of the strongly agree, agree, disagree, strongly disagree responses, provided a better picture of what respondents perceive about challenges facing the use of alternative sources of energy to power ICT equipment in the local secondary schools in Nandi County. Table 4.2 below shows the respondents responses regarding the electric power challenges facing the use of alternative sources of energy to power ICT equipment in Nandi County of Kenya.

Table 4.2
Challenges Facing the Use of Alternative Sources of Energy to Power ICT Equipment in Local Secondary Schools

Item	Response	Frequency	Percentage
There is a scarcity of electricity in our school	Strongly disagree	19	17
	Agree	74	67
	Strongly agree	19	17
Kenya Power electricity is expensive	Strongly disagree	19	17
	Agree	74	67
	Strongly agree	19	17
The school experiences electric power outages	Strongly disagree	19	17
	Agree	55	50
	Strongly agree	36	33
There is lack of standalone generators in the our school	Strongly disagree	19	17
	Agree	55	50
	Strongly agree	36	33
	Strongly agree	36	33
Solar power panels are expensive	Strongly disagree	19	17
	Disagree	19	17
	Agree	55	50
	Strongly agree	19	17
There are no solar power fitting technicians	Strongly disagree	19	17
	Agree	74	67
	Strongly agree	19	17
There are no standby generator mechanics	Strongly disagree	19	17
	Agree	74	67
	Strongly agree	19	17

The majority of the respondents representing 74 (67%) schools out 101 of agreed, while 17% of the respondents (representing 19 schools) strongly agreed that there was a scarcity of electricity in their schools. Only 17% of the respondents (representing 19 schools) indicated that schools had electricity. This indicates that there was scarcity of electricity in the local secondary schools. Odinga (2008) confirms that there is a scarcity of electricity in Kenya. In Kenya eighty percent (80%) urban and ninety-nine point five percent (99.5%) rural areas respectively have no access to electricity (Rabah, 2004). There is a power demand that exceeds power supply in Kenya (European Regional Survey of the World (2007). In 2002, demand for electricity in Kenya grew by 4.9 % (Power engineer, 2009) and since then, electricity consumption has increased by about 8 % a year over the past five years (Water technology.net, 2009). According to the K.P.L.C. (2006), the consumption of electricity has risen sharply to the extent that there is need to expand energy generation sources. Atur and Kennedy (2000), support this claim, by indicating that forecast electricity production growth rates are lower than those for electricity consumption. There was scarcity of electricity in most local secondary schools in Nandi County of Kenya because forecast electricity production growth rates are lower than those for electricity consumption and most of the rural areas have no access to electricity.

The majority of the respondents representing 74 schools or 67% agreed, while 17% of the respondents representing 19 schools strongly agreed that Kenya Power Company power bills were high. Only 17% of the respondents representing 19 schools indicated that the bills were low. This indicates that the Kenya Power Company electricity bills were high. Njoroge (2011) reported that Kenya Power charges customers high bills because the power consumed is generated by burning fuel which is expensive. Kamau (2011) agrees with Njoroge that with time, cost of fuels has kept on increasing, a factor that has made electricity bills to escalate now and again. Many people in Kenya are paying high electricity bills that leave them with no savings to invest in order to improve their lifestyles (Mwanje et al., 2008). The Kenya Power Company electricity bills are high. They are high because the power consumed is generated by burning fuel which is expensive.

Half of the respondents (50% representing 55 schools) agreed, while 33 % of the respondents representing 36 schools strongly agree that the schools experienced power outages, but 17% of the respondents representing 19 schools strongly disagreed that the schools experienced power outages. This indicates that the local secondary schools that were supplied with electricity from the Kenya Power Company experienced power outages. Obonyo (2011) testifies that Kenya experiences a lot of power outages. Cheison (2012) concurs with Obonyo and adds on that the small number of schools supplied with electricity in Nandi County suffer from a lot of power outages because of outdated technologies of transmission and distribution of electricity. Local secondary schools that are supplied with electricity from the Kenya Power Company experienced power faults because of weak transmission or distribution network, low countrywide electricity access and over-reliance on hydropower which is vulnerable to weather variation.

Half of the respondents (50% representing 55 schools) agreed and 33% of the respondents representing 36 schools strongly agreed that the schools lacked standalone generators to power ICT equipment. However, 17% of the respondents representing 19 schools strongly disagreed that the schools lacked standby generators to power ICT equipment. This reveals that lack of a standby generator is a drawback to the use of ICT in instruction in secondary schools. Chesion (2012) while assessing Nandi County take-off to prosperity found out that the secondary schools in Nandi County lacked standby generators. He added on that lack of standby generators affected the use of ICT in those secondary schools. According to Lyakurwa (2007), many schools lack standby generators because their cost is prohibitively high for small firms (Lyakurwa, 2007). According to CTA (2007) considering the going up of diesel generators price and the ever rising cost of diesel fuel many schools cannot afford to buy diesel and also buy spare parts for the running of these generators CTA (2007). Lack of a standby generator is a drawback to the use of ICT in instruction in the local secondary schools because most of the schools are not able to purchase standby generators and the cost of running them is high.

On one hand, half of the respondents or 50% representing 55 schools out of 110 agreed while 17% of the respondents representing 19 schools out of 110) strongly agreed that solar power system were expensive to install. On the other hand, 17% (representing 19 schools out of 110) strongly disagreed and another 17% (representing 19 schools out of 110) disagreed that installing power inverter systems was expensive. This shows that installing solar power systems in schools is expensive. Import duties and other charges on PV modules and the associated fittings make the initial installation of solar power systems expensive (Fishbein, 2000). According to Madson (2011), to produce a substantial amount of electricity from solar power require a significant investment on PVs and other related solar power fittings. Modi (2012) supports Madson by revealing that the cost of the PVs and their associated fittings is still high. Solar energy installation initial costs are high (Solar & Wind energy (2009).

The majority of the respondents representing 74 schools out of 110 (67%) agreed, while 17% of the respondents (representing 19 schools) strongly agreed that there were no qualified solar power fitting technicians. Only 17% of the respondents (representing 19 schools) indicated that that there were qualified solar power fitting technicians. This reveals that there were no qualified solar power fittings technicians to install service and maintain solar power systems in the local secondary schools in Nandi County. In remote areas, there often no qualified solar power fitting technicians to install and repair solar power systems (Vaccaro, et al, 2010). PV systems are more likely to fail in areas that lack the technical skills that are needed to ensure long-term sustainability (Winrock International, 2004). In a study conducted by Venezky (2001) most schools technical lack of qualified technicians was reported as a major barrier to usage of solar powered systems. There was problem to find qualified solar power technicians to install and repair the local schools solar power systems because they were situated in remote areas and where many young people have not been encouraged to train as solar power technicians.

The majority of the respondents representing 74 schools out of 110 (67%) agreed, while 17% of the respondents (representing 19 schools) strongly agreed that there were no qualified standby generator mechanics. Only 17% of the respondents (representing 19 schools) indicated that that there were qualified standby generator mechanics. This indicates that there that there were no qualified standby generator mechanics to service and maintain standby generators in the local secondary schools. Use of standby generator is affected with technical problems such as lack of a qualified technician in case if it breaks down (Modi, 2010). Attracting young students into careers as engineers, technologists, or technicians is a serious problem in most countries (Ragaller and Dandliker, 2010). There was a problem to find a qualified mechanic to repair the standby generators in most local schools because of lack of encouraging young people into careers as engineers, technologists or technicians in Nandi County.

The above findings show that schools in Nandi County face a number of challenges as far as the use of alternative sources of energy. The challenges include; high cost of electricity, a series of power outages, lack of standby generators, high costs of generators fuels, expensive solar power fittings, lack of qualified solar power fitting technicians, and lack of qualified standby generator mechanics.

4.3 Principals' Opinions on the Use of Alternative Energy Sources to Power ICT Equipment in Nandi North County Local Secondary Schools

In this part, the respondents were asked to indicate their level of agreement with the different statements that described each of the factors using a four-point Likert scale. The researcher used the following four Likert scale interpretation: agree (4), tend to agree (3), tend to disagree (2), and disagree (1). Analysis of the frequencies, means and percentages of the agree, tend to agree, tend to disagree and disagree responses, provided a better picture of what principals' attitudes towards the use of the alternative sources of energy to power ICT equipment in the local secondary schools in Nandi County. Table 4.3 below shows the schools principals' opinions in regard to the use of alternative sources of energy to power ICT equipment in Nandi County of Kenya.

Table 4.3
Principals' Opinions on the Use of Alternative Energy Sources to Power ICT Equipment in Nandi North County Local Secondary Schools

Item	Response	Frequency	Percentage
Solar power would assist to power ICT equipment	Agree	91	83
	Strongly agree	19	17
Wind generated electricity would assist to power ICT equipment	Disagree	36	33
	Agree	55	50
	Strongly agree	19	17
Standby generator is cheaper than Kenya Power electricity	Strongly disagree	19	17
	Agree	91	83
Solar power is cheaper than Kenya Power electricity	Disagree	19	17
	Agree	36	33
	Strongly agree	55	50

The majority of the respondents or 83% representing 91 schools out of 110 agreed, and 17% of the respondents representing 19 schools out of 110 strongly agreed that the use of solar power will assist in powering of ICT equipment in the secondary schools. This indicates that solar power can assist in the powering of ICT equipment in secondary schools in Kenya. This finding is supported by Odinga (2008) who affirmed that there is a high potential of generating electricity from solar energy because Kenya lies astride the equator and has an average annual installation of between 4 and 6 Kilowatt-hours per square meter per day. In a study conducted by Macintosh and Hamilton (2007), a large proportion of both men and women prefer to get their electricity from solar power i.e. 44% and 56% for men and women respectively. Photovoltaic power offers a proven and reliable source of electrical power for remote, small-scale ICT Facilities (Pandey and Acharya, 2004). Solar power can assist in the powering of ICT equipment in secondary schools because there is plenty of sunshine that can be harnessed to power small scale

ICT facilities in remote areas. Also the computers being manufactured currently consume less power and can be powered from solar and wind powered electricity.

Half of the respondents, (50% representing 55 schools out of 110) agreed, 17% of the respondents representing 19 schools out of 110 strongly agreed and the remaining 33% of the respondents representing 36 schools out of 110 disagreed that the use of wind generated electricity would assist in powering of ICT equipment in the secondary schools. This indicates that wind generated electricity would assist in the powering of ICT equipment in secondary schools. Wind generated electricity would assist in the powering of ICT equipment in secondary schools because it is a potential source of energy for electrical power in rural and remote areas. There is a high potential of generating electricity from solar energy because Kenya lies at the equator and has an average annual installation of between 4 and 6 Kilowatt-hours per square meter per day (Odinga, 2008). EnergyPedia agrees with Odinga by revealing that the channeling and hill effects due to the presence of the Rift Valley and various mountain and highland areas have endowed Kenya with some excellent wind regime areas which can be utilized to generate electricity from wind energy (EnergyPedia, 2012).

Half of the respondents (50 % representing 55 schools out of 110) strongly agreed, and 33% of the respondents representing 36 schools out of 110 agreed that solar power was cheaper than Kenya Power Company electricity. Only 17% of the respondents representing 19 schools out of 110 disagreed that solar power was cheaper than Kenya Power Company electricity. This indicates that solar power is cheaper than Kenya Power Company electricity. Anyanzwa (2012) reveals that solar power generated electricity is cheaper than electricity supplied by the Kenya Power Company. Solar power is cheaper than the Kenya Power Company electricity because solar panels are typically no moving parts in PV systems, they require minimal maintenance and the use of solar panels to power lights or anything electrical can save you a lot on your electricity bills since solar is a natural resource which you do not have to pay for.

From the findings above, it is evident that alternative sources of energy can be harnessed and used to generate electricity that can be used to power ICT equipments in secondary schools in Nandi County. However, it is interesting to reveal that alternative sources of energy are not used to generate electricity which is a scarce resource in Nandi County secondary schools.

4.4 The Use of Solar Power to Power ICT Equipment in Nandi County

In this section, respondents were asked to indicate their agreement with the different statements that described each of the factors using a Yes and No scale. The researcher used the following scale interpretation: Yes (1) and No (2). Analysis of the frequencies and percentages of the Yes and No responses provided a clear picture of what respondents perceive about the use of solar power to power ICT equipment in local secondary schools in Nandi County.

Table 4.4
Use of Solar Energy to Power ICT in Nandi County secondary schools

Item	Response	Frequency	Percentage
Our school use of solar power to power overhead projectors used teaching and learning.	No	110	100
Our school use of solar power to power computers used in teaching and learning.	No	110	100

All the respondents 110 (or 100%) indicated that all the schools did not use solar power to power overhead projector in teaching and learning. All the respondents 110 (or 100%) indicated that all the schools did not use solar power to power computers for teaching and learning. In general, this indicates that the secondary schools did not use solar power to power ICT equipment. This is in agreement with Muwanga_Zake (2007), who reported that many local schools do not use solar power as a source of electricity for lighting and powering their electronic equipment because of lack of awareness of the potential. Low awareness of the potential opportunities and economic benefits offered by solar power, and lack of adherence to system standards are some of the barriers affecting the use of solar energy resource (SREP, 2011). According to Modi (2011) people are afraid of using solar power because the PVCs and associated fittings have high initial costs.

4.5 The Cons and Pros of using Solar Power to Power ICT in Nandi County Secondary Schools

From the interview schedule, the principals indicated that many local secondary schools were not supplied with electricity from Kenya Power Company and a few that were supplied with electricity experienced power outages which affected the use of ICT equipment in the local secondary schools. The principals also confirmed that there was no use of solar and wind as alternative sources of energy in various secondary schools in Nandi County. To alleviate the challenges of accessing electricity for ICT use in Nandi County, the principals recommended that solar energy can be used to generate electricity to power ICT equipment in Nandi County secondary schools. This opinion concurs with the Kenya's Ministry of Education recommendation that schools without mains electricity to be supported to acquiring solar panels as a means to generating electricity to power ICT equipment (MOEST, 2005). A long term study conducted by World Bank, Columbia Earth Institute and the Kenya Power and Lighting Company (KPLC) that assessed Kenya's electricity needs reported that there is a need to install solar PV in remote areas to help the energy sector to meet national electricity needs (World Bank, 2007).

This findings show that alternative sources of energy (solar and wind energy) can be harnessed to generate electricity that can be used to power ICT equipments in Nandi County secondary schools in most regions that are not supplied with electricity from the National Grid.

4.6 Discussion

4.6.1 The Available Alternative Sources of Energy that can be used to Power ICT Equipment in Nandi County Schools.

The problem of using ICT equipment in Nandi County is mainly as a result of inadequate supply of electricity by Kenya Power from the national grid and lack of the use of alternative sources of energy. In this study, it comes out clearly that most of the schools were not supplied with electricity from the national grid. Table 4.1 shows that majority of the schools, i.e. 74 schools out of 110 representing 67%, were not supplied with electricity from the Kenya Power Company. This was due to the shortage of electricity in the county. This is underscored by Chapari (2009) who laments that there is a serious shortage of electricity in Kenya. This problem is compounded because most of these schools are located in remote areas where grid extension is expensive. In most of the remote areas, there is no access to the grid because the grid extension is unaffordable

(Winrock International, 2004). Kenya has inadequate electricity generation capacity because it relies on hydro generated power which is hampered by lack of many big rivers. This is in line with ICS (2011) assertion that most of African countries have inadequate electricity generation capacity. The schools in Nandi country lacked electricity because there was a general scarcity of electricity and the little electricity available could not reach remote areas due to high cost in electric power grid extension.

It is also revealed by this study that the schools did not use solar power generated electricity. Table 4.1 also indicates that all 110 sampled secondary schools (representing100%) did not use solar power. All the sampled secondary schools were not using solar power to power ICT infrastructure because of lack of awareness. Chandak (2011) attributes lack of the use of solar power to higher level of ignorance and awareness of the benefits accrued from the use of solar energy. Also the solar power fittings were perceived by many schools administrators as being expensive. In his study of the factors affecting the use of solar power to generate electricity, Madson (2011) reported that to produce sufficient amounts of electricity, a large number of panels may be needed resulting to a significant financial investment. Modi (2010) supports Madson by indicating that the PV technology and some associated fitting costs have a high initial cost. Lack of government initiative and encouragement to use solar power has made people to lose confidence on the use of solar power. Chandak (2011), in his study of the use of solar power to power ICT equipment in India reported that people’s loss of confidence in the use of solar power is the reasons for failure of solar energy to power ICT equipment in the schools. The schools in Nandi County did not use solar power electricity because they lacked awareness of its benefits, there were no government incentives and the administration felt that the cost of solar power fittings was expensive.

The study also shows that there was no use of wind generated power in Nandi County schools. Table 4.1 reveals that all respondents in 110 schools (100%) indicated that all the sampled secondary schools had no installed wind power generator. This was because many people in the county were ignorant of the use of wind power generated electricity. Poor level of awareness is a factor that has led to many local secondary schools lack of utilization wind power generated electricity (Chandak, 2011). Another reason that leads to lack of the wind power generated electricity is that small scale wind turbines sometimes generate intermittent electricity which is not quality for the use of ICT equipment. This is underscored by Pyakuryal (2002) who says that among the decentralized electricity systems, small-scale wind system is intermittent and weather dependent. Big wind power generator requires a substantial investment making many school administrations blush aside its installation. High capital cost and lack of sufficient wind regime data are some of the barriers affecting the exploitation of wind energy resource (SREP, 2011). This indicates that the local secondary schools had no wind power generated electricity installed in the institution because of poor levels of awareness, high initial capital cost and lack of sufficient wind regime.

The sampled secondary schools did not also use standalone generators to power ICT equipment. Table 4.1 also shows that all 110 (100%) sampled secondary schools did not have standalone generators to generate power. This is because of high prices of generator fuel. High prices for gasoline prevent many local schools from making use of standby generators (Zweibei, 2008). The use of a standalone generator can be faced with difficulties of investment, financing and operating-cost (Modi, 2010). All sampled secondary schools had no standalone generator generated power to be used to power ICT infrastructures because the cost of running a standalone generator was considered high.

4.6.2 The Challenges Facing the use of Alternative Sources of Energy in Schools in Nandi County

The secondary schools in Nandi County faced a number of challenges in the use of alternative sources of energy. This study revealed that all sampled secondary schools lacked solar power generated electricity. Table 4.2 shows that half of the respondents representing 55 schools out of 110 or 50% agreed and 33% of the respondents representing 36 schools out of 110 strongly agreed that schools lacked solar power to power ICT equipment. This is because lack of awareness of the merits of using solar power and administrators perceptions that, solar power system fittings are expensive. Low awareness of the potential opportunities and economic benefits offered by solar technologies are some of the barriers affecting the exploitation of solar energy resource (SREP, 2011). The variation of weather conditions is a challenge to the use of solar power. The off-site opportunities for solar power energy are limited in most areas and cannot be significantly developed (Nicholson, 2010). According to Njeri (2011), the weather has been quite unpredictable in some regions in Kenya making it difficult to utilize solar power. The local schools lacked solar power to power ICT equipment because of high initial capital costs and low awareness of the potential opportunities and economic benefits offered by solar technologies. For the case of Nandi County, weather conditions are not a drawback as such since the area enjoys a substantial amount of sunshine.

The lack of the use of standalone generators was another drawback to the use of ICT in the secondary schools. *Table 4.2* again indicates that half of the respondents representing 55 schools out of 110 or 50 % of the respondents agreed and 33% of the respondents representing 36 schools out of 110 strongly agreed that the schools lacked the use of standalone generators to power ICT equipment. This is because the imported fuel that is used to run the generators is expensive. Standalone generators rely on expensive oil to generate electricity making the average cost of power production extremely high (ICS, 2011). Menjo and Boit (2005) agree with ICS by stating that the use of standalone generators is challenging because diesel is expensive. The high price of fuels is a drawback to the use of standby generators to power ICT equipment in the Nandi County secondary schools.

There was no solar power systems installed in the schools because the administrators felt that solar power system fitting were expensive. Table 4.2 shows that half of the respondents representing 55 schools out of 110 or 50% agreed while 17% of the respondents representing 19 schools out of 110 strongly agreed that solar power system were expensive to install. This shows that installing solar power systems in schools is expensive. Nicholson (2010) reports that solar power system fittings are expensive making the installation of solar power systems a big challenge. The initial cost of solar power is high but its use has long term benefits that outweigh the incurred initial costs. While often more expensive than other renewable technologies, the modularity of PV systems and the broad availability of the solar resource, sunlight, often make PV the most technically and economically feasible power generation option for small installations in remote areas(USAID, 2004). The installation of solar power systems in schools is expensive because photovoltaic are high in cost and are highly taxed once imported.

The installation of solar power systems require qualified technicians who are not available in Nandi County. *Table 4.2* indicates that majority of the respondents representing 74 schools out of 110 or 67% agreed while 17% of the respondents representing 19 schools out of 110 strongly agreed that getting a qualified solar power electrician to install and service a solar power system was a problem. This indicates that there was a problem to find a qualified solar power electrician to install and repair schools solar power systems. Where electrical energy sources are present, there often is insufficient operations, maintenance and repair capability on the part of the local people (Vaccaro, et al, 2010). The schools may be willing to install solar power systems but they need qualified technicians to service them when they fail. PV systems are more likely to fail in areas that lack the commercial and technical equipment needed to ensure long-term sustainability (Winrock International, 2004). In a study conducted by Venezky (2001), most schools technical difficulties were reported as a major barrier to usage and a source of frustration for students and teachers. There is a problem to find a qualified solar power electrician to install and repair the local schools solar power systems. This has led to solar power systems insufficient operations, maintenance and repair capability on the part of the local people.

The running of a standby generator involves rotation of parts that wear out due to friction and therefore require a qualified mechanic to occasionally service them. In Nandi county schools, there were no qualified mechanics to service standby generators. *Table*

4.2 reveals that majority of the respondents representing 74 schools out of 110 or 67% agreed that getting a qualified mechanic to service a standby generator is a problem. This indicates that is was a problem to find a qualified mechanic to repair a standby generator in most schools. The use of standby generators is faced with technical problems such as lack of qualified technicians in case it breaks down (Modi, 2010). Regaller and Dandliker (2010) lament that, attracting young students into careers as engineers, technologists or technicians is difficult in most countries (Ragaller and Dandliker, 2010). Lack of local knowledge, including illiteracy in some cases, contribute to once-functioning systems languishing in a state of disrepair (Vaccaro, et al, 2010). There was a problem to find a qualified mechanic to repair the standby generators in most local schools in Nandi County. This could be because of lack of many young people interested in engineering, technologist or technician carriers.

4.6.3 The Principals' Opinions on the Use of Alternative Energy Sources to Power ICT Equipment in Nandi North County Local Secondary Schools

The schools principals had a positive attitude towards the use of alternative sources of energy to power ICT equipment in the schools. *Table 4.3* shows that Majority of the principals representing 91 schools out of 110 or 83% tended to agree, and 17% of the principals representing 19 schools agreed that the use of solar power will assist in powering of ICT equipment in the secondary schools. This indicates that solar power can assist in the powering of ICT equipment in secondary schools. Since solar panels are solid state devices with no moving parts, they are likely to function well beyond the 20-30 year standard warranties making them true investments in the future of the community (McLaughlin et al., 2010). The use of solar energy in the schools will help to clean the environment and cut down electricity expenses. Bennets (2008) reveals that the installation of solar power in the school will help the school become earth friendly and save the school from high electricity bills. Zweibei (2008), while investigating the benefits of using solar energy in the United States of America found out that a massive switch from coal, oil, natural gas and nuclear power plants to solar power plants could supply 69 percent of the U.S.'s electricity and 35 percent of its total energy by 2050. The use of solar power in Nandi County is a viable option since most schools in the region are situated in remote areas which are not supplied with electricity from the national grid but enjoy plenty of sunshine. Photovoltaic power offers a proven and reliable source of electrical power for small-scale ICT facilities in remote areas (USAID, 2004). Nandi County receives a substantial amount of sunshine daily making solar power a feasible project. Kenya receives daily insolation of 4-6kWh/m^2 (SREP, 2011). Solar PV is also argued to have enhanced value within an electrical grid because the extra power produced from solar energy is fed to the National grid Borenstein, 2008). Also solar power is used where it is generated and therefore reduces the costs of transmission and distribution investments. Solar power can assist in the powering of ICT equipment in secondary schools because photovoltaic power offers a proven and reliable source of electrical power in remote areas.

The use of wind generated electricity can help to power ICT equipment in Nandi County schools. *Table 4.3* indicates that half of the respondents representing 55 schools out of 110 or 50% tended to agree and 17% of the respondents representing 19 schools out of 110 agreed that the use of wind generated electricity would be used to power ICT equipment in secondary schools. This indicates that wind generated electricity would assist in the powering of ICT equipment in secondary schools. Generating electricity from wind power is an option that should be embraced in Nandi County because wind is provided freely by nature. There is increasing evidence that both oil and gas global extraction rates could peak in the near future and this will force people to use alternative energy sources like wind generated electricity (Dodds and Venables, 2010). Most parts of Nandi County are located in remote areas inaccessible by the national grid making the use of wind energy to generate electricity a viable project. Wind power is a potential source of electrical power in rural and remote areas ((USAID, 2004). Unlike the use of diesel engines, generating electricity by wind power is a less air pollution project. The manufacture of wind generator blade by use of fiber-reinforced plastic (FRB) and reasonable aerodynamic shape has made the machine to run with very low noise (Alibaba, 2014). The importance of wind power is increasing in the sense that comparatively with other sources; it lessens air pollutants or greenhouse gases (Pyakuryal, 2002). Wind power is infinitely free source of energy, does not emit greenhouse gases or any pollutants, has over 15 years lifetime span, little or no maintenance required, automatically operated, no fuel required, can be used in conjunction with other renewable energy technologies, and saves time which can be spent in natural resource management (Harper and Oglethorpe, 2009). A survey conducted by SREP (2011) on the viability of using wind power to generate electricity in Kenya reveals that Kenya has a proven wind potential of as high as $346 w/m^2$ in some parts of Nairobi, Rift Valley, Eastern, North Eastern and Coast Provinces with the current installed capacity is 5.1 MW operated by KenGen at the Ngong site. Kenya has a potential to generate electricity from wind power that can be used to powering of ICT equipment in secondary schools.

Solar is another source of energy provided freely by nature and therefore a long term cheap source of electricity once it is properly harnessed. *Table 4.4* shows that a half of the respondents representing 55 schools out of 110 or 50% agreed and 33% of the respondents representing 36 schools out of 110 tended to agree that solar power was cheaper than KPL company electricity. This indicates that solar power generated electricity is cheaper source than Kenya Power Company electricity. The use of solar panels to generate electricity saves a lot on electricity bills (Bennet's, 2008). The Energy Saving Trust (EST) estimates that a typical local school can knock over nine thousands Kenya shillings (Kshs. 9,000/=) in one year off their bills with a typical 2.7 Kwp system (Jenny, 2011). Solar electricity equipment once properly installed can last for a long period of time since they don't have rotating parts that can be won out by friction. This is in agreement with USAID (2004) which reported that solar panels typically have no moving parts in PV systems therefore require minimal maintenance. Solar power is cheaper than the Kenya Power Company electricity because it is obtained freely from nature and the solar PV systems require minimal maintenance.

Generating electricity by use of standalone generators in Nandi County schools is expensive as compared to the power obtained from Kenya Power. *Table 4.4* reveals that majority of the respondents representing 91 schools out of 110 or 83% disagreed that standalone generator power was cheaper than Kenya Power Company electricity. This indicates that standalone generators power is expensive than Kenya Power Company electricity. This is because the fuel used to run generator keeps on rising now and again.

The cost of generation from these diesel plants is high and unpredictable due the fluctuating international crude oil prices (SREP, 2011). Barbier (2011) argues that due to high dependence on the imported combustible fossils, Kenya has been very much affected by the increase in prices of hydrocarbons during the last decade. The economic risk of relying primarily on imported energy has grown in recent years as oil prices have become less stable, doubling in less than two years to over $60 per barrel (Flavin and Aeck, 2005). Where there was no grid power, electrical power for the services was provided by small petrol driven generators which have proved to be restrictive due to the high cost and limited availability of fuel (Nordhausen, 2011). Standalone generator power is expensive than Kenya Power Company electricity because using generators that are oversized for small loads results in expensive or inefficient use of fuel and generators are high dependence on importation of combustible fossils which are very expensive.

4.6.4 The Use of Solar Power to Power ICT Equipment in Nandi County Secondary Schools

There was no use of solar power to power ICT equipment in Nandi County secondary schools. In this study, it comes out clearly that all the schools did not use solar energy to power ICT equipment. Table 4.2 shows that all the respondents 110 (or 100%) indicated that all the schools did not use solar power to power overhead projector in teaching and learning. All the respondents 110 (or 100%) indicated that all the schools did not use solar power to power computers for teaching and learning. In general, this indicates that the secondary schools did not use solar power to power ICT equipment. This is in harmony with Muwanga_Zake (2007), who revealed that many local schools did not use solar power generated electricity to power ICT equipment because of lack of awareness of the solar power potential. Low awareness of the potential benefits offered by solar power is one of the barriers affecting the use of solar energy resource (SREP, 2011). Another possible reason that affects the use of solar power to power ICT equipment in Nandi Count secondary schools is the high prices of solar power fittings. This is in line with Modi (2011) who reported that people are afraid of using solar power because the PVs and associated fittings have high initial costs.

4.6.5 The Cons and Pros of Using Solar Power to Power ICT Equipment in Nandi County Secondary Schools

There is a potential of using solar power to power ICT equipment in secondary schools in Nandi County. From the interview, the principals preferred most the use of solar energy as compared to other sources of renewable sources of energy. This is in agreement with Singh (2008) who reported that solar energy is of a great potential as future energy in regions where sunshine is available for longer hours per day and in great intensity. Energy efficient information and communication technology equipment paired with appropriate solar panels, personal computers (PCs) can be introduced in areas where there is lack of supply of electricity (Mash et al., 2011). Wavion (2008) supports both Singh and Mash et al. by asserting that fewer base stations per school, with low power consumption per base station will enable schools to save the expenditure on power from the national grid. In a recent study that incorporated the “possibility” of a significant reduction in costs by 2030 conducted by Matsuo Yuhji, an economist and nuclear energy “expert” at the Institute of Energy and Economics, Japan, indicate that a lot of electricity can be generated from solar power that can be used to power ICT equipment (Clean Technica, 2012). In his study on viability of using solar power in schools in Canada and

Kenya, Smith (2009) found out that there is abundant sunlight in Kenya that can be used to generate electricity to power ICT in Kenya that can be used to power ICT equipment in schools. A feasibility study conducted in June 2010 by three members of San Diego Professional Chapter to determine the possibility of building a PV solar electric system in Rusinga and Mfangano islands schools revealed that it was possible to generate electricity that can be used to power ICT equipment in many schools in Kenya (Engineers Without Borders-USA, 2012). This reveals that solar power can be used to generate electricity to power ICT equipment in Nandi County schools. There is need to use solar and wind power technologies to generate electricity. Potocnic (2006) advises that a wide range of energy technologies need to be employed to meet the challenges of a liberalized market and a changing climate.

4.7 Summary

Majority of the schools in this study were not supplied with electricity from the National Grid and did not use any alternative sources of energy to power ICT equipment. Lack of electricity in many secondary schools, power outages in the schools supplied with electricity, high cost of electricity and high cost of diesel were the major draw backs of using ICT equipment in the local secondary schools. Lack of the use of alternative sources of energy was another drawback to the use of ICT equipment in the local secondary schools.

CHAPTER FIVE

FINDINGS, CONCLUSION AND RECOMMENDATIONS

5. 0 Introduction

This study focused on the challenges of accessing electricity for ICT use in Kenyan secondary schools in Nandi County. In this chapter, the major findings of the study are highlighted and conclusion drawn from the study. The recommendations derived from the research findings are stated. In addition, this section also presents suggestions for further research.

5.1 Findings

The purpose of this study was to assess the challenges of accessing electricity for ICT use in Kenyan secondary schools. The challenges are characterized by shortage of electricity, cost of electricity, power outages and lack of use of alternative sources of energy to generate electricity for ICT use.

The following were the findings of the study:

1. Majority of the local secondary schools were not supplied with electricity by the Kenya Power Company.
2. The few schools that were supplied with electricity experienced power outages.
3. All sampled local secondary schools had no solar generated electricity, wind generated electricity or reliable standby generators.
4. The Kenya Power company power electricity bills were high. This is because the schools do not have an energy management system, electricity is a scarce resource provided by one company (Kenya Power) that monopolizes the market and there

is no competitor. Also the use of alternative sources of energy have not been embraced to cater for the deficit and change the electricity market from a monopolistic type to a perfect competitive market where the prize of a commodity is determined by the law of demand and supply.

5. Solar power systems were expensive to install in the local secondary schools.
6. Scarcity of electricity, high bills of electricity, power outages, lack of standby generators and lack of use of alternatives sources of energy were the challenges facing the use of ICT in teaching and learning in Nandi County secondary schools.
7. Solar power and wind power generated electricity can assist to power ICT equipment in Nandi County secondary schools.

5.2 Conclusions

From the finding of this study the following conclusions are drawn:

1. ICT is important and must be embraced by all schools.
2. The use of ICT in teaching and learning majorly relies on the availability of electricity.
3. It is possible to run ICT equipment using alternative sources of energy.

5.3 Recommendations

Based on the foregoing discussion of the findings and conclusion, the following recommendations are offered.

1. The government should supply electricity to all secondary schools. This will help the schools to fully use ICT in teaching and learning.

2. The government should initiate renewable sources of energy projects to cater for the electricity deficit. This will reduce the cost of electricity because generating electricity from renewable sources of energy is cheaper than electricity generated by diesel generators which relied on imported and expensive fuel.
3. The power distribution companies should use modern power distribution methods that are less prone to breakages due to the natural phenomena. This will reduce to power outages and greatly protect the ICT equipment from power surges and destruction.

5.4 Suggestions for Further Research

To bring more light into the issue investigated in this study, it was suggested that the following studies be conducted.

1. A similar study should be conducted in other counties to determine the electric power challenges facing the schools in the use of ICT equipment in local secondary schools. This will help to compare and contrast the degree of effect of electric factors affecting the use of ICT equipment in various counties in Kenya.
2. Future research should be conducted to establish the feasibility initiating alternative sources of energy projects in secondary schools.

REFERENCES

Abramowski, J. and Posorski, R (2000) Wind energy for developing countries. *DEWI Magazin Nr. 16, February 2000*. Retrieved on November 4, 2014, from, http://www.dewi.de/dewi_res/fileadmin/pdf/publications/Magazin_16/06.pdf.

Adams, A. S. and Keith, D. W. (2013) Are global wind power resource estimates Overstated. *IOP Science*. Retrieve on September 22, 2013, from, http://iopscience.iop.org/1748-9326/6/2/025101?rel=ref&relno=3.

Afonso, J. L., Freitas, M. J. S., and Martins, J. S. (2003) P-Q theory power components calculation. *IEEE Journal*. Rio de Janeiro, Brasil, 9-11 Junho de 2003, ISBN: 0-7803-7912-8.

Afrosocialmedia (2011). ICT rural development. *Social Media Africa, March 3, 201*. Retrieved May 6, 2011, from http://afrosocialmedia.wordpress.com/2011/03/03/icts-in-rural-development/

Ajegbomogun, F. O. (2007) Impediments to Harnessing Scholarly Electronic Journals on the Internet in Developing Countries: A Nigerian University Case Study. *Journal of Library Hi Tech News, Volume:24, Number:6, Year:2007, pp:27-32*. Retrieved May 4, 2011, from http://www.emeraldinsight.com/journals.htm?articleid=1623708&show=html

Akakpo, J. (2008). Rural access: Options and challenges for connectivity and energy in Ghana. *Ginks, October 2008*. RetrievedSeptember 6, 2011, from, http://www.iicd.org/files/Rural-Access-Ghana.pdf.

Akanga, E. (2006). Power shortage has become a problem in recent time. *Rwanda Development Gateway*. Retrieved February 20, 2010, from http://www.rwandagateway.org/article.php3?id_article=3731.

Alibaba (2014) Three-phase-hybrid solar wind powered generator for household. *Alibaba*. Retrieved November 3, 2014, from, http://www.alibaba.com/product-detail/Three-phase-hybrid-solar-wind-power_6024506169.html?s=p.

Anayanzwa, J. (2012) Effort to enhance green energy gets 1.3b boost. *The Standard*. Thursday, September 20, 2012. Pg 39.

Amedzo, E. K. (2007*). Integration of Information and communication technology into rural schools of South Africa: A case study of Schools in Malamulele*. A thesis presented in partial fulfillment of the requirements for the degree of Master of Philosphy (Information and Knowledge Management) Stellenbosch University. Retrieved August 23, 2011. From http://scholar.sun.ac.za/bitstream/handle/10019.1/2135/Amedzo.pdf?sequence=1

Asakura, K., Tanaka, T., and Babasaki, T. (2010). Higher-voltage Direct Current Power-feeding System. *NTT Technical Review*. Retrieved January 4, 2012, from, https://www.ntt-review.jp/archive/ntttechnical.php?contents=ntr201102fa2.html

Baburajan, R. (2011). Renewables to be the fastest-growing source of world energy: REWE . *TMCnet. May 02, 2011*. Retrieved May 3, 2011, from http://green.tmcnet.com/channels/renewable-energy/articles/170318-renewables-be-fastest-growing-source-world-energy-rewe.htm

Backburn, J. O. and Cunninggham, S. (2010) Solar and nuclear costs- The historic crossover: Solar energy is now the better buy. *NC WARN*. Retrieve August 28, 2011, from, http://www.ncwarn.org/wp-content/uploads/2010/07/NCW-SolarReport_final1.pdf.

Barasa, M. (2010). *Wind regime analysis and reserve estimation (case study: - Kenya)*. A Master of Science in Energy Management, University of Nairobi. Retrieved on November 4, 2014, from, http://cae.uonbi.ac.ke/sites/default/files/cae/cae/MAULIDI%20BARASA%20F56-65971-2010.pdf

Barbier, E. (2011) Electricity: a major growth lever for the East African economy. *Ufaransa Leo Lighting Up Kenya, Issue No. 8*. Retrieved August 30, 2011, from, http://www.ambafrance-ke.org/IMG/pdf/Ufaransa_Leo_-_issue_28-2.pdf.

Battery Council International (2005). Lead Acid Batteries. *Electropedia: Battery and Energy Technologies*. Retrieved 9th December 2009, from http://www.mpoweruk.com/leadacid.htm

Bayless, C. and Hardy, B. (2007) *Transmission and Distribution Electrical Engineering*. Third edition. New York: USA. Elsevier Ltd.

Bayero University (2002). Information and communication technology profile. *Bayero University Kano, July 2002*. Nigeria. Retried June 20, 2011, from, http://www.foundation-partnership.org/linchpin/buk.htm

Bennet's (2008) Solar power! reduce, reuse and recycle! *Reduce Recycle Reuse*. Retrieved August 24, 2011, from, http://yr6rrr.wikispaces.com/Solar+power-+ideas+for+the+future.

Beumann, S. Rockford, Beatty, C., Brownell, S. And et al. (2009) Activities to incorporate installed photovoltaic systems into the classroom learning environment. *Schools Going Solar.* Retrieved Auguast 24, 2011, from, http://www.need.org/needpdf/SchoolsGoingSolar.pdf.

Birchall, J. (2009). Sampling and samples. *Marketing Network*. Research Portals Ltd. Retrieved February 12, 2010, from http://www.marketresearchworld.net/index.php?option=com_content&task=view&id=23&Itemid=1

Boit, J., Menjo, D. and Kimutai, J. (2012) ICT and education: Enabling two rural Western Kenyan schools to exploit information technology. *Journal of Emerging Trends in Educational Research and Policy Studies (JETERAPS) 3 (1): 55-60.* Retrieved 26 July, 2012., from, http://jeteraps.scholarlinkresearch.org/articles/ICT%20and%20Education.pdf.

Boit, J. M. and Menjo, D. K. (2012) *ICT in School Administration in Kenya*. Retrieved on 26 September 14, 2012, from, http://jeteraps.scholarlinkresearch.org/articles/ICT%20and%20Education.pdf.

Borenstein, S. (2008) the market value and cost of solar photo electricity production. *Center of Study of Energy Markets, January 2008*. Retrieved August 30, 2011, from, http://www.ucei.berkeley.edu/PDF/csemwp176.pdf.

Bratley, J. (2013) Pros and cons of solar energy. *Clean Energy Ideas*. Retrieved on September 18, 2013, from, http://www.clean-energy-ideas.com/solar/solar-energy/pros-and-cons-of-solar-energy.

Bridges.org (2003). IT: Case study on busy internet, Accra, Ghana. *Common Wealth Telecomunications Organization, January 31, 2003*. Retrieved June 12, 2011, from, http://www.cto-ict.org/index.php?dir=04&sd=30&aid=1145.

Cadeau, Charlise (2013) Solar power pros and cons. *Ezine Articles*. Retrieved on September 18, 2013, from, http://ezinearticles.com/?Solar-Power-Pros-and-Cons&id=5697968.

Cary, R. (2010) Future proof: An electricity network for the 21st century. Green Alliance. Retrieved Seeptember 6, 2011, from, http://www.green-alliance.org.uk/uploadedFiles/Publications/reports/Future%20proof%20electricity%20network%20for%2021st%20century.pdf.

Casci, F., Kuyvenhover, S., Warrick, C., Hay, J., Cardozo, G. C., Jansen, V. O., Antidormi, R. Tosato, G. Hayes, E.(2005). Energy powering your world. *European Fusion Development Agreement.* Retrieved September 5, 2011, from, http://www.efda.org/multimedia/downloads/booklets_and_articles/EPYW_english.pdf.

Cardenas, V. and Gonzales, M. (2008) *The Kalman Filter in Power Quality Theory and Application*. Mexco: USA. University of San Luis Potosi.

Castle, Kevin (2013) Solar energy come to Holston View Elementary School. ***TriCities.com***. Retrieved on September 19, 2013, from, http://www.tricities.com/news/local/article_97979ede-f3f3-11e2-83d5-0019bb30f31a.html

Chabari, B. (2009). Ours is a country of shortages, Why? *The Standard.* Saturday, August 11, 2009, P.16.

Chandak, A. (2011) Practical Aproach to Renewable Energy Appliations. *Association of Energy Management Professionals*. Retrieve August 24, 2011, from, http://www.ese.iitb.ac.in/esa/prof.chandak_prince.pdf.

Cheison, S.C. (2012). Nandi County take-off to prosperity: Core issues for 2012 and beyond. *Facebook.* Retrieved pm September 25, 2012, from, http://www.facebook.com/note.php?note_id=167268733334945&_ft_=fbid.228599730515991

CISCO (2013) Portuguese Schools Cut Energy Use by25 Percent. *Cisco*. Retrieved on September 23, 2013, from, http://www.cisco.com/en/US/prod/collateral/switches/ps5718/ps4324/parque_escolar_epe_external_case_study_fnl_02_13_13.pdf.

Clark II, W. H. (1997) *Retrofitting for Energy Conservation*. USA. McGraw Hill Companies Inc.

Clarke, S. (2014) Electricity generation using small wind turbines at your home or farm. *Ministry of Agriculture, Food and Rural Affairs*. Retrieved on November 5, 2014, from, http://www.omafra.gov.on.ca/english/engineer/facts/03-047.htm

Clean Technica (2012). Japan: ignorance and / or dishonesty of energy experts. *Clean Technica*. Retrieved September 5, 2012, from http://cleantechnica.com/2012/06/11/japan-ignorance-andor-dishonesty-of-energy-experts/.

Cohen, L and Manion, L (1992) *Research Methods in Education, Third Edition*. New York. Routledge.

Combs, S. (2011). Wind energy. *Window on State Government.* Retrieved September 1, 2011, from, http://www.window.state.tx.us/specialrpt/energy/renewable/wind.php.

Crowley, I. F. and Leung, H. F. (2011) *PWM Techniques: A Pure Sine Wave Inverter*. Worcester Polytechnic Institute . Retrieve on November 4, 2014, from, https://www.wpi.edu/Pubs/E-project/Available/E-project-042711-190851/unrestricted/PWM_Techniques_final.pdf

CTA (2007) Renewable energy in agriculture. *Rural Radio Resource Pack*. Retrieved September 5, 2011, from, http://www.anancy.net/documents/file_en/RRRP-08-3-en.pdf.

Czarnecki, L. S. (2008). Effect of supply voltage harmonics on IRP –based switching compensator control. *IEEE Trans. On Power Electronics 2008*.

Daamani, D. (2008) Challenges facing technical institute graduates in practical skills acquisition in the Upper East Region of Ghana. *Asia-Pacific Journal of Cooperative Education 2008*.

Demand Media (2011) Factors determining the energy produced by wind turbine. *Demand Media*. Retrieved June 13, 2011, from, http://www.ehow.com/info_8187276_factors-energy-produced-wind-turbines.html

Dodds, R. and Venables (2010). Engineering for Sustainable Development Principles. *The Royal Academy for Engineering*. London: Great Britain. Faculty of Engineering, Univeristy of Liverbool. Retrieved August 25, 2011, from, http://www.raeng.org.uk/events/pdf/Engineering_for_Sustainable_Development.pdf.

Durkee, Debra (2013). Pros and cons of solar panels. *Ehow*. Retrieved on September 18, 2013, from, http://www.ehow.com/facts_4779099_pros-cons-solar-panels.html.

Eberhard, A., Rosnes, O., Shkaratan, M. and Vennemo, H.(2011) Africa's power infrastructure: Investment, integration and efficiency. *The World Bank*. Washington DC. Retrieved on November 4, 2014, from, http://www.ppiaf.org/sites/ppiaf.org/files/publication/Africas-Power-Infrastructure-2011.pdf

Ehsan, R., Rabiee, A., Aghaei, J. and Nezhad, A. (2013) On the management of wind power intermittency. *Renewable and Sustainable Energy Reviews, 28 (December, 2013), 643-653*.

Ehow (2011). Solar Powered Schools. *Ehow*. Retrieved May 4, 2011, from http://www.ehow.com/info_7943229_solar-powered-schools.html

EnergyPedia (2012).Kenya County Situation. *Energypedia*. Retrieved on September 25, 2012, from https://energypedia.info/index.php/Kenya_Country_Situation.

Engineers Without Borders-USA (2012) Building a better world, one community at a time. *Engineers Without Borders-USA*. San Diego Professional Chapter. Retrieved September 5, 2012, from, http://www.ewb-sandiego.org/projects/kenya/.

Ericsson (2011) What is connect to Learn? *Ericsson Press Information September 2011*. Retrieved January 2012, from, www.ericsson.com.

Ericsson (2013) The impact of mobile connectivity on the millennium development goals in Africa. *Millennium Village Project.* Retrieved on September 18, 2013, from, http://www.ericsson.com/res/thecompany/docs/corporate-responsibility/2010/MVP_M_&_E_Final_Report_August_31_2010.pdf

ESA21 (2010). Alternative energy: Solar energy. *Environmental Science Activities for the 21st Century*. Retrieved August 28, 2011, from, http://esa21.kennesaw.edu/activities/solar/solaractivity.pdf.

ESRSE (2014) Earth sun relationship and solar energy. *ESRSE*. Retrieved on November 5, 2014, from, http://www.cengage.com/resource_uploads/downloads/0495555061_137179.pdf

EUEI PDF (2007). Financing development conferences. *Energy and National Financing Africa: A Background Paper, African Union Finance Ministers Meeting. Accra, 30 - 31 May 2007.* Retrieved February 19, 2010, from, http://www.euei-df.org/uploads/media/31_EUEI_PDF_Energy_and_National_Finances_in_Africa_English.pdf

European Regional Surveys of the World (2007*). Africa South of the Sahara 2007, 36th Edition*. London: Great Britain. Routeledge, Taylor and Francis Group.

Ezine (2009). Advantages of a sun powered battery charger. *Ezine Articles*. Retrieved November 21, 2009, from http://ezinearticles.com/?Advantages-of-a-Sun-Powered-Battery-Charger&id=342917

Farrell, G. (2009) *Survey of ICT and Education in Africa: Kenya Country Report Kenya*. Nairobi: Kenya. Longman Publishing House. Retrieve September 3, 2012, from, www.infodev.org

Fishbein, R. E. (2003) Survey of productive uses of electricity in rural areas. *African Energy Unit World Bank, April 2003.* Washington DC. Retrieved September 7, 2011, from, http://martinot.info/Fishbein_WB.pdf.

Flavin, C. and Aeck, M. (2005) The potential role of renewable energy in meeting the millennium development goals. *Energy for Development*. Retrieved September 2, 2011, from, http://www.worldwatch.org/system/files/ren21-1.pdf.

Foley, G. (1995). *Photovoltaic Applications in Rural Areas of Developing World: Technical Paper Number 304, Energy Series*. USA: Washington DC. Library of Congress Cataloging-in-Publishing Data.

Frank, W. (2008). Power electronics solar power inverter system. *Haerst Electronic Product.* Retrieved August 30, 2011, from, http://www2.electronicproducts.com/power_electronics_for_solar_power_Inverter_systems-article-fcpoinfmarch2008-html.aspx.

Frede, B.; Ramus and T.; Zhe, C. (2005). *Power Converters and Control of Renewable Energy Systems.* Denmark. Aalborg University. Institute of Energy Technology. Retrieved on April 4, 2009 from http:www.cateraendesared.citcea.upc.edujouraldes/jie2005/ponenciespower5520converters%20 and %20and%20controlof%20renewable%20energy%20%20paper.pdf.

Fuchs, E. F. and Masoum, M. A. (2008) *Power Quality in Power Systems and Electrical Machines.* New York: USA. Elsevier Inc.

Galava P. A. (2009) *Factors Associated With Integration Of Computer Technology As An Instruction Resource In Selected Secondary Schools In Uasin Gishu District.* Unpublished Masters of Education Thesis, University of Eastern Africa, Baraton.

Gay, L., Mills, G. & Airasian, P. (2009). *Educational Research: Competencies for Analysis and Application, Eighth Edition*. USA: Prentice-Hall, ISBN 0-13-118534-9). Retrieved January 28, 2010, from http://www.mnstate.edu/wasson/ed603/ed603lesson12.htmsurvey

George D. and Mallery, P. (2011). *SPSS for Windows Step By Step: A Simple Guide and Reference.* Boston: USA. Pearson Education Inc.

Gordon, D. E. (2010) National Clearignhouse for educational facilities. *National Institute of Building Sciences.* Retrieved August 25, 2011, from, http://www.ncef.org/pubs/greenschools.pdf.

Green Technology World (2011). Renewable energy. *Green Technology World*. Retrieved May 3, 2011, from, http://green.tmcnet.com/channels/renewable-energy/

Green Touch (2012). ICT industry combats climate change. *Green Touch*. Retrieved January 4, 2012 from, http://www.greentouch.org/index.php?page=how-the-ict-industries-can-help-the-world-combat-climate-change.

Gitonga, G. (2012) South Korea pledges to aid Kenya exploit electricity from geothermal sources to meet growing demands and drive economic growth. *The Standard.* Tuesdays, July 10 2012. Pg. 40.

Government of Kenya (2005). *Ministry of education KNEC complete syllabus and examination schedule for ICT-* Nairobi. Government printers.

Hahn, J. H. (2006) Modified Sine-wave Enhanced. *Power Electronics Technology*. St. Lous. Penton Media Inc. Retrieved August 30, 2011, from, Http://www.power_semiconductors/power_mosfets /power_ modified_sinewave_inverter.

Harper, D. Denruyter, J., and Oglethorpe, J. (2009) Sun, Wind, Water and More Renewable Energy in WWF Field Project. *International and Wildlife Fund-US*. Retrieved August 29, 2011, from, http://assets.wwf.ch/downloads/sun_wind_water.pdf

Heid, B. (2011). Amazing "solar generator" is like having a secret power plant hidden in your home! *Free Solar Generator Inro Packet*. Retrieved September 6, 2011, from, http://www.mysolarbackup.com/.

Hennessy, S. (2009). Developing use of ICT to enhance teaching and learning in East African schools. *Paper presented at the Zanzibar Round Table 2: 30th July to 2nd August, 2009.* Retrieved May 4, 2011, from http://www.educ.cam.ac.uk/centres/cce/initiatives/projects/ict/Lit_review_longer_paper.pdf

Herselman, ME (2003) *ICT in Rural Areas in South Africa: Various Case Studies.* Technikon Pretoria, Pretoria, South Africa. Retrieved August 23, 2011, from, http://www.informingscience.org/proceedings/IS2003Proceedings/docs/120Herse.pdf

Heydt, G. T. (2000) *Contemporary Topics in Electric Power Quality*. Arizona. Arizona State University.

Hosman, L. (2011). The St. Julie Model Primary School computer lab. *Inveneo*. Postdoctoral Fellow at University of California, Berkeley. Retrieved January 5, 2012, from, http://www.inveneo.org/?q=sisters-casestudy.

Hubbert, M. K. (2003) Resource and man. *Developing Energy to Meet Development Need*. Retrieved September 4, 2011, from, http://www.unesco.org/water/wwap/wwdr/pdf/chap10.pdf.

IEA (2007) Biomas for power generation and CHP. *IEA Energy Technology Essentials*. Retrieved September 4, 2011, from, http://www.iea.org/techno/essentials3.pdf.

IATF(2011) National security telecommunications advisory committee information assurance task force electric power risk assessment. *Information Assurance Task Force*. Retrieved August 29, 2011, from, http://www.solarstorms.org/ElectricAssessment.html.

ICA (2011) Energy. *Catalysing Africa's Infrastructure Development*. Retrieved June 19, 2011, from, http://www.icafrica.org/en/infrastructure-issues/energy/

Ifeachor, E. C. and Jevis, B W. (2001) *Digital Signal Processing: A Practical Approach. 2nd edition*. New York. Prentice Hall.

Igo, S. E. (2007). *The Averaged American: Surveys, Citizens, and the making of a Mass Public*. Cambridge, MA: Harvard University Press.

Imamura, M. S., Helm, P. and Palz, W. (1992). *Photo Voltaic System Technology: Commission of European Handbook*. German: Muenchen. H. S. Stephensons Inc.

Intel (2013) Rurla solar PC (Mindanao). *Solar Power for PC Developments: Enabling ICT Beyond the Grid*. Retrieved on September 15, 2013, from, http://www.intel.com/Assets/PDF/casestudies/WA-324794.pdf

Inveneo (2010) CLS deploys solar computing solutions at 52 Ugandan Schools. *Inveneo Newsfeed on 9 June 2010.* Retrieved January 5, 2012, from, http://www.inveneo.org/cls-computers-for-schools-uganda.

InvenoDev (2010) ICT in school education (primary and secondary) *InvenoDev*. Retrieved on September 26, 2013, from, http://www.infodev.org/infodev-files/resource/InfodevDocuments_1016.pdf.

Inveneo (2011) Solar power for PC deployments: Enabling ICT beyond the grid. *Inveneo*. Retrieved on September 11, 2013, from, http://www.ictworks.org/2011/07/04/solar-power-pc-deployments-enabling-ict-beyond-grid/

IREC (2007). Schools going solar activities: Activities to incorporate school PV systems into the classroom learning environment. *Interstate Renewable Energy Council*. Retrieved January 4, 2012, from http:www.NEED.Org.

Isidor, B. (2005). The nickel-based battery, its dominance and the future (BU4). *Battery University.com*. Retrieved 20, 2009, from http://www.batteryuniversity.com/partone-4.htm

Israel, G. D. (2013) *Determining Sample Size*. Florida: USA. University of Florida Publication.

Iwasaki, S. (2011) Engineers without borders install solar power in Los Achiotes. *Hohduras Weekly. Tuesday, 08 November 2011. Pg 1*. Retrieved January 2012, from, http://www.hondurasweekly.com/engineers-without-borders-installs-solar-power-in-los-achiotes-201111084422/.

Laaria, M. (2013) Leadership challenges in the implementation of ICT in public secondary schools, Kenya, *Journal of Education and Learning* 2 (1) 32-43 http://dx.doi.org/10.5539/jel.v2n1p32

Lal, A. and Raturi, A (2012) Techno-economic analysisi of a hybrid mini-grid system for Fiji islands. *International Journal of Energy and Environmental Engineering*. http://www.journal-ijeee.com/content/3/1/10.

Lynn, P. A. (201) *Electricity From Sunlight*. London: England. A John Willey & sons, Ltd; Publications.

Jenkins, D., Menzies, G., Kilpatrick, R. and Parnell, T. (2011) Currie Community High School energy Audit report. *Urban Energy Group.* Retrieved on September 23, 2013, from, http://sites.ace.ed.ac.uk/ekep/files/2012/08/Currie-Community-High-School-Energy-audit-report190511.pdf.

Jenny K.(2011) Solar panels. *Money Saving Expert.com.* Retrieved August 24, 2011, from, http://www.moneysavingexpert.com/utilities/free-solar-panels.

Johnsen, T. and Olsen, O. J. (2007) The relationship between wholesale and retail electricity prices to household in Nordic countries. *Roskilde University*. Denmark. Retrieved September 2, 2011, from, http://www.vaasaemg.com/pdf/Johnsen-Olsen.pdf.

Joseph, K. (2011) Electricity: Kenya power workers replace old posts. *Daily Nation*. Monday 26, 2011. Pg.24.

Kaboutis, J. and Hatziargyriou (2010). *Wind Power in Greece-Current Situation, Futurre Developments and Prospects.* Retrieved September 1, 2011, from, http://www.science.smith.edu/~jcardell/Readings/Wind/Kabouris-%20Greece.pdf.

Kamau, J. (2011) Disband ERC. *Daily Nation.* Tuesday August 16, 2011, p. 14.

Kamau, M (2011) Three suspected vandals arrested. *The Standard*, Tuesday, August 30, 2011, p. 24.

Karambu, I. (2011). Most Kenyans worried about cost of living, study reveals. *Daily Nation.* Thursday Septermber 8, 2011, p. 28.

Karambu, I. (2012). KenGen seeks 100,000 acres in Marsabit. *Daily Nation.* Tuesday Septermber 25, 2012, p. 3.

Kennedy, B. W. (2000) *Power Quality Primer*. New York. McGraw-Hill Inc.

Khalid, S. and Dwivedi, B. (2011) Power quality issues, problems, standards and their effects in industry with corrective means. *International Journal of Advances in Engineering & Technology, May 2011, ISSN: 2231-1963*.

Kim, H. S. and Akagi, H. (2000) The theory of instantaneous power in three phase four wire system: A comprehensive approach". *IEEE/IAS '99 Ann. Meeting, Oct.1999,pp.431-439.*

Kiran, C. N. (2014) Power quality improvement using active and passive power filters. International *Journal of Modern Engineering Research (IJMER).Vol.2, Issue 1, pp 076 -079.*

Knight, W. and King, A. (2003) *Uninterruptible Power Supplies and Standby Power Systems*. USA. McGraw-Hill Companies Inc.

Komor, P. (2009). Wind and solar electricity: Challenges and opportunities. *New Center Global Climate Change*. Retrieved on November 5, 2014, from, http://www.c2es.org/docUploads/wind-solar-electricity-report.pdf.

Korovesis, P. N;Vocas, G. A.; Cones, I. F. and Topalis, F. V. (2004) Influence of large-scale installation of energy Saving lamps on the line voltage of a weak network supplied by photovoltaic station. *Power Delivery IEEE Transactions On*. Volume 19, Issue 4, October 2004 page(s)1787 – 1793. http://ieee.org.xplore/ligin jsp?url.

K.P.L.C (2006). Demand for power rises sharply. *Sitima: House Journal of the Kenya Power and Lighting Company. Ltd*. October – December 2006. PP. 1-8.

Krich, K., Augenstein, D., Batmale, JP., Benemann, J. Rutlege, B., Salour, D. (2005).

Biomethane from dairy waste: A Sourcebook for the production and use of renewable Natural Gas in California. *USDA.* Retrieved September 4, 2011, from, http://www.suscon.org/news/biomethane_report/Full_Report.pdf.

Layzell, D. B., Stephen, J. and Wood, S. M. (2011) Exploring the potential for biomass power in Ontario: A Response to the OPA supply mix advice report. *BIOCAP, Canada*. Retrieved September 7, 2011, from, http://www.iseee.ca/media/uploads/documents/BIOCAP/Ont_bioenergy_OPA_Feb23_Final.pdf.

Liebrand, C. B. and Ing, K. C. (2009). Cooperative approach for implementation of dairy manure digesters. *USDA, Research Reoprt 217*, April 2009. Retrieved September 4, 2011, from, http://www.rurdev.usda.gov/rbs/pub/RR217.pdf.

Lime, A. B. (2011) Lack of infrastructure affects e-learning. *Nail Nations*, Thursday January 20, 2011. Pg. III.

Lin, C., Wei, J., Lee, Y. and Yen, C. (2007) Applied grey system theory to power quality of utility center in campus. Taiwani: Chienkwo Technology University. *IEEE Xplorer, March 18, 2009*.

Locayo, A. (2006). Off-grid Energy in Rural India: Policy Recommendations for Effective UN Projects. *WWS Undergraduate Task Force: Energy for Sustainable Development.* Retrieved January 8, 2012, from, https://www.princeton.edu/~mauzeral/wws402d_s06/Lacayo.pdf.

Lords View (2011) Uninterruptable electricity supply. *Lirds View Industrial Park.* Retrieved January 6, 2012, from, http://www.lordsview.co.za/privatised-electricity/173-uninterruptable-electricity-supply.

Lyakurwa, W. M. (2007) The business of exporting transaction costs facing suppliers in Sub-Saharan Africa. AERC CREA. Retrieved September 5, 2011, from, http://www.aercafrica.org/documents/export_supply_working_papers/Lyakurwa18DB3.pdf.

Macharia, S. M. (2010) *Provision of Information to Users at the United Nations Environmental Programme Headquarters, Nairobi*. Unpublished Masters of Philosophy Thesis, University of Eldoret. Kenya. Eldoret.

Macintosh, A. and Hamilton, C. (2007). What do Australians prefer? *Greenhouse Strategies*. Retrieved September 5, 2011, from, https://www.tai.org.au/documents/downloads/WP102.pdf.

Mckenna, E. (2013) Somalia: Wind bring light to Somaliland. *Allafrica*. Retrieved on September 22, 2013, from, http://allafrica.com/stories/201304220654.html.

Madson, N. (2011). Solar power. *WiseGEEK*. Retrieved August 24, 2011, from, http://www.wisegeek.com/what-is-solar-power.htm.

Maehlum, M. A. (2011) Solar energy pros and cons. *Energy Informative: the Homeowner's Guide to Solar Panels*. Retrieved on September 18, 2013, from, http://energyinformative.org/solar-energy-pros-and-cons/

Makewa, L., Meremo, J., Role, E. and Role, J (2013) ICT in secondary school administration in rural southern Kenya: An educator's eye on its importance and use. *International Journal of Education and Development using Information and Communication Technology (IJEDICT)*, 2013, Vol. 9, Issue 2, pp. 48-63.

Makhanu, E (2010) Principals' literacy in ICT: towards improving secondary school performance in Kenya. PhD thesis, University of South Africa.

Manwell, J. F., Mcgowan, J. N. and Rogers, A. L. (2009) *Wind Energy Explained: Theory, Design and Application, Second Edition*. USA. John Wiley & sons Ltd.

Mash, B., Baybay, S., and Balleza, D. (2011). Solar power for PC developments: Enabling ICT beyond the grid. *Inel, White Papr, 2011*.

Mash, B., Baybay, S. and Balleza, D. (2013) Solar power or PC developments: Enabling ICT beyond the grid. *Solar Power for PC Development*. Retrieved on September 10, 2013, from, http://www.intel.com/Assets/PDF/casestudies/WA-324794.pdf.

Marsh, B., Nordhausen, B., Overgaag, J., Perales, S. and Seale, S. (2011). Solar power for rural PCs. *Inveneo.* Retrieved on Septermber 11, 2013, from, http://www.ictworks.org/sites/default/files/uploaded_pics/2011/Inveneo_Solar_Power_Deployment_Guide.pdf.

Mashelkar R. A. (2006). Report of the Working group on CSIR volume one: Eleventh five year plan 2007 – 2012. *CSIR Establishments***.** Retrieved September 7, 2011, from, http://dst.gov.in/about_us/11th-plan/rep-csir.pdf.

Mbugua, K. (2004). *The Administration Policy, Integrity and Policy 2004-2009*. Nairobi: EUAP. Retrieved September 12th, 2008, from http://www.administration policy.go.ke/home.html.

McDame, S., Lallement, D. and Saghir, J. (2005). Energ services for the millennium development goals. *United Nations Development Programme*. Retrieved September 2, 2011, from, http://www.unmillenniumproject.org/documents/MP_Energy_Low_Res.pdf.

McLaughlin, D., McDonald, N. Nguyen, H. T. and Pearce, J. M. (2010) Leveraging solar photovoltaic technology for sustainable development in Ontario's Aboriginal Communities. *Journal of Sustainable Development, Vol. 3, No. 3; September 2010*. Retrieved September 1, 2011, from, www.ccsenet.org/jsd.

Mehta, A. (2002). *The Economics and Feasibility Of Electricity Generation Using Manure Digesters on Small and Mid-Size Dairy Farms*. Department of Agricultural and Applied Economics Energy Analysis and Policy Program. University of Wisconsin – Madison. January, 2002. Retrieved September 4, 2011, from, http://www.mrec.org/pubs/Biogas_Economics_Metha.pdf.

Menjo, D. K. & Boit J. N. (2005) *The challenges of using information communication technology (ICT) in school administration in Kenya*. A Research Paper Presented In Partial Fulfillment of the Requirement for the Degree of Doctor of Philosophy, School of Education, University of Eldoret. Retrieved June 12, 2011, from, http://www.kaeam.or.ke/e-journal/articles/vol1/menjofulltext.pdf

Millennium Consolidated Consultancy Services (2010) Development rules on standby generation. *Electricity Control Board of Namibia*. Retrieved January 6, 2012, from, http://www.ecb.org.na/download.php?fl_id=156.

Mingaine, L. (2013) Skills challenges in adoption and use of ICT in public secondary schools, Kenya. *International Journal of Humanities and Social Science, Vol. 3 No. 13; July 2013*. Retrieved on September 15, 2013, from, http://www.ijhssnet.com/journals/Vol_3_No_13_July_2013/8.pdf.

Mingaine, L. (2013) Challenges encountered by principals during implementation of ICT in public secondary schools, Kenya. *Journal of Sociological Research* ISSn 1948-5468 2013, Vol. 4, No.2.

Minnaar, A. (2011). The implementation and impact of crime prevention / crime control open street closed-circuit television surveillance in South Africa Central Business District. *Surveillance and Society.* Retrieved August 2011, from, http://www.surveillance-and-society.org/articles4%283%29/southafrica.pdf.

Ministry of Agriculture, Food and Rural Affairs (2011) Electricity generation using small wind turbines at your home or farm. *Ministry of Agriculture, Food and Rural Affairs . Ontario*. Retrieved June 13, 2011, from, http://www.omafra.gov.on.ca/english/engineer/facts/03-047.htm

Modi, V. (2010). Energy services for the millennium development goals. *United Nations Development Program*. Retrieve August 29, 2011, from, http://www.unmillenniumproject.org/documents/MP_Energy_Low_Res.pdf

MOEST (2004) *Development of Education in Kenya Ministry of Education Science and Technology*. Nairobi. Ministry of Education of Education Science and Technology, August 2004.

MOEST (2005). *ICT in Education Options Paper.* Nairobi. Kenya. Ministry of Education, Science, & Technology Government of Kenya, 31 July 2005.

MOEST (2006). *National Information and Communication Strategy for Education and Planning.* Nairobi. Ministry of Education Science and Technology.

MPND (2005) Millennium development goals in Kenya. *UNDP*. Retrieved on October 7, 2013, from, http://planipolis.iiep.unesco.org/upload/Kenya/Kenya%20MDG%20Needs%20Assessment.pdf.

Motto, K. (2000). *Application of High-Power Snubberless Semiconductor Switches in High-Frequency PWM Converters*. Unpublished masters thesis. Virginia Polytechnic Institute and State University. USA. Virginia.

Mugenda, O. M. & Mugenda, A. G. (2003). *Research Methods: Quantitative and Qualitative Approaches.* Nairobi. Kenya. African Center of Technology Studies (A.C.T.S).

Mungai, M. (2012) *Twelve Challenges Facing Computer Education in Kenyan Schools*. Hokkaido: Japan. Hokkaido University Press.

Munguti, R. (2009). Magistrate work under candle light to ensure justice is seen to be done. The *Daily Nation*, Tuesday, August 11, 2009, P.5.

MPD (2008). Summary of key investment opportunities in Kenya. *Macro Planning Directorate*. Ministry of the Prime Minster of State Planning, National Development and Vision 2030. Nairobi: Kenya.

Muiri, K. (2012) Kenya must liberalise power generation and smash cartels. *Daily Nation*. Tuesday April17, 2012. Pg. 14.

Muthoka, J. (2011) Reading the signs of the times: Go solar. *The Standard*. Thursday, September 1, 2011. p.10.

Muwanga_Zake, J. W. F. (2007) Introducing educational computer programmes through evaluation: A case in South African disadvantaged schools. *International Journal of Education and Development using Information and Communication Technology (IJEDICT), 2007, Vol. 3, Issue 3, pp. 30-48.*

Mwangi, M. (2011). Integrate ICT into our school curriculum. *Daily Nation*, Thursday May 12, 2011.

Mwanje, I., Akoten, J., Riechi, A., Barasa, T., Oyugi, L., Omolo, J., Junge, L., Kimbwarata, J. and Mukasa, G. (2008) Radical reform for Kenya's education sector: Implementing policies to vision 2030. *Institute of Policy Analysis and Research*. Policy view issue 4, 2008. Retrieved August 25, 2011, from, http://www.ipar.or.ke/Documents/Policy_View_4.pdf.

Naing, K., and Times, M. (2003) *Solar Power Seen as Solution For Remote Villages*. Retrieved January 4, 2012, http://www.myanmar.gov.mm/myanmartimes/no186/MyanmarTimes10-186.

Ndume, V., Tlya, F. N., Twaakyondo, H. T. (2010). *Challenges of Adaptive E-learning at Higher Learning Institutions: A Case Study in Tanzania.* Dar es Salaam Institute of Technology. Retrieved April 28, 2010, from http://www.ijcir.org/volume2-number1/article6.pdf

Nicholson, R. (2010). Road to zero carbon: final report of the zero carbon task force. *School Children and Families, January 2010.* Retrieved August 25, 2010, from https://www.education.gov.uk/publications/eOrderingDownload/00111-2010DOM-EN.pdf.

Njeri, A. B. (2011) Using sloar energy for cooking fuel in Kenya. *Globalgiving*. Retrieved Auguat 24, 2011, from, http://www.globalgiving.org/projects/help-use-solar-energy-africa/updates/.

Njoroge, J. (2011) Don't blame Kenya Power, high prices due to rise cost of inputs. *Daily Nation.* Tuesday August 16, 2011, p.14.

Nordhausen, B. (2011) Solar power for pc deployments: enabling ICT beyond the grid. *Intel.* Retrieved September 6, 2011, from, http://web.pdx.edu/~rueterj/courses/ESM342-solar/Intel%20Solar%20White%20Paper.PDF.

NTT (2010). Green infrastructure to address the needs of future generations. *NTT Group CSR Report 2010*

Obonyo, J. (2011). Calling rates to go up, warns Safaricom. *Daily Nation*. Friday September 9, 2011, p. 9.

Odinga, R. A. (2008). A summary of key investment opportunities in Kenya. *Ministry of State for Planning, National Development and Vision 2030.* Nairobi: Kenya. Kenya Government Publication. Retrieved on September 25, 2012, from, www.planning.go.ke.

Ogembo, J. G., Ngugi, B. and Polowski, M. (2012) Computerizing primary schools in rural Kenya: Outstanding challenges and possible solutions**.** *The Electronic Journal on Information Systems in Developing Countries, (2012) 52, 6, 1-17*. Retrieved on September 14, 2012, from *http://www.ejisdc.org*

Okwemba, D. (2010). Power bills to remain high. *The Sunday Nation*,March 7, 2010, Page 8.

Olingo, A. (2011) Reading the signs of the times: Go solar. *The Standard*. Thursday, September 1, 2011. P.9.

Omati, C. (2012) Power blackouts hit several towns. *The Standard*. Monday, April 16, 2012, pg.8.

Ombese, R. (2011). *Administrative variables associated with the principals' performance in the implementation of computer studies in Rongo District, Kenya.* Unpublished Masters of Education Thesis, University of Eastern Africa, Baraton.

Ombok, E. (2010). Kenya suffering gasoline shortages on refinery power problems. *Bloombergg.* New York, February 18,2010. Retrieved February 20, 2010, from http://www.bloomberg.com/apps/news?pid=20602099&sid=avtgXIbWQ.h4&refer=energy.

Owens, L. K. (2002). Introduction to survey research design. *Research Planning Survey Research Laboratory, SRL Fall 2002 Seminar Series*. Retrieved On September 18, 2012, from, http://www.srl.uic.edu

Oyedoja, K. O. and Obiyemi, O. O. (2013) Wavelet transform in detection of electrical power quality disturbances. *International Journal of Engineering and Applied Sciences, April 2013. Vol.3, No.2.*

Pandey, B. and Acharya, B. (2004) Guide to energy options for small-scale rural ICT projects. USAID. Retrieved September 6, 2011, from, http://www.winrock.org/clean_energy/files/Winrock_Energy_for_Rural_ICT_Guidebook.pdf.

Parliamentary office of science and technology (2006) ICT in developing countries. *Postnote, March 2006, Number 261*. Retrieved September 2, 2011, from, http://www.parliament.uk/documents/post/postpn261.pdf.

Potocnic, J. (2006) European smartgrids technology: Vision and strategy for Europe's electricity networks of the future. *European Commission Community Research*. Retrieved September 2, 2011, from, http://ec.europa.eu/research/energy/pdf/smartgrids_en.pdf.

Power Engineers (2009) Kenya power and lighting company, transmission projects feasibility study, Kenya. *Power Engineers Inc*. Retrieved on April 5, 2009 from http://www.powering.com/projects/index.aspx?id=241.

Power Nucleus (2005) Why use power nucleus? *Power Nucleus Inc*. Retrieved August 30, 2011, from, http://www.powernucleus.com/invertera_data_sheet/why_power_nucleus.pdf.

PowerStream (2007) NiCad Charging. *PowerStream*. Retrieved August 29, 2011, from, http://www.powerstream.com/NiCd.htm

Prasa, D. K. & Snow M. (2011) *Designing with solar power: A source book for building integrated.* Retrieved June 5, 2011, from, http://books.google.co.ke/books?id=_sC32NrngP8C&pg=PA223&lpg=PA223&dq=barriers+associated+with+solar+power+pv+installation+technology&source=bl&ots=0u19rlaAmL&sig=N4RHTzkvNvUAmYTAxtvkxe68oow&hl=en&ei=fZy-TfuhFs_HrQf,Jn9BQ&sa=X&oi=book_result&ct=result&resnum=1&ved=0CC0Q6AEwAA#v=onepage&q=barriers%20associated%20with%20solar%20power%20pv%20installation%20technology&f=false

Punch, K. F. (2005) *Introduction to Social Research, Quantitative and Qualitative Approach*. London: Sage Publications Ltd.

Pyakuryal, B. (2002) Green technology for sustainable agriculture development: Assessing the policy impact in selected members countries of ESCAP-APCAEM. *United Nations – Nations UNIES Economic and Social Commission for Asia and the Pacific*.Retrieved August 28, 2011, from, http://www.unapcaem.org/publication/GreenTech.pdf.

Quipp, R. (2011) Turning cow into electricity. *Daily Nation*. Friday, October 7, 2011. Pg. 18.

Rabah, K. V. O. (2004) Integrated solar energy systems for rural electrification in Kenya. *Science Direct: Renewable Energy, Volume 30, Issue 1, January 2005, Pages 23-42.* Retrieved on April 4, 2009 from http//:www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6vs-4CN9.

Ragaller K. and Dandliker (2010). Future engineering challenges. *CAETS*. Retrieved August 25, 2011, from, http://www.caets.org/cms/7337.aspx.

Recharchargeable Battery battery info (2005). What are the disadvantages of fast charging over slow charging? *Rechargeable Battery Info*. Retrieved January 8, 2010, from http://rechargeablebatteryinfo.com/rechargeable-batteries-charging.php

Reegle (2014) Energy resource *Reegle.* Retrieved on November 4, 2014, from, http://www.reegle.info/policy-and-regulatory-overviews/KE.

Reynold, D, Treharne, D. Tripp, H.(2003) ICT- the hope and the reality. *British Journal of Educational Technology Vol 34 No 2 2003* 151–167. Retrieved June 5, 2011, from, https://www.hull.ac.uk/php/edskas/Reynolds%20article.pdf

Robers, M. (2013) Solar PV system at Analy High School. *Solar Sebastopol*. Retrieved on September 19, 2013, from, http://solarsebastopol.org/analy.html

Rost & Sullivan Research Service (2004) *World DC-AC Power Inverter Markets.* Retrieved on April 4, 2009 from http://www.frost.com/prod/servlet/report-brochure.pag?id=A791-01-00-00-00

Ruffles, P.(2004). The cost of generating electricity. *The Royal Academy of Engineering*. Retrieved September 2, 2011, from, http://www.raeng.org.uk/news/publications/list/reports/Cost_of_Generating_Electricity.pdf

Sankaran, C. (2002) *Power Quality*. Washington D.C.: USA. CRC Press LLC.

SEIA (2010) The history of solar energy: A look at the used of solar energy from BC to ICT. *Solar Energy Industries Association, March 19, 2010.*Retrieved August 28, 2011, from http://www.seia.org/galleries/FactSheets/Factsheet_solar%20history.pdf.

Shields, Sherri (2013) Solar electric system provides emergency power and teaching tool for Haines High School. *The Energy Chronicle. A Newsletter of the Florida Solar Energy Center*. Retrieved on September 19, 2013, from, http://blog.floridaenergycenter.org/echronicle/2013/05/haines-city-high-dedication/

Shin, Y., Powers, E. J. and Grady, M. (2006) Power quality indices for transient disturbances. *IEEE Transactions on Power Delivery, Vol.21, No. 1, January 2006*.

Siele, D. (2006). Online education. "*Educa" eLearning Conference*. Berlin, German, November 30, 2006.

Silvers, Christie (2013) What are the pros and cons of solar energy? *Ehow*. Retrieved on September 18, 2013, from, http://www.ehow.com/about_4778822_pros-cons-solar-energy.html.

Singh, M. (2008). Towards building solar India. *Jawaharlal Nehru National Solar Mission*.

Smith, R. A. (2009).Twining Canadian and Kenya schools with solar power. *OPLC News.* Retrieved September 5, 2012, from, http://www.olpcnews.com/countries/canada/canadian_kenyan_schools_solar_power.html

Solar and wind energy (2009) Solar energy advantages and disadvantages. *Go Solar.net. Solar and Wind Resources for Homeowners*. Retrieved December 21, 2009, from www.batterytender.com/

Solar Server (2013) Light at the end of the tunnel: The beginning of PV industry recovery in Q2 2013. *SolarSever: Global Solar Industry Website*. Retrieved on September 16, 2013, from, http://www.solarserver.com/solar-magazine/solar-report/solar-report/light-at-the-end-of-the-tunnel-the-beginning-of-pv-industry-recovery-in-q2-2013.html.

Solar Solutions & Systems (2010) How to Make a Solar Power Generator for less than $300. *Solar Solutions & Systems*. Retrieved January 5, 2012 from, http://www.rain.org/~philfear/how2solar.html.

SREP (2011) Investment plan for Kenya. *Scaling-up Renewable Energy Program, May 2011*. Retrieved August 30, 2011, from, http://www.energy.go.ke/wp-content/uploads/2010/08/Updated%20%20SREP%20Draft%20Investment%20Plan-May%202011.pdf.

Thompson, M. J. (2010) *Fundamental and Advancements in Generator Synchronizing Systems.* Sydney: Australia. Schweitze Engineering Laboratories, Inc.

Trace Engineering (2014) Review of inverter design and topologies. *Trace Engineering.* Trace Engineering Company, Inc. 5916 - 195th Street N. E. Arlington, WA 98223. Retrieved on November 5, 2014, from, http://www.dieselduck.info/machine/04%20auxiliary/2000%20Inverter%20technology.pdf.

St. Arnaud, B. (2013) ICT and climate change impact or NRENS. *Canarie*. Retrieved on September 22, 2013, from, https://register.nordu.net/speakers/files/BillSt%20Arnaud.pdf

The Solar Bus (2011) Solar energy. *The Solar Bus*. Retrieved August 24, 2011, from, http://solarbus.org/links.shtml#solar.

Theraja, B. B. and Theraja, A. K. (2010) *A Textbook of Electrical Technology*. India: New Delhi. S. Chand & Company Ltd.

UNESCO (2013) Information and communication technology (ICT) in education in five Arab states: A comparative analysis of ICT integration and e-readiness in schools in Egypt, Jordan, Oman, Palestine and Qatar. *Unesco*. Retrieved on September 23, 2012, from, http://www.uis.unesco.org/Communication/Documents/ICT-arab-states-en.pdf

UNESCO (2013) ICT in education toolkit for policy makers, planners and practitioners. *UNESCO*. Retrieved on October 18, 2013, from, http://www.ictinedtoolkit.org/usere/p_page.php?section_id=20.

UPDEA (2009) Comparative study of electricity tariffs used in Africa. *UPDEA*. Retrieved on October 6, 2013, from, http://www.updea-africa.org/updea/DocWord/TarifAng2010.pdf.

USAID (2004) Guide to energy options for small-scale rural ICT Project. *USAID, September 29, 2004.* Retrieved 28th August 28, 2011, from, http://www.winrock.org/clean_energy/files/Winrock_Energy_for_Rural_ICT_Guidebook.pdf.

U.S. EPA(2008) Clean energy strategies for local governments. *On-sit Renewable Energy Generation*. Retrieved August 24, 2011, from, http://www.epa.gov/statelocalclimate/documents/pdf/on-site_generation.pdf.

Vaccaro, A., Baseil, R., Hagras, H., Ho, M., Krein, P., Larsen, R., McKnight, G., Modi, V., Passino, A. E., Passino, K., Perusich, K., Zobaa, A (2010) Reliable power for developing countries. *Humanitarian Technology Challenge*. Retrieved August 23, 2011, from http://www.ieeehtc.org/files/Reliable_Electricity_Challenge_Description.pdf.

Venezky,R. (2001) *ICT in Innovative Schools: Case Studies of Change and Impacts*. University of Delaware, United States. Retrieved August 23, 2011, from, http://www.oecd.org/dataoecd/11/11/41187025.pdf

Victoria L. T. (2002) Survey of Information & Communication Technology Utilization in Philippine Public High Schools. Center of International Cooperation for computerization *Government of Japan.* Retrieve May 4th , 2011, from http://www.aijc.com.ph/pccf/observatory/pfd%20files/papers%20&%20Publications/education/Survey%20of%20ICT%20in%20Public%20High%20Schools.pdf

Volker, Q. (2005) *Understanding Renewable Energy Systems*. UK. Bath Press.

Vota, W. (2012). Win government contracts with solar power computing. *ICTworks by Inveneo*. Retrieved January 5, 2012, from, http://www.ictworks.org/tags/uganda?page=3.

Wachira, M. and Kimani, J. (2012). Huge geothermal project to reduce reliance over rivers. *Daily Nation*. Tuesday 24, 2012. Pg. 1.

Wade, L (2011) Solar powered schools. *Ehow*. Retried August 24, 2011, from, http://www.ehow.com/info_7943229_solar-powered-schools.html

Wahome, M. M. (2010). Kenya suffering gasoline shortages on refinery power problems. Bloombergg. *Kenya Power and Lighting Company. February 18, 2010*. Nairobi: Retrieved February 20, 2010, from http://www.bloomberg.com/apps/news?pid=20602099&sid=avtgXIbWQ.h4&refer=energy.

Wahome, M. and Mwaniki, M. (2012) Poor rains likely to push up power costs. *Daily Nation*. Tuesday, April 10, 2012. Pg. 5.

Wamgombe, A. W. and Ikara, M. *(2009)* Building a global competitive economy. *Kenya Research Institute for Public Policy Research and Analysis, 2009.*

Wang, C. and Prinn, R. G. (2011) Potential climate impacts and reliability of large scale offshore wind farms. *IOP Science*. Retrieved on September 22, 2013, from, http://iopscience.iop.org/1748-9326/6/2/025101?rel=ref&relno=3.

Water Technology.net (2009) African nations increase hydropower alliance. *Water Technology.net.* SPG Media Ltd. Retrieved on April 4, 2009 from http://www.water-technology.net/features/feature496351.

Watts, A. (2013) Rethinking wind power – Harvard study shows it to be overestimated. *WattsUp With That?* Retrieved on September 22, 2013, from, http://wattsupwiththat.com/2013/02/25/rethinking-wind-power-harvard-study-shows-it-to-be-overestimated/.

Watt, M. E. and Outhred (2011). Strategies for the adoption of renewable energy technologies. *Energy Policy*. University of New South Wales, Sydney, Australia. Retrieved September 1, 2011, from, http://www.eolss.net/Sample-Chapters/C08/E3-21-03-06.pdf.

Wavion (2008) WIFI for K-12 Schools. *Wavion Wireles Networks*. Retrieved January 5, 2012, from , http://www.wavionnetworks.com/education.html.

WBDG (2011) Photovoltaics. *National Institute of Building Sciences*. Retrieved January 6, 2011, from, http://www.wbdg.org/resources/photovoltaics.php?r=minimize_consumption.

Williams S. (2009) Use of ICT in Enhancing Teaching and Curriculum Delivery in Marginalised Secondary Schools in Kenya. *HP Innovations in Education Grant May 2009.*

Wind Energy Basics (2010). Basic information on wind energy and wind power technology, resources, and issues of concern. *Wind Energy and Wind Power*. Retrieved May 5, 2011, from http://windeis.anl.gov/guide/basics/index.cfm

Winrock International (2004) Guide to energy options for small-scale rural ICT projects. *USAID*, September 29, 2004. Retrieved August 23, 2011, from http://www.winrock.org/clean_energy/files/Winrock_Energy_for_Rural_ICT_Guidebook.pdf

Wiser, J. and Bolinger, M (2003). Policies and market factors driving wind power development in the United States. *National Renewable Energy Laboratory, July 2003*. Retrieved September 1, 2011, from, http://eetd.lbl.gov/ea/emp/reports/53554.pdf

Woodbank (2005) Battery and energy technologies. *Electropedia*. Woodbank Communications Ltd.

World Bank (2007) National electrification coverage planning investment costing estimation model: Kenya Final report. *World Bank*. November 25, 2007.

World Nuclear Association (2011) Renewable energy and electricity. *World Nuclear Association*. Retrieved January 6, 2012, from, http://world-nuclear.org/info/inf10.html

Yumkella, K. (2007) Energy fo sustainable development: Policy options for Africa. *UN-Energy/Africa*. Retrieved September 2, 2011, from, http://www.uneca.org/eca_resources/publications/unea-publication-tocsd15.pdf

Yusufu, M. O. (2007). *Trends and Barriers on the integration of information and communication technology in the Nigerian school system*. Department of Science Education, faculty of Education, University of Illorin, Ilorin, Nigeria.

Zhang, W., Markfort, C. D., and Porte-Agel, F. (2013) experimental study of the impact of large-scale wind farms on land-atmosphere exchanges. *IOP Science*. Retrieved on September 22, 2013, from, http://iopscience.iop.org/1748-9326/8/1/015002?rel=ref&relno=1.

Zervos, A. and Teske, S. (2009). Infrastructure needs a safe climate. *European Renewable Energy Council*.Retrieved September 6, 201, from, http://www.greenpeace.org/raw/content/international/press/reports/renewables-24-7.pdf.

Zweibei, K. (2008) Solar grand plan. *Scientific American, January 2008*. Retrieved August 24, 2008, from, http://www.scientificamerican.com/article.cfm?id=a-solar-grand-plan.

APPENDICES

APPENDIX I: Questionnaire for School Principals

May, 2011.

Dear Principal,

The researcher is a University of Eldoret, Technology Education (Electrical and Electronics) master of philosophy student. He is conducting a research on "challenges of accessing electricity for ICT use in Kenyan secondary schools."

The researcher is kindly requesting you to participate in this study by answering all questions that focus on the following areas: your school's background information, sources of energy used in your school and factors affecting the use of the various energy sources that power the ICT equipment in your school. You will need around 40 minutes to complete all the questions. There are NO right or wrong answers. Please do this on your own and answer honestly, just indicating whatever you think is right. Your participation is very important in this study. Your opinion will help in determining whether there is a need to improve the supply and availability of the alternative energy sources in your school to facilitate the use of Information and Communication Technology in the learning and teaching in your school.

All information and answers you give will be treated confidentially. Please do not write your name. Your will not be identified or mentioned in any report. I appreciate your help in giving your opinion about the questions below so that the results of this study can be useful to schools, families, communities, planners and government policy makers.

Thank you very much for your help.

SECTION A: BACKGROUND INFORMATION

Please provide the information about the school by checking [√] or writing as appropriate:

School level: □$_1$ Primary school □$_2$ Secondary school

School operates as: □$_1$ Day school □$_2$ Boarding school

Type of school: □$_1$ Boys school □$_2$ Girls school
□$_3$ Mixed school

School classification: □$_1$ District school □$_2$ Provincial school
□$_3$ National school

School category: □$_1$ Public □$_2$ Private

Sponsorship: □$_1$ Government □$_2$ Church
□$_3$ Company □$_4$ Sole proprietor

Location of the school: □$_1$ Urban □$_2$ Rural

The school teaches computer science
□$_1$ Yes □$_2$ No

The school has a computer lab to teaching computer courses
□$_1$ Yes □$_2$ No

SECTION B: INFORMATION RELATED TO ALTERNATIVE ENERGY SOURCES

INSTRUCTIONS:

On this questionnaire, I need your opinion about whatever you know, think or feel about this school and the education this school gives to students. Please indicate your level of agreement with each of the statements below by circling the appropriate number.

KEY

1 = Yes	
2 = No	

Example:

Example: If my answer is No, then I show this by circling 2 representing “No”

QUESTION-X. At this school—	YES	NO
Our school has a working standby generator	1	2

No.	STATEMENT		
1.	The school is supplied with Electricity from Kenya Power and Lighting Company	YES	NO
2.	The school has a working standby generator used when Kenya power fails	1	2
3.	The school utilizes solar power energy to power ICT equipment in case Kenya power fails	1	2
4.	The school is located in a region with plenty of sunshine	1	2
5.	The school has a wind powered electricity generator	1	2
6.	Our school is located in a region that experience continuous blow of wind	1	2
7.	The school board of governors encourage the use of alternative sources of energy in the school	1	2

SECTION C: PERCEPTION

INSTRUCTIONS:

On this questionnaire, I need your opinion about whatever you know, think or feel about your school and the education your school gives to students. Please indicate your level of agreement with each of the statements below by circling the appropriate number.

KEY

1 = Strongly Disagree
2 = Disagree
3 = Not Sure
3 = Agree
4=Strongly Agree

Example:
Example: If I disagree with the following statement, then I show this by circling 2 representing 'Disagree'.

QUESTION-X. At this school—	Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree
Alternative sources of electricity are not a necessary	1	2	3	4	5

No.	STATEMENT	Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree
1.	This school can 100 % rely on Kenya power electricity	1	2	3	4	5
2.	Solar power from the sun would assist to generate electricity to use in the absence of Kenya power electricity in this school	1	2	3	4	5
3.	Standby generator power electricity is cheaper as compared to the use of electricity supplied by the Kenya Power.	1	2	3	4	5
4.	Solar power could be cheaper than the electricity from the Kenya power.	1	2	3	4	5
5.	Solar power system can help us power computer for instruction purposes.	1	2	3	4	5
6.	There is enough sunshine that goes into a waste that could be converted into electricity for use in our schools.	1	2	3	4	5
7.	The location of this school make it difficult to be supplied by electricity.	1	2	3	4	5
8.	The purchase of diesel for the school generator is very expensive.	1	2	3	4	5
9.	Lack of solar energy is a drawback to the use of ICT in teaching and learning in our school.	1	2	3	4	5
10.	Lack of a standby generator is a drawback to the use of ICT in teaching and learning in our school.	1	2	3	4	5
11.	Lack of wind power generated electricity is a drawback to the use of ICT in teaching and learning in our school.	1	2	3	4	5

No.	STATEMENT	Strongly disagree	Disagree	Not sure	Agree	Strongly agree
1.	The school generator breaks down now and again	1	2	3	4	5
2.	Sometimes it is difficult to find a mechanic to service or repair the generator when it fails to work	1	2	3	4	5
3.	Solar power system fittings are expensive to buy	1	2	3	4	5
4.	Solar DC-AC power inverter systems and fittings are expensive to buy	1	2	3	4	5
5.	There is a problem in getting a qualified electrician to install or repair the solar power system	1	2	3	4	5
6.	There is a problem in getting a qualified mechanics to repair or service the standby generator		2	3	4	5
7.	The lack of stable electricity has made it difficult to use the ICT equipment in our school	1	2	3	4	5
8.	Lack of standby generator has made it difficult to use the ICT equipment in our school	1	2	3	4	5
9.	The Kenya power electricity bills are very high	1	2	3	4	5
10.	The school experiences power supply failures and this affect the use of ICT equipment	1	2	3	4	5
11.	The school experiences standby power generator failures	1	2	3	4	5
12	The school is located in a region where sunshine is not enough to power solar panels	1	2	3	4	5
13	There is a lot of crowd cover which prevents the sun from shining on solar panel	1	2	3	4	5
14	The school is located in a region where there are a lot of rains making the use of solar power impossible	1	2	3	4	5
15	The Kenya Power and Lighting Company can solve problems associated with the powering and use of ICT in schools.	1	2	3	4	5
16	The Solar power electricity can help to solve problems associated with the powering and use of ICT in schools.	1	2	3	4	5
17	Use wind power generated electricity can help to solve problems associated with the powering and use of ICT in schools.	1	2	3	4	5
18	Use of standby generator generated electricity can help to solve problems associated with the powering and use of ICT in schools.	1	2	3	4	5
19	Our school use solar power to power overhead projectors used in teaching and learning.	1	2	3	4	5
20	Our school use solar power to power computers used in teaching and learning.	1	2	3	4	5

APPENDIX II: School Principals Interview Schedule

Guiding questions

1. What sources of energy are available in your school that can be used to power ICT equipment?
2. What problem do you face when you use or try to use various sources of energy like; solar power, standby generator, wind power, and electricity from the Kenya Power company?
3. What is your perception on the use of solar power, biogas, standby generator, wind power, and electricity from the Kenya Power company to power ICT equipment in your school?
4. What do you think can be done to improve the use of alternative sources of energy to power ICT equipment in your school?
5. What drawbacks or hindrances you know that affect the use of alternative sources of energy in your school?
6. What are your plans towards the future use of alternative sources of energy in your school?
7. Which source of energy do your prefer to use most and why do you think it is appropriate for you?
8. What advice would you give concerning the use of alternative sources of energy to power ICT equipment in local secondary schools?

APPENDIX III: Letter of Introduction

P.O. Box 1125-30100, ELDORET, Kenya
Tel: 053-2063111
:0202410415
Fax No. 020-2141257
E-Mail: admissions@chep.ac.ke

Chepkoilel
UNIVERSITY COLLEGE
flame of knowledge and innovation
A Constituent College of Moi University

SCHOOL OF EDUCATION
TECHNOLOGY EDUCATION DEPARTMENT

10TH September, 2012

TO WHOM IT MAY CONCERN

RE: ORIBO CALLEB MAGUTU / EDU/PGT/41/05)

The above named is a Master of Philosophy Student in the School of Education Technology. He has completed him course work and is doing Research titled: Challenges of accessing Electricity for ICT use in Kenyan Secondary Schools: A case of Nandi County:

Please give him the assistance he requires to complete writing his thesis.

CHEPKOILEL UNIVERSITY COLLEGE
Dept. of Technology Education
P.O. Box 1125 Eldoret 30100

Prof. Peter Okemwa
Head, Technology Education Department

APPENDIX IV: Letter of Research Authorization

REPUBLIC OF KENYA

NATIONAL COUNCIL FOR SCIENCE AND TECHNOLOGY

Telephone: 254-020-2213471, 2241349, 254-020-2673550
Mobile: 0713 788 787 , 0735 404 245
Fax: 254-020-2213215
When replying please quote
secretary@ncst.go.ke

P.O. Box 30623-00100
NAIROBI-KENYA
Website: www.ncst.go.ke

Our Ref: **NCST/RCD/13/013/22**

Date: **23rd April, 2013**

Calleb Magutu Oribo
Moi University
P.O.Box 3900-30100
Eldoret.

RE: RESEARCH AUTHORIZATION

Following your application dated ***4th April, 2013*** for authority to carry out research on "***Challenges of accessing electricity for ICT use in Kenya Secondary Schools: A case of Nandi County,***" I am pleased to inform you that you have been authorized to undertake research in **Nandi County** for a period ending **31st December, *2015.***

You are advised to report to **the District Commissioners and the District Education Officers, Nandi County** before embarking on the research project.

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

DR M.K. RUGUTT, PhD, HSC.
DEPUTY COUNCIL SECRETARY

Copy to:

The District Commissioners
The District Education Officers
Nandi County.

"The National Council for Science and Technology is Committed to the Promotion of Science and Technology for National Development".

APPENDIX V: Research Permit

PAGE 2

THIS IS TO CERTIFY THAT:
Prof./Dr./Mr./Mrs./Miss/Institution
Calleb Magutu Oribo
of (Address) Moi University
P.O.Box 3900-30100, Eldoret.
has been permitted to conduct research in

Location
District
Nandi County

on the topic: Challenges of accessing electricity for ICT use in Kenya secondary schools: A case of Nandi County.

for a period ending: 31st December, 2015.

PAGE 3

Research Permit No. *NCST/RCD/13/013/22*
Date of issue *23rd April, 2013*
Fee received *KSH. 1,000*

Applicant's Signature

Secretary
National Council for Science & Technology

CONDITIONS

1. You must report to the District Commissioner and the District Education Officer of the area before embarking on your research. Failure to do that may lead to the cancellation of your permit.
2. Government Officers will not be interviewed with-out prior appointment.
3. No questionnaire will be used unless it has been approved.
4. Excavation, filming and collection of biological specimens are subject to further permission from the relevant Government Ministries.
5. You are required to submit at least two(2)/four(4) bound copies of your final report for Kenyans and non-Kenyans respectively.
6. The Government of Kenya reserves the right to modify the conditions of this permit including its cancellation without notice

GPK6055Dut10/2011

REPUBLIC OF KENYA

RESEARCH CLEARANCE PERMIT

(CONDITIONS—see back page)

APPENDIX VI: Map of Nandi County

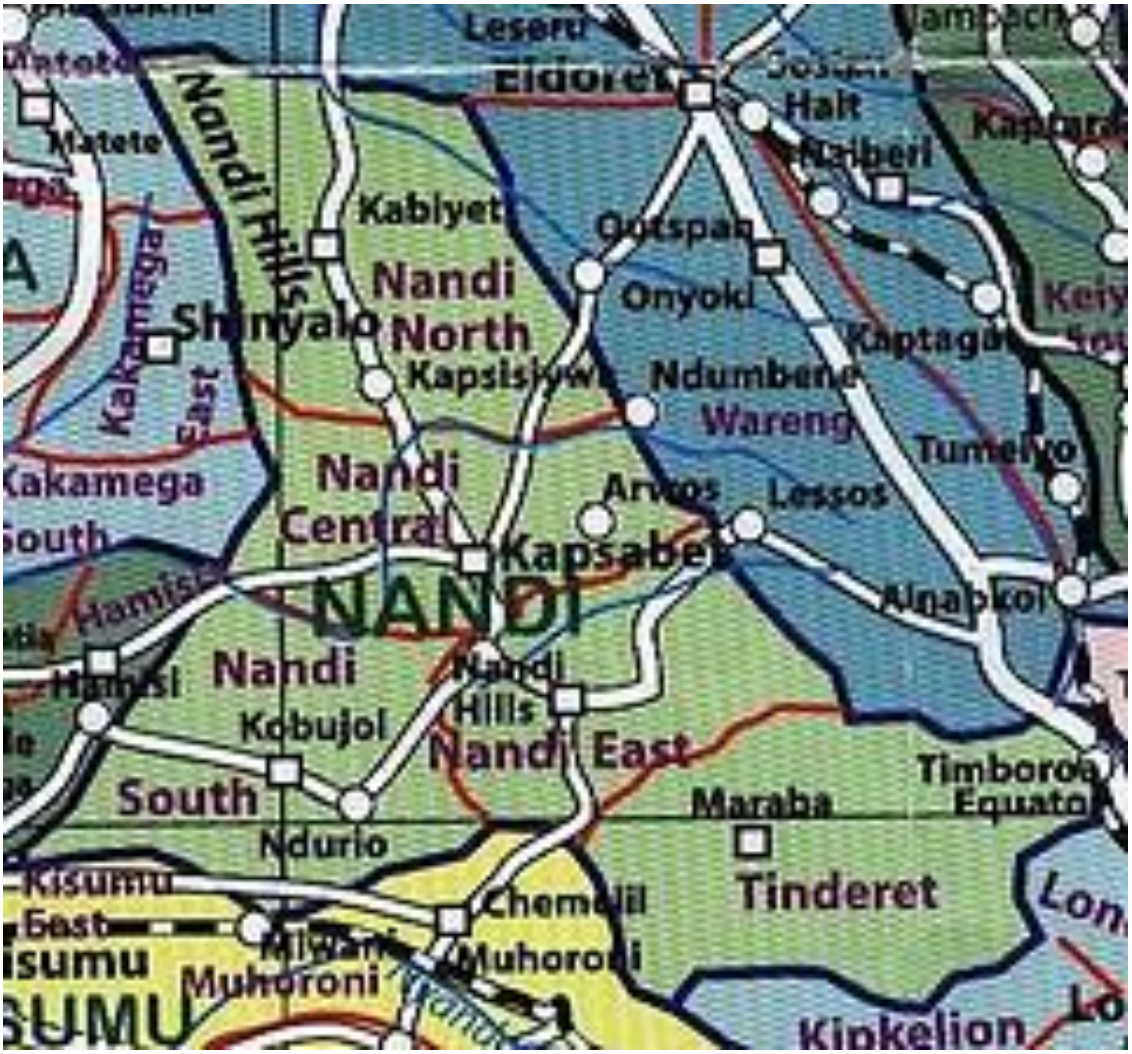


Figure 22: Map of Nandi County (Source : Google maps, 2013)

Appendix VII: Comparison of seven African Countries electrical Power Tariff

Africa – Comparative Tariff (cents US/kWh)

Company		REGIDESO	PHCN	ZESA	KPLC	EEPCO	EEHC	SNEL
Country		BURUNDI	NIGERIA	ZIMBABWE	KENYA	ETHIOPIA	EGYPT	DR CONGO
Single phase domestic usage	2 kWh	3.82kW	3.12	1.46	13.50	5.09	1.56	3.90
(E=200kWh/Month)	4 kWh	3.82kW	3.12	1.46	13.50	5.09	1.56	3.90
Commercial usage	12 kWh	11.79	3.04	1.01	15.40	6.26	2.50	8.70
(E = 1800kWh/month)	15 kWh	11.79	3.12	1.01	15.40	6.26	2.50	8.70

Source: (UPDEA, 2009)

Appendix VIII: Public Secondary Schools in Nandi County

Public Secondary Schools in Nandi County

1 29513101 KAPSABET GIRLS HIGH SCHOOL – Girls Boarding
2 29513103 CHEMUNDU SECONDARY SCHOOL – Mixed Day
3 29513104 KABIKWEN SECONDARY SCHOOL – Mixed Day
4 29513105 KAPTILDIL SECONDARY SCHOOL – Mixed Day
5 29513106 KAMOBO SECONDARY SCHOOL – Mixed Day
6 29513109 KIPSIGAK HIGH SCHOOL – Boys Boarding
7 29513112 ST. BARNABAS HIGH SCHOOL TEGAT – Mixed Day
8 29513201 KAPTEL BOYS HIGH SCHOOL – Boys Boarding
9 29513202 KIBORGOK HIGH SCHOOL – Mixed Day & Boarding
10 29513203 CHEMUSWA SECONDARY SCHOOL – Mixed Day
11 29513204 SANIAK SECONDARY SCHOOL – Mixed Day
12 29513205 KOMBE SECONDARY SCHOOL – Mixed Day
13 29513206 KAPSISIYWA SECONDARY SCHOOL – Mixed Day
14 29513208 CHEPKUMIA SECONDARY SCHOOL – Mixed Day
15 29513209 KABWARENG SECONDARY SCHOOL – Mixed Day
16 29513210 FR.KUHN SECONDARY SCHOOL – Mixed Day
17 29513211 ST. PAUL'S ACK GIRLS SECONDARY SCHOOL- KAPTEL – Girls Boarding
18 29513212 A.I.C. KAMOIYWO GIRLS SECONDARY SCHOOL – Girls Boarding
19 29513213 KIMNYOASIS SECONDARY SCHOOL – Mixed Day
20 29513301 KILIBWONI HIGH SCHOOL – Boys Boarding
21 29513302 KAPCHEMOIYWO GIRLS SECONDARY SCHOOL – Girls Boarding
22 29513303 OUR LADYOF VICTORY GIRLS KAPNYEB – Girls Boarding
23 29513304 TERIGE SECONDARY SCHOOL – Boys Boarding
24 29513305 TULON HIGH SCHOOL – Mixed Boarding
25 29513306 NDUBENETI SECONDARY SCHOOL – Mixed Boarding
26 29513307 KABIRIRSANG SECONDARY SCHOOL – Mixed Day
27 29513308 KAPKAGAON SECONDARY SCHOOL – Mixed Boarding
28 29513309 ST. ROBERTS ARWOS MIXED DAY SECONDARY SCHOOL – Mixed Day
29 29513310 KIPTURE SECONDARY SCHOOL – Mixed Day
30 29513401 ST.JOSEPH'S GIRLS-CHEPTERIT – Girls Boarding
31 29513402 CHRIST THE KING HIGH SCHOOL CHEPTERIT – Mixed Day
32 29513403 KOSIRAI HIGH SCHOOL – Mixed Day
33 29513404 A I C KOSIRAI GIRLS SEC SCHOOL – Girls Boarding
34 29513405 ST. PATRICK NDAPTABWA SECONDARY SCHOOL – Mixed Day
35 29523101 KEMELOI BOYS SECONDARY SCHOOL – Boys Boarding
36 29523102 KAPSENGERE SECONDARY SCHOOL – Boys Boarding
37 29523103 SEREM SECONDARY SCHOOL – Boys Boarding
38 29523104 KOIBARAK SECONDARY SCHOOL – Mixed Day
39 29523105 BANJA SECONDARY SCH – Mixed Day & Boarding
40 29523106 KAPKEBEN AIC GIRLS SECONDARY SCHOOL – Girls Boarding
41 29523107 BONJOGE A.I.C BOYS SECONDARY SCHOOL – Boys Boarding
42 29523108 KAPKURES SECONDARY SCHOOL – Mixed Day
43 29523109 KEMELOI GIRLS SECONDARY SCHOOL – Girls Day & Boarding
44 29523110 KOITABUT SECONDARY SCHOOL – Mixed Day
45 29523111 CHEBARA SECONDARY SCHOOL – Mixed Day
46 29523112 BISHOP MAKARIOS BOYS-KESENGEI – Boys Boarding
47 29523113 CHEPKUNY SECONDARY SCHOOL – Mixed Day
48 29523114 ST. ANNE'S GIRLS' KAPKEMICH – Girls Boarding
49 29523201 KIMAREN SECONDARY SCHOOL – Mixed Day
50 29523202 MARABA SEC SCH – Mixed Day
51 29523203 KAPTUMEK SECONDARY SCHOOL – Mixed Day
52 29523204 FR. MAIR GIRLS SECONDARY SCHOOL – Girls Boarding
53 29523205 A.I.C CHEPKEBUGE SECONDARY SCHOOL – Mixed Day
54 29523301 KAPTUMO BOYS HIGH SCHOOL. – Boys Boarding
55 29523302 ALDAI GIRLS SEC SCH – Girls Boarding
56 29523303 CHEPKONGONY SECONDARY SCHOOL – Mixed Day
57 29523304 NDURIO SECONDARY SCHOOL – Mixed Day
58 29523305 KOYO SECONDARY SCHOOL – Mixed Day
59 29523306 KESOGON SECONDARY SCHOOL – Mixed Day
60 29523307 AIC CHEBISAAS GIRLS SECONDARY SCHOOL – Girls Boarding
61 29523308 KAPKOLEI GIRLS SEC SCH – Girls Boarding
62 29523309 KIPTULUS SECONDARY SCHOOL – Mixed Day
63 29523310 KEBURO SECONDARY SCHOOL – Mixed Day
64 29523401 CHEMASE SECONDARY SCHOOL – Mixed Day & Boarding
65 29523402 ST.PAULS CHEMALAL A.C.K SECONDARY SCHOOL – Mixed Day
66 29540101 KABIYET BOYS SECONDARY SCHOOL – Boys Boarding
67 29540102 CHEPTIL SECONDARY SCHOOL – Mixed Day & Boarding

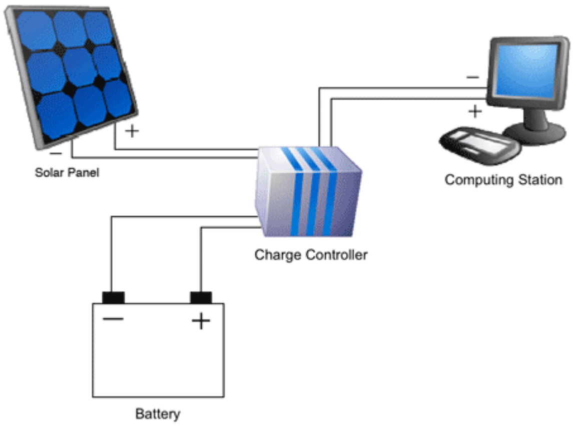
68 29540103 SANG'ALO SECONDARY SCHOOL – Mixed Day
69 29540104 STEPHEN KOSITANY GIRLS' HIGH SCHOOL – Girls Boarding
70 29540105 KEBULONIK SECONDARY SCHOOL – Mixed Day
71 29540106 ST MICHAEL'S SECONDARY SCHOOL KABISAGA – Mixed Day
72 29540107 EISERO GIRLS SECONDARY SCHOOL – Girls Boarding
73 29540109 ST. PATRICK'S CHEMNOET SECONDARY SCHOOL – Mixed Day
74 29540111 A C K KIMOGOCH SECONDARY SCHOH OOL – Mixed Day
75 29540112 TABOLWA SECONDARY SCHOOL – Mixed Day
76 29540113 ST. THOMAS SECONDARY SCHOOL – KAIBOI – Mixed Day
77 29540201 KURGUNG SECONDARY SCHOOL – Boys Boarding
78 29540202 LABORET BOYS HIGH SCHOOL – Boys Boarding
79 29540203 ST. TERESA OF AVILA GIRLS – NDALAT – Girls Boarding
80 29540204 TULWO GIRLS HIGH SCHOOL – Girls Boarding
81 29540205 NDALAT GAA GIRLS' SECONDARY SCHOOL – Girls Boarding
82 29540206 ST MONICA SEC. SCHOOL. KAPKOROS – Mixed Day & Boarding
83 29540207 ST.BRIGITTA GIRLS HIGH SCHOOL – Girls Boarding
84 29540208 ST. CLEMENT SECONDARY SCHOOL-NYIGOON – Mixed Day
85 29540209 KAPKOIMUR SECONDARY SCHOOL – Mixed Day
86 29540210 A.I.C CHEPKEMEL SECONDARY SCHO OL – Mixed Day
87 29540211 AIC KAMANYINYA SECONDARY SCHOOL – Mixed Day
88 29540213 ST. PETERS NGENYILEL SECONDARY SCHOOL – Mixed Day
89 29540214 ST. JOSEPH'S KAPKENYELOI – Mixed Day
90 29540215 OLMAROROI SECONDARY SCHOOL – Mixed Day
91 29540216 TANGARATWET SECONDARY SCHOOL – Mixed Day
92 29540217 AIC KIMONG' SEC SCH – Mixed Day
93 29540218 KAMUNGEI SECONDARY SCHOOL – Mixed Day
94 29540301 LELMOKWO HIGH SCHOOL – Boys Boarding
95 29540302 MOI HIGH SCHOOL, SIRGOI – Boys Boarding
96 29540303 ITIGO GIRLS SECONDARY SCHOOL – Girls Boarding
97 29540304 NGECHEK SECONDARY SCHOOL – Mixed Day & Boarding
98 29540305 ST FRANCIS CHEPTARIT SECONDARY SCHOOL – Girls Boarding
99 29540306 SIGOT SECONDARY SCHOOL – Mixed Day
100 29540307 AIC CHEPTWOLIO SECONDARY SCHOOL – Mixed Day
101 29540308 NDONYONGARIA SECONDARY SCHOOL – Mixed Day
102 29540309 ST JUDES KOKWET SECONDARY SCHOOL – Mixed Day
103 29540310 AIC MOSORIOT SEC SCHOOL – Mixed Day
104 29540311 AIC ITIGO MIXED SEC SCH – Mixed Day
105 29541101 LELWAK SECONDARY SCHOOL – Boys Boarding
106 29541102 SOCHOI SECONDARY SCHOOL – Boys Boarding
107 29541103 SOCHOI A.I.C GIRLS SECONDARY SCHOOL – Girls Boarding
108 29541104 KOILOT SECONDARY SCHOOL – Mixed Day
109 29541105 OL'LESSOS MIXED DAY SECONDARY SCHOOL – Mixed Day
110 29541106 SIWO SECONDARY SCHOOL – Mixed Day
111 29541201 SAMOEI BOYS SECONDARY SCHOOL – Boys Boarding
112 29541202 OUR LADY OF PEACE GIRLS' SECONDARY SCHOOL – Girls Boarding
113 29541203 TAITO K.T.G.A SECONDARY SCHOOL – Mixed Boarding
114 29541204 CHEPKUNYUK SEC SCHOOL – Girls Boarding
115 29541205 KABOTE ADVENTIST SEC. SCHOOL – Mixed Boarding
116 29541207 KAPLELMET SECONDARY SCHOOL – Mixed Day
117 29541208 KAPSIMOTWA SECONDARY SCHOOL – Mixed Day
118 29541209 SAVANI SECONDARY SCHOOL – Mixed Day
119 29541210 SIRET SECONDARY SCHOOL – Mixed Day
120 29541211 KOSOIYWO SECONDARY SCHOOL – Mixed Day
121 29542101 METEITEI BOYS SECONDARY SCHOOL – Boys Boarding
122 29542102 ST.MARY'S TACH ASIS GIRLS SECONDARY SCHOOL – Girls Boarding
123 29542103 GOT NE LEL SECONDARY SCHOOL – Mixed Boarding
124 29542104 A I C SETEK SEC SCHOOL – Mixed Day
125 29542105 ST JOHN TACHASIS MIXED DAY SECONDARY SCHOOL – Mixed Day
126 29542106 FR.MARTIN BOYLE KABOLEBO SECONDARY SCHOOL – Mixed Day
127 29542107 ST. ANDREW SECONDARY SCHOOL – SENETWO – Mixed Day
128 29542108 KAPKOROS SECONDARY SCHOOL – Mixed Day
129 29542109 FR. MARTIN BOYLE ACADEMY SECONDARY SCHOOL – Mixed Day
130 29542201 HENRY KOSGEI SECONDARY SCHOOL – Mixed Boarding
131 29542202 KIMWANI SECONDARY SCHOOL – Mixed Day
132 29542203 TAUNET SEC SCHOOL – Mixed Day
133 29542301 TINDERET SECONDARY SCHOOL – Mixed Day & Boarding
134 29542302 CHEPTONON MIXED SECONDARY SCHOOL – Mixed Day & Boarding
135 29542303 CHEMAMUL SECONDARY SCHOOL – Mixed Day
136 29542304 MUTUMON SECONDARY SCHOOL – Mixed Day

Appendix IX: The use of alternative sources of energy to power ICT

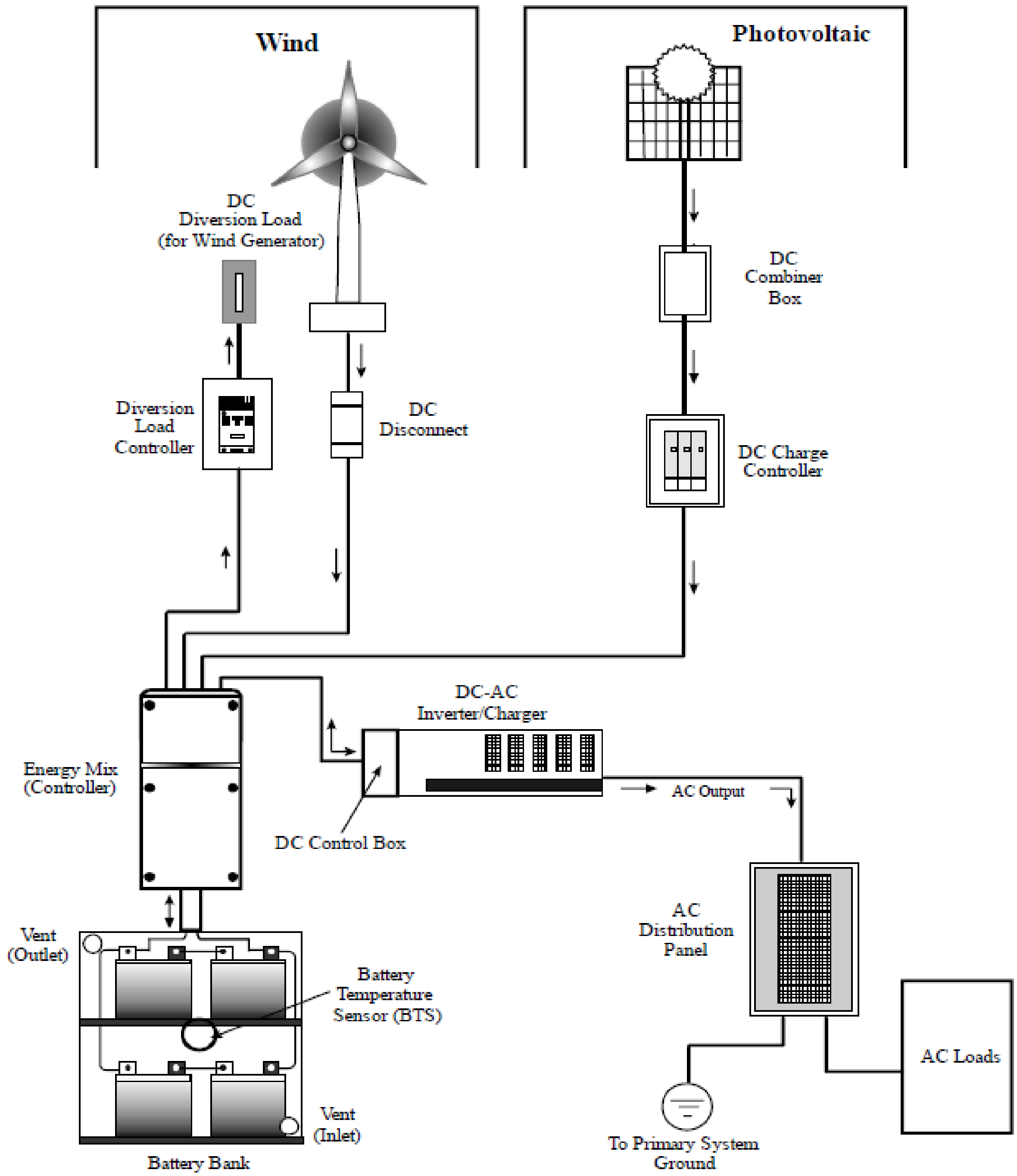
Installed solar panels at Holston View Elementary School (Castle, 2013).

One hundred seventy-eight solar modules installed in a saw tooth roofline of Analy High School's wood shop building. The system's six inverters are connected to a special meter that displays the system's power output located inside the woodshop building (Roberts, 2013).

Pete Blair of CCEnergy and Marty Webb, Analy principal, get a roof-top view of the solar panels (Roberts 2013).



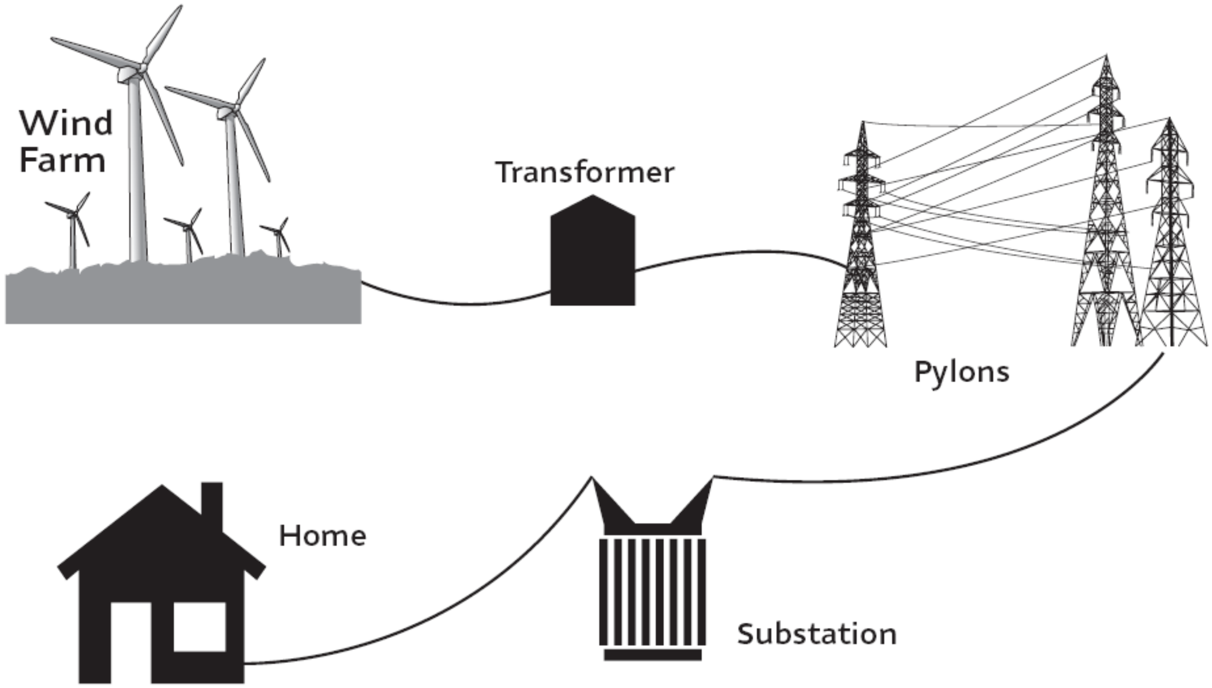
Zambia, Southern Africa -- Jonathan Sims-Chikanta High School Computer Lab (Inveneo, 2010).



Schematic diagram of Hybrid (Renewable) Solar – Wind Power Source (Adejumobi et al., 2011)

Tehachapi wind farm 4 (Watts, 2013)

Ecotricity in UK builds windmills at data center locations with no capital cost to user (St. Arnaud, 2013).



(Watts, 2013).

(INVENEO, 2013)