FACTORS INFLUENCING UTILIZATION OF SOLAR ENERGY IN KENYA INDUSTRIES: THE CASE OF TEA PROCESSING FACTORIES IN MERU COUNTY

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ABSTRACT

One of the major challenges facing the Tea sector in Kenya is the high cost of energy. To address this challenge, a study was conducted in order to determine the energy consumption in five factories in Meru County, Kenya, in order to determine factors influencing implementation of solar energy use as an alternative source of energy. Energy consumption data for five years as collected and analyzed. Plant survey was carried out in order to establish energy requirements for a tea processing factory. The researcher established the extent to which government promotional policies influence implementation of solar energy utilization in tea processing factories in Meru County, determined how use of solar energy awareness influence implementation of solar energy utilization in tea processing factories in Meru County, determine how Sociotechnical factors influence implementation of solar energy utilization in tea processing factories in Meru County, determine how Economic fluctuations influence implementation of solar energy utilization in tea processing factories in Meru County and determine how environmental stewardship influence implementation of solar energy utilization in tea processing factories in Meru County as the main objectives. The study adopted the descriptive survey design with stratified random sampling and sample size drawn from five tea processing factories. Each factory had 28 respondents making a total of 140 respondents in all the five factories. Primary data was collected using structured questionnaires that were self-administered survey. Responses to the questions were anchored on a 5-point Likert scale and close ended questions. Data from the structured questionnaires were entered in a computer and analyzed using the Statistical Package for Social Sciences (SPSS) software version 2015. The study determined the sectional electrical energy demands for withering, processing, drying, grading and others respectively. The researcher identified factors which affected energy indicators and consumption. The study was used to show opportunities for energy cost reduction through energy conservation and renewable energy utilization as a viable alternative source of energy for tea factories. The study found that government requirement for rooftop solar heating installation for commercial establishments and that laws enacted greatly influence solar energy utilization in tea processing factories in Meru County. The study found that knowledge of technology benefits influences solar energy utilization in tea processing factories in Meru County to a great extent. The study also found that availability of technical services and knowledge on solar energy influence solar energy utilization in tea processing factories in Meru County greatly. The study found further that technology influences solar energy utilization in tea processing factories in Meru County to a great extent. The study found that environmental stewardship factors influences solar energy utilization in tea processing factories in Meru County to a great extent. The study concluded that government policies had the greatest effect on the solar energy utilization in tea processing factories in Meru County, followed by sociotechnical factors, then environmental stewardship, then economic fluctuations while solar energy awareness had the least effect to the solar energy utilization in tea processing factories in Meru County. The study recommends that the Government of Kenya and especially the Ministry of Energy need to provide training and education to increase the level of knowledge and awareness on the use of solar energy. The study also recommends that the Meru County government should provide incentives such as tax waivers and import duty waivers to encourage tea industries to engage in installation and implementation of solar energy technologies hence catering for the industry needs.

Key Words: *utilization, solar energy, Kenya industries, tea processing factories, Meru County*

INTRODUCTION

The renewable energy industry is one which can ensure national energy security and reduce greenhouse gas emissions. This would eventually lead to a reduction in energy demand and reduce Green House Gas emissions. The world's major industrialized countries have fully understood the importance of renewable energy utilization for industrial use. The spread of solar and other modern energy technologies in African countries is considerably low. Despite the global viability and growth in the solar energy market, African countries continue to lag behind. They represent less than 1% of the market demand for solar energy.

The region accounts for only 9% of the global installed capacity of photo-voltaics (PV) which convert light into electricity using semi-conducting materials. The solar PV technology power generation rate rose from 1% in 2010 to just between 3% and 4% in 2013. This is despite the fact that Africa has the best solar resource in the world. Most countries on the African continent receive between 4–6 kWh/m2/day in most months of the year. This means that in a day, a square meter of solar panel can generate 4 to 6 kilowatt units of electricity. In simple terms, it could power 400 - 600 10-watt light bulbs for one hour. In the past, the poor diffusion of modern energy technologies in developing countries, especially in rural areas, was attributed to poverty and ignorance. But recent market dynamics challenge this theory. Mobile telephony technologies, for example, have had huge success in market penetration in the same environments and under even tougher conditions. So there is need to examine what is holding the solar energy sector back (Da Silva, Strathmore University).

The United Nations in recognition of the importance of energy for sustainable development declared the year 2012 as the year of sustainable energy for all (UNEP, 2012). This brought about an opportunity to raise awareness about the importance of increasing sustainable access to energy, energy efficiency, and renewable energy at the local, regional and international levels. Energy is core to everything that we do, from powering our economies, creating job opportunities to improving security (Ban K 2012). Provision of adequate, affordable, reliable and efficient energy lies at the heart of every country's core interests. For instance, in Kenya, Vision 2030 highlights ways that Kenya can be sufficient in energy supply (NESC, 2006).

Kenya depends on traditional biomass of firewood, charcoal and agricultural waste, a bulk of which is used in rural households and small businesses. Kenya is also dependent on hydro-power whose potential has dramatically reduced in the past 20 years due to the destruction of water catchment areas, yet the country's demand has grown higher than the supply leaving a reserve margin of about 7% (MoE, 2011). There was a postulated energy gap of 23% in 2015 (Day, 2010).The approximation seems higher but its not very far from the reality. This calls for an urgent need to look for alternative sources of energy which are sustainable and affordable to the majority in rural and urban areas as well as in industrial setups and also institutions.

Owing to climate change, the situation is likely to be more adverse. This has been characterized by the country’s prolonged drought and flooding that affects the water levels hence leading to low hydro power production potential. To address such challenges, the response strategy has given a lot of emphasis on Green Energy options, which are sources of energy with zero or low levels of greenhouse emissions. Such energy sources include wind power, solar power and renewable biomass sources. The Sessional Paper No. 4 of 2004 on energy connotes that despite the massive potential of Kenya to harness and exploit solar power technology its uptake is still very low. Awareness has been created in the rural and urban areas of the region on the need to switch to greener and effective alternative energies, whereby solar energy forms the best alternative but in spite of these efforts and the apparent potential in the County, technology uptake in some areas has been generally slow according to 2011 KNDB report. This study therefore aims to evaluate the root causes for the low level of solar energy uptake in the tea factories in Imenti south sub county, Meru County, Kenya.

While hydroelectric energy is the most developed form of energy, solar energy is the most abundant form of energy on earth. It is available to every location on the planet and can easily meet all of the energy needs of mankind. Optimizing a photovoltaic system can turn a bad design into a productive one and applying optimizing techniques to an original design will create a photovoltaic system that will produce more energy than initially anticipated.10% of about 600 million people in Africa use clean solar energy to power their homes. This significant uptake has been made possible by the decreasing prices of solar panel systems with the cost being lower compared to diesel, kerosene and hydropower. GreenMatch.co.uk (2018) outlines the advantages of photovoltaic solar power that make it, one of the most promising renewable energy sources in the world. It is non-polluting, has no moving parts that could break down, requires little maintenance and no supervision, and has a life of 20-30 years with low running costs. It is especially unique because no large-scale installation is required. Remote areas can easily produce their own supply of electricity by constructing as small or as large of a system as needed. Solar power generators are simply distributed to homes, schools, or businesses, where their assembly requires no extra development or land area and their function is safe and quiet. As communities and industries grow, more solar energy capacity can be added, thereby allowing power generation to keep in step with growing needs without having to overbuild generation capacity as is often the case with conventional large scale power systems. Compare those characteristics to those of coal, oil, gas, or nuclear power, and it’s easy to see that solar energy technologies offer a clean, renewable, domestic and industrial energy source.Previous research on the diffusion of solar PV in Africa has mainly focused on solar home systems (SHS) in individual countries and thus overlooked developments in other PV market segments that have recently emerged.

Solar energy is most sought today in developing countries, the fastest growing segment of the photovoltaic market. People go without electricity as the sun beats down on the land, making solar power the obvious energy choice. It is much more practical than the extension of expensive power lines into remote areas, where people do not have the money to pay for conventional electricity. With solar energy being so economical, would factories embrace it in place of already working power sources? If they do, how would the factories management react to the initial installation? Would they resist the adoption of solar energy based on the initial costs if they perceive that it will take a while to recoup the costs?

This research paper will focus on solar energy as a substitute for hydro power energy in order to ensure effective utilization of energy. This would ensure optimal utilization of power by the factory which would significantly reduce their electricity bills thereby improving the overall factories profitability. For this purpose, the research was conducted in Kionyo tea factory, Imenti tea Factory, Kinoro tea Factory, Githongo tea Factory and Weru tea factory in Meru County, Kenya.

STATEMENT OF THE PROBLEM

Kenya is well known for a large-scale market-driven penetration of very small photovoltaic (PV) systems in rural areas. It is estimated that about 200,000 rural households already use PV systems, and that the figure is growing by about 20,000 users’ per annum (Tanui, 2002). There are several factors that influence utilization of solar energy in the world. The market potential for solar PV is excellent in Kenya for a number of reasons that echo across East Africa according to KCIC.They include reducing trend of solar PV products such as panels and batteries and continuing to increase the affordability of the product ,tax exception to solar PV products that has similarly reduced product costing and the growing credit financing of solar PV product that has enabled gradual payment of solar products hence reduced shock on high upfront cost that has led to a low adoption of the technology for decades. Despite the increasing adoption of solar PV products by consumers coupled with the attraction of a large number of market players, the solar energy utilization has been influenced by several factors; (1) Government Policy promotion on solar energy utilization: The Government policy does not specify a role of solar PV for Solar Home Systems in “pre-electrification” of areas proximate to the grid (where >300 kWp/year demand for SHS is located). Unlike Tanzania and Uganda, Kenya does not provide incentives or subsidies for industrial and household solar PV systems. This has led to limited PV implementation to public sector procurement in remote areas where there is little commercial interest (when most PV business in Kenya is currently in the private sector in high potential cash crop area). Also it does not provide a role for PV in support of grid electrification in high potential areas. Given that there are 4 million un-electrified of-grid rural households, mostly located in high potential farming areas, and grid-based rural electrification is only completing (at most) 100,000 connections per year, there is a largely suppressed demand for electricity; (2) Lack of solar energy awareness: The sector is also experiencing challenges from solar energy knowledge in terms of not having formal skills, and yet they have connections with solar distributors and retailers who subcontract them. These ‘behind the scenes’ operations are contrary to the government regulations which require that only licensed technicians are allowed to design and install solar PV systems; and to be licensed, technicians have to undertake a solar training course, gazette solar PV regulations 2012; (3) Sociotechnical factors: Although solar PV technology has advanced tremendously in the last decades, there are still several sociotechnical barriers to adoption. It can be influenced by not only the local conditions of the user’s environment but also the political and financial arrangements that may change from country to country. For instance, in Kenya, various fake solar PV products have infiltrated the market; (4) Economic fluctuations: Economic barriers are usually related to the high cost of solar PV modules. Since these products are distributed by retail networks, additional cost is added by middlemen, and this is felt by the end user. Moreover other economic burdens including regional competition, difficulty to access finance, low purchasing power of consumers and rising counterfeit products build on the already strained market. The effective implementation of solar energy as a substitute to hydro power is due to the costs incurred by factories in the course of running their operations. Introduction of green energy substitutes require re-engineering of business processes, which many organizations find hard to adopt. The organizations’ lack sufficient knowledge on how to implement the alternative energy sources; (5) Environmental stewardship: This is where the solar energy end user needs to be aware of the importance of utilization of green renewable energy. Users’ desire to protect the environment through the use of clean energy. The gap addressed by this study was to empirically establish whether unstable economic fluctuations, solar energy awareness, government policies, social technical factors and environmental stewardship have any influence in the implementation of solar energy use in tea processing factories in Meru County.

PURPOSE OF THE STUDY

The purpose of that study was to determine the factors that influence implementation of solar energy use in tea processing factories of Meru County. The research study involved five tea processing factories that include Kionyo, Imenti, Githongo, Kinoro and Weru tea processing factories in Meru County.

OBJECTIVES OF THE STUDY

1. To establish the extent to which government policies influence utilization of solar energy in tea processing factories in Meru County.
2. To determine how solar energy awareness influence utilization of solar energy in tea processing factories in Meru County.
3. To determine how Sociotechnical factors influence solar energy utilization in tea processing factories in Meru County.
4. To determine how Economic fluctuations influence solar energy utilization in tea processing factories in Meru County.
5. To determine how environmental stewardship influence solar energy utilization in tea processing factories in Meru County.

LITERATURE REVIEW

Solar Energy Utilization Policies in Kenya Industries

According to the Energy Regulation Commission, Kenya receives daily insolation of 4-6 kWh/m2. Solar utilization is mainly for photovoltaic (PV) systems, drying and water heating. The solar PV systems are used mainly for telecommunication, cathodic protection of pipelines, lighting and water pumping. Some of the barriers affecting the exploitation of solar energy resource include high initial capital costs, low awareness of the potential opportunities and economic benefits offered by solar technologies, and a lack of adherence to system standards by suppliers. The Government has zero-rated the import duty and removed Value Added Tax (VAT) on renewable energy equipment and accessories. The Energy Regulatory Commission has prepared and gazettes the Energy (Solar Water Heating) Regulations 2012 and The Energy (Solar Photovoltaic) Regulations 2012 to provide the much needed policy framework.

A vibrant solar energy market has developed in Kenya over the years for providing electricity to homes and institutions remote from the national grid and for medium temperature water heaters for domestic and commercial usage. A preliminary survey done in 2005 established that the annual market demand for Photo Voltaic (PV) panels was 500 kilowatt peak (kWp) and this was projected to grow at 15% annually.

The use of solar resources in Kenya started in the 1870s, following government's use of solar photovoltaic (PV) systems to operate broadcast installations (masts) in remote areas (Hansen et al., 2014a; Hansen et al., 2015). In the 1980s, international donors and NGOs played a key role in the development of solar energy sector to provide electric power to social services, such as school lighting, water pumping and vaccine refrigeration (Ondraczek, 2013). However, donor support has gradually reduced over the years; and since 1990s the sector has been mainly driven by the private sector. Arguably, the growth of solar home systems market in Kenya is mainly attributed to marketing efforts of the private sector with little support from the government (ATPS, 2014). Donor support is also considered as a crucial and complimentary factor in facilitating the development of solar home systems niche market in Kenya (Byrne et al., 2014).

Lately, the government has shown increasing interest for solar electric energy. For instance, since the mid-2000s, the government has been providing boarding schools and health facilities in remote areas access to electricity through PV panels. From 3000 institutions in remote areas, about 2050 institutions, including primary and secondary schools, dispensaries, health and administrative centers, have been electrified by solar PV systems (Ministry of Energy, 2015). In the early years of PV sector development in Kenya, solar systems were relatively larger, complicated and expensive. Most of them failed because of lack of capability for appropriate installations and maintenance (Ondraczek, 2013).

Despite the challenges, significant success was achieved in the commercial diffusion of battery-based solar home systems, driven by a desire for TV viewing of the rural community (Ondraczek, 2013). It is estimated that over 320,000 rural households have solar home systems (SHSs) as of 2012 (Lay et al., 2012).PV systems commercially distributed to rural areas of Kenya typically consist 4 The Kenyan government's support to development of solar PV particularly through public institutions since 2005/06 to date including creation a conducive environment for entry of the private sector has not been explicitly documented hence the need to generate empirical evidence in this regard. 4 of 14 to 20Wp, wiring, rechargeable battery, sometimes a charge controller system, lighting systems, and connections to small appliances (such as a radio, television, or mobile phone charging units) (Lay et al., 2012). Despite the tremendous market growth of pico-solar and SHSs in Kenya, the diffusion of large scale (grid-connected) solar plants is relatively limited, and solar energy potential of the country is untapped5. This is due to attributed to high capital investment requirements, limited awareness of potential investors and the government on the opportunities and risks of large-scale solar investment (Ministry of Energy, 2015).

Solar Energy Utilization by factories/industries in Kenya

Since the industrial revolution, factories have been among the world's biggest consumers of energy due to their mass scale and high volume of processes centralized in one location. Much of the excitement around solar energy in the 21st century has been due to its rapid decline in price across the globe. At the end of 2016, solar power became the cheapest energy source in the world, surpassing wind and its fossil fuel counterparts like natural gas. However, much of modern skepticism about solar still lies in the question of what to do for power supply at night or during bad weather when the sun is not shining. While net metering and new storage solutions help to remedy that problem, many homeowners still rely on grid-sourced electricity for part of the day.

When it comes to commercial applications like corporate offices and manufacturing plants, the beauty of solar is that most energy use occurs during the day. Large commercial plants can benefit from solar power without needing to buy a storage solution to cover nighttime energy usage. When a factory's energy use is at its peak, a solar system will equivalently be at peak production whereas at night, the facility requires little energy while the solar system is dormant. Furthermore, larger commercial solar systems are an even better deal in terms of long-term savings because of the economies of scale dynamic with solar power. Energy Sage Solar Marketplace pricing data, as well as other third party data providers, is in consensus that the cost per watt a consumer will pay for a solar system will decrease as the system size increases. Commercial and utility-scale solar installations are largely responsible for giving solar the title of cheapest energy resource in the world. For bigger manufacturing facilities, a commercial solar installation will be at a very affordable rate, which guarantees a fast break-even point, in potentially just a few years, Richardson, 2018.

Kenya is the world leader in the number of solar power systems installed per capita. More Kenyans are now turning to solar power every year rather than make connections to the country's electric grid. This is due to a number of challenges that one faces when connecting to the national grid the first and foremost being costs of such a setup and also the high cost of buying power from Kenya Power. The increase in solar power installations has necessitated the need to enact regulations in the sector. In 2012, there was the enactment of the Energy (Solar Photovoltaic Systems) Regulations (the "Regulations") by the Energy Regulatory Commission ("ERC"). These regulations came about as a consumer protection measure to ensure that low quality solar products as well as poorly trained or unqualified technicians do not infiltrate the market. The Regulations require that all persons designing and installing solar PV, all manufacturers, vendors, distributors and contractors of solar PV systems shall be licensed by the ERC. Further, vendors and contractors are to be held liable for any faults in the design and specifications of complete solar PV systems, except in situations where customers purchase individual system components from different vendors, in which case the customers shall indicate in the signed system design declaration form that they did not require the said design or specifications from the vendor or contractors.

Solar utilization in the country is mainly for photovoltaic systems which are used for telecommunications, lighting and cathodic protection of pipelines. Solar power is also used in drying and water heating. Furthermore we have seen more and more factories install solar panels on their rooftops to counter against, the cost of buying power from the grid and also mitigating against the instability of the grid since power outages are a regular feature of the Kenyan industrial and residential landscape. We have also seen an appetite for solar products from remote high end - exclusive game lodges. As compared to an expensive diesel powered generator that causes disturbances in Kenya's game parks, a solar powered plant would be the exact opposite and not affect the lodge's operations.

The Kenyan Government has played a big role in advancement of the use of solar energy. It has removed import duty and zero-rated Value Added Tax (VAT) for renewable energy equipment and accessories. Further, its aim is to keep on increasing the factors of production. A study done by ERC in 2015, estimated the total megawatts (MW) produced in the solar sector to be over 20 with an expected growth of 15% annually. The Kenya Government aim is to have the sector produce 600 MWp by 2030. To attain this goal the government has launched several projects across the country (Mehta et al 2016) that include:

1. Samburu Solar Project (40 MWp)
2. Kopere Solar Park in Kisumu (22,7 MWp)
3. Witu Solar Project (40 MWp)
4. Garissa Solar Project (55MWp)
5. Isiolo County Solar Project (40 MWp)
6. Nakuru Solar Project (25MWp)

In addition to the above initiatives the ERC has produced a standardized power purchase agreement (“PPA”) and Feed-in-Tariffs for IPPs below 50 MWp. The new Energy Bill allows for concepts such as net-metering for private consumers while cutting out the need for licensing for plants that are for internal consumption which are lower than 1 MWp. Another key player in the growth of the solar energy sector in Kenya is the private sector whose activities have seen an estimated 200,000 rural households get connected to the solar home systems. The high level of uptake has been through sale of products that best fit the purchasing power and making products available within mobility range of potential customers. This therefore justifies the existence of over 800 rural outlets that sell solar products.

The sector has also seen the emergence of a number of innovative products. One such is the M-KOPA solar project to enable more Kenyans embrace solar energy. Its basic model is to make solar power products affordable to low income households through a 'pay-per-use' installment plan. With the input from the government, the private sector and also the innovations being made in the sector, solar energy is indeed the next frontier in Kenya's renewable energy sector. Williamson Tea has constructed the biggest solar power plant in East Africa, generating 1MW of electricity and reducing the company’s annual electricity costs by 30 per cent. The solar power plant is at the Changoi tea factory in Rift Valley. Uhuru flower farm is the second largest commercial solar powered organized. It is situated on the northern slopes of Mount Kenya near the town of Timau. The farm lies at an altitude of 2,600 m above sea level, making it one of the highest rose farms in Kenya.

The latest development towards energy efficiency is the recent commissioning of a grid tied solar PV system of 72 kWp capacity installed together with five SMA Tripower Inverters. Each inverter has a capacity of 15 kW. With this installation 30 % savings in kWh consumption has been realized within the time.

Government Policies on Solar Energy utilization by Tea Factories in Kenya

Commercial enterprises are quickly learning about how using a clean, renewable energy source like solar power can help their business cut costs and become more energy independent. It is often assumed that our energy problems are solved when renewables reach ‘grid parity’ – the point at which they can generate electricity for the same price as fossil fuels. The Government has zero-rated the import duty and removed Value Added Tax (VAT) on renewable energy equipment and accessories. The Energy Regulatory Commission has prepared and gazetted the Energy (Solar Water Heating) Regulations 2012 and The Energy (Solar Photovoltaic) Regulations 2012 to provide the much needed policy framework.

A vibrant solar energy market has developed in Kenya over the years for providing electricity to homes and institutions remote from the national grid and for medium temperature water heaters for domestic and commercial usage. A preliminary survey done in 2005 established that the annual market demand for Photo Voltaic (PV) panels was 500 kilowatt peak (kWp) and this was projected to grow at 15% annually. On 12th June 2014 the magazine "Alternative Energy Africa" published: Kenya to Stop Taxing Solar.Solar products in Kenya are already on the rise, and now expect to see even more products particularly in the off-grid arena grow even more.

Since 2006-2007, the Ministry of Energy has been actively promoting use of solar energy for off grid electrification. In particular, it has funded the solar for schools programme and is targeting to extend this to off grid clinics and dispensaries. There are no tea factories in Meru that have fully adopted solar energy as a source of energy for any of their operations. 1MW PV plant installed at Williamson Tea’s Changoi farm in Bomet County. The project was launched in 2014. The solar system has cut Williamson Tea’s energy costs by around 30%, supplying clean electricity during the daytime to meet most of the tea processing factory’s energy demand. According to innovation and Renewable Electrification in Kenya the project was installed by the British Solar energy company Solar Century. The success in the costs of energy Williamson Tea has saved from the grid has inspired tea factories to look into adopting solar energy.

Solar Energy Awareness and its Utilization in Factories in Kenya

According to Kenya Climate Innovation Center, the transition towards market-based diffusion has been facilitated to varying degrees by conducive enabling frameworks comprising innovative financing schemes, exemptions from VAT and import taxes, standardized power-purchasing agreements and feed-in tariffs (FIT), although few analyses have been conducted on the effects of these general measures. Most of the solar products are sold in the rural and peri-urban areas where there is low access to electricity. About 57% of sales are made in the rural area and 35% in the peri-urban areas. About 24% of Kenyans also use solar PV for mobile charging and 15% for reading. Solar cook kits have been promoted however with low adoption rate due to interalia, cultural practice, cooking habits and believes, product specific attributes including the cost of the cook kits, user ability, and accessibility. The solar market segment in Kenya is diverse attracting various market players.

Consumer acceptance of any technology is critical to its wide adaptability. Consumer awareness campaigns, capacity development for rural entrepreneurship, setup of decentralized after sales services and setup of payment models that match the BoP customers' irregular cash-flow. The solar market has impinged with numerous bottlenecks including counterfeits, product quality, and upfront cost of solar products and lack of understanding on the limitation of solar products hence giving the wrong impression on the performance of solar. Closer to Meru Tambuzi, a large flower farm in Nanyuki, which specializes in scented roses, has adopted green energy with a 60KW solar power system supplied and installed by Chloride Exide. The system will dramatically reduce the farm's operational expenses and cut carbon emissions in the environment. Tim Hobbs, the Managing Director of the 64 hectare farm, explained that normal solar power systems, solar panels charge batteries, batteries run an inverter, and an inverter supplies the power. The set up at Tambuzi Farm is different. It is a direct solar feed and there are no batteries involved and this reduced their installation costs. The power is fed directly to the farms needs as it is generated. With the solar installation the farm was able to save between 8,000KW and 10,000KW from its monthly electricity bills.

Influence of Socio-technical Factors on Solar Energy Utilization by Tea Processing Factories in Kenya

Availability of technical assistance in the proximity of the end users is a key factor in countering the effects of market spoilage. The presence of technicians well versed in trouble-shooting, repair and maintenance of the MET systems in the locality increases the trust of the consumers. Due to the novelty of most of the solar energy products, it is important to develop local maintenance capacity in the area where the products are being marketed. Nevertheless, the scattered nature of BOP consumers coupled with their low buying power makes the notion of setting up service centres in the distribution regions unsustainable.

Influence of Economic Fluctuations on Solar Energy Utilization in Kenya

The cost of the electricity generated by a PV system is determined by the capital cost, the discount rate, the variable costs, the level of solar irradiation and the efficiency of the solar cells (Bank, 2010). Of these parameters, the capital cost, the cost of finance and efficiency are the most critical and improvements in these parameters provide the largest opportunity for cost reductions. The capital cost of a PV system is composed of the PV module cost and the Balance of system (BOS) cost. The PV module is the interconnected array of PV cells and its cost is determined by raw material costs, notably silicon prices, cell processing/manufacturing and module assembly costs (Bank, 2010). The BOS cost includes items, such as the cost of the structural system, the electrical system costs and the battery or other storage system cost in the case of off grid applications (Kersten, et al. 2011).According to Komoto (2010), the absolute cost and structure of PV modules varies by technology. Conventional c-Si PV modules are the most expensive PV technology, with the exception of CPV modules, but they also have the highest commercial efficiency. In densely populated and concentrated rural areas of poor developing countries grid extension may be feasible and cost effective (Chaurey et al, 2004). However, in practice, utility companies are usually not attracted to extend grid electricity to ‘isolated’ or remote rural areas because of cost implications and the relatively low revenue per kilometer (Chaurey et. al., 2004, Munda and Russi, 2005). For example, the high cost of electrification makes it financially unbearable to provide electricity to rural areas in Pakistan where 67.5% of the people lived (Aslam, 2000). In remote areas, where the extension of grid-electricity is found to be expensive, solar PV systems and other energy sources including mini-hydro, wind, bio-fuel powered generators have largely demonstrated their potential for meeting the expectations of off-grid rural communities (Lorenzo, 1997). Although solar PV systems are cost-effective alternatives for low voltage applications, high installed system cost, lack of local market, lack of sustainable financing among others impede the expansion of solar PV electrification in poor developing countries (Basnyat, 2004;Johansson et al, 2004; Sawin, 2004; WCRE, 2004)

Environmental Stewardship and Utilization of Solar Energy in Tea Processing

Vision 2030, Kenya’s development blueprint for the period 2008–2030, envisions transforming the country into middle-income status where citizens enjoy a high quality of life. The blueprint has three pillars: economic, political and social. The thread that binds the three pillars is the natural environment, which supplies both renewable and non-renewable resources. Unfortunately, development in the other sectors may easily compromise the conditions of the natural environment and put the supply of clean water, food and fiber in jeopardy. For example, processing of agricultural products may increase gains from agriculture and lead to rapid expansion of the sector. If this is not carefully done, it may be characterized by wastage of resources, cutting down of forests to provide fuel and more land for cultivation, disposal of raw wastes into water bodies and over-exploitation of the soils. Using the example of tea processing factories in the country, this study sought to understand the environmental effects influencing implementation and utilization of solar energy power in tea processing factories. Tea processing factories were chosen because they have been implementing environmental efficiency-enhancing techniques in their production, yet no study had endeavored to test whether their initiatives were yielding positive results.

THEORETICAL FRAMEWORK

The conversion of solar energy to electricity creates the basis of the research study. Theoritical framework involves the appreciation of usage of photovoltaic energy in the processing of tea in factories. Photovoltaic materials use the sun’s energy to produce electricity and therefore result in none of the greenhouse emissions. The adoption of solar energy technologies in both developed and developing countries can be better understood by utilizing the theory of metabolic rift. For the developing countries policies that encourage solar energy technology at the commercial and utility scale are arguably addressing a fundamental rift in the relationship between humans and nature as expressed in the concept of an energy metabolism. Developing countries have the opportunity to adopt solar energy technologies in order to limit the extent to which they rely on the fundamental rift in human nature metabolisms, rifts caused by relying on energy sources that surpass the solar energy balance and by the possible carbon metabolism, in order to promote economic and social development.

Ecological modernization is a school of thought in the social sciences that argues that the economy benefits from moves towards environmentalism. The theory will enable policy development by putting industrial and institutional measures that will enable environmental stewardship. Although environmental values are often framed as related to values off pre modernity ,because of the influential forms of environmentalism that emerged in modern cultural contexts during the 1960s,ecological modernization theory(EMT) argues that advanced states of industrialization result in the potential for environmental values to be adopted into production practices and policy formulation. According to EMT, institutional action is not merely window dressing but is evidence that ecological modernization can and will occur within the institutional structure of advanced industrial societies. Ecological modernization theorist contend by extension that the use of solar energy technology is yet another step in the process in capitalist production processes, geared towards ecological sustainability for the sake of both profit and industrial longevity. EMT provides a practical theoretical framework for the policy development. By considering specific industrial measures and political programs to direct an environmental policy.

RESEARCH METHODOLOGY

Research Design

The study adopted descriptive research design. This method helped in obtaining the basic information required on exploring solar energy as an alternative source of energy. According to Mugenda and Mugenda (2003), this type of research attempts to describe such things as possible behavior, attitude, values and characteristics. Descriptive research gives an accurate account of particular features, situations, community or the person under study. This approach will be appropriate because the data collected mainly involved descriptions of the variables in the study. This descriptive research design will enable the researcher to capture both qualitative and quantitative data that will provide in depth information about the impact of solar energy as an alternative in tea processing factories. Five years processed tea data, electricity, fuel wood, fuel oil and diesel consumption including corresponding cost will be obtained from five tea processing factories in Meru. The proposed period to be covered will be from March 2014 to March 2018 on monthly basis. Data on factors that influence energy indicators among the factories will be collected for analysis to study any relationship. Plant survey to collect data for financial analysis will be carried out at Kionyo Tea Factory to estimate energy requirements for a Tea factory. Primary data on factory end use electrical energy requirements will be used to size and carry out the financial analysis of the renewable technologies. Financial and technical analysis assumptions will be collected through literature review. Some assumptions may be made.

Target Population

Population is defined as the total collection of elements about which a researcher wish to make some inference (Mugenda 1999). Having an average population of 7000 tea farmers deliver there unprocessed tea leaves to each of the five tea processing factories under the study excluding the factory managerial team the researcher opt to stratify the population into six sets. Due to time and cost constraints the researcher will focus on a target population of five factories in Meru County. The targeted population in each factory will be managers, supervisors, stakeholders, leaders, County Ministry of Energy representatives, and a few farmers.

Sample size and Sampling Procedure

A sample is a group on which information is gathered and the finding after analysis can be used to make generalization about a population (Kothari, 2004 and Mugenda, 1999). The sample size of this study was determined by the population using the sample size formula ‘return sample size method ‘for categorical data as propounded by Bernett, Kotrilik and Higgins(2001) emphasized by Mugenda and Mugenda (2003).

$$n = (z^2 p\ (1-p))/d^2$$

Where: n-the desired sample size; z-is the corresponding standard score with the probability of error at 0.005 and a confidence level of 95% which is 1.96; p-is the occurrence level of the phenomenon under study and is equal to 0.5 where the occurrence level was b not known; d-is the selected probability of error of the study corresponding to 95% confidence level in this case 0.05

Substituting for the values:

$$n = (1.96^2 * 0.5(1-0.5))/0.05^2 = 384$$

However since the target population to the study (7000) was less than 10,000 hence the final sample size could be adjusted as recommended by Mugenda (2003):

$$f^n = n/\ (1+n/N)$$

Where: n-is the sample size when population is less than 10,000; n-the sample size when the; population is above 10,000; N-the population of the target sub population

Substituting the values:

f^n = 384/ (1+384/1400) = 384/ (1+0.2742857143) = 384/1.2742857143 = 301

Due to the limitations of this research study this sample size still was large. According to Mugenda 1999, accessible population is enough for sampling and therefore we adopt Mugenda's model of determining the accessible population that made the sample size. Mugenda 2004 recommends 10% is appropriate for the sample drawn from accessible population. The 10% of accessible population of 1,400 is 140 which was adopted as the sample size of this research study.

Sample Procedure

The study population was comprised of 5 tea processing factories. These factories and health facilities were located in the greater Meru region: Kionyo tea factory, Imenti tea Factory, Kinoro tea Factory, Githongo tea Factory and Weru tea factory. For purposes of this study, due to financial considerations and time, convenience sampling was used to sample area of this study from the 7 regions under Kenya Tea Development Agency management. Kionyo Tea factory was used for planning the survey. The co-ordinates of the factories and their codes that were used in the study were as tabulated in table 1.

Table 1: Geographical Location of selected Tea Factories

Code	Factory	Latitude	Longitude
F1	Kionyo Tea Factory	-0.11822 N	37.59825 E
F2	Kinoro Tea Factory	-0.17983 N	37.63076 E
F3	Imenti Tea Factory	-0.06327 N	37.59796 E
F4	Githongo Tea Factory	-0.00152 N	37.590698 E
F5	Weru Tea Factory	0.04639 N	37.65275 E

Data Collection Instruments

Structured questionnaires were designed as the instrument for collecting and facilitating data collection. The instrument underwent several drafting with objective of making it valid and reliable for data collection. The instrument was given to the county ministry of energy experts to help in fine tuning before the same was forwarded to the research supervisor Dr.Naomi Gikonyo for comment and correction and later finalization.

Data Collection Procedure

Monthly made tea quantities, electricity and fuel wood as well as cost of secondary data were obtained from five tea factories in Meru, Kenya. The proposed period to be covered was five years from March 2014 up to March 2019 and all monthly energy consumption; cost of energy and production records for the period under study was completed. Data on factors considered to influence energy indicators was also collected from the factories. Cost of the viable technologies for purposes of carrying out financial analysis was sourced from Eskartec Energy Solutions Ltd. Primary data was collected using structured questionnaires that were self-administered survey. The questionnaires were delivered physically to the respondents participating in the study so as to ensure an acceptable response rate for the study. The questionnaires were administered at the workplace setting to diminish the effect of bias among the respondents. Responses to the questions were anchored on a 5 point Likert scale ranging from; 5- strongly agree, 4- agree, 3 – not sure, 2 – disagree and 1- strongly disagree and close ended questions.

Data Analysis and Presentation

The questionnaires were edited for accuracy and completeness. Data from the structured questionnaire items was entered in a computer and analyzed using the Statistical Package for Social Sciences (SPSS) software (Version 15) and Microsoft Excel. Data was presented using tables in order to show the conclusive interpretation of collected data and help the researchers give objective recommendations.

RESEARCH RESULTS

The study sought to establish the extent to which government policies influence utilization of solar energy in tea processing factories in Meru County. The study found that government policies influence solar energy utilization in tea processing factories in Meru County greatly. The study also found that government requirement for rooftop solar heating installation for commercial establishments and that laws enacted greatly influence solar energy utilization in tea processing factories in Meru County. Furthermore, the study found that government initiatives influence solar energy utilization in tea processing factories in Meru County to a little extent.

The study aimed at determining how solar energy awareness influence utilization of solar energy in tea processing factories in Meru County. This study found that solar energy awareness influences solar energy utilization in tea processing factories in Meru County greatly. The study found that knowledge of technology benefits influences solar energy utilization in tea processing factories in Meru County to a great extent. Moreover, from the outcomes the study found that access to innovation and knowledge influence solar energy utilization in tea processing factories in Meru County to a moderate extent.

The study sought to determine how Sociotechnical factors influence solar energy utilization in tea processing factories in Meru County. The study implied that social technical factors influence solar energy utilization in tea processing factories in Meru County greatly. The study found that availability of technical services as and knowledge on solar energy influence solar energy utilization in tea processing factories in Meru County greatly. Moreover, the study established that performance of products moderately influence solar energy utilization in tea processing factories in Meru County.

The study sought to assess how economic fluctuations influence solar energy utilization in tea processing factories in Meru County. The study found that technology influences solar energy utilization in tea processing factories in Meru County to a great extent. The study also found that solar PV and solar hot water technologies and alternative renewable energy technologies greatly affect the solar energy utilization in tea processing factories in Meru County. The study further found that availability of solar installation technicians influences solar energy utilization in tea processing factories in Meru County to a little extent.

The study also aimed to examine how environmental stewardship influence solar energy utilization in tea processing factories in Meru County. The study found that environmental stewardship factors influences solar energy utilization in tea processing factories in Meru County to a great extent. From the findings, the study found that awareness of climate change and attitude towards solar energy greatly affect the solar energy utilization in tea processing factories in Meru County. The study further found that recognition of hydropower scarcity influences solar energy utilization in tea processing factories in Meru County to a little extent.

The study sought to establish the trend of aspects of utilization of solar energy in tea processing factories in Meru County for the last 5 years. The study found that sustainable development and poverty reduction as a result of increased profits had greatly improved while reduced indoor pollution in the factory and reduced cost of production had improved.

REGRESSION ANALYSIS

This was applied to determine the relative importance of government policies, solar energy awareness, sociotechnical factors, economic fluctuations and environmental stewardship with respect to the solar energy utilization in tea processing factories in Meru County. The findings were presented in Table 2, 3 and 4.

Table 2: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.827	0.684	0.667	2.471

The outcome of table 2 found that adjusted R-Square value (coefficient of determination) is 0.667, which indicates that the independent variables (government policies, solar energy awareness, sociotechnical factors, economic fluctuations and environmental stewardship) explain 66.7% of the variation in the dependent variable (solar energy utilization in tea processing factories in Meru County). This implies that there are other factors that influences the solar energy utilization in tea processing factories in Meru County attributed to 32.3% unexplained.

Table 3: Analysis of Variance

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1268.88	5	253.776	39.820	0.000
	Residual	586.33	92	6.373		
	Total	1855.21	97			

The results shown in Table 3 revealed that p-value was 0.000 and F calculated was 39.820. Since the p-value was less than 0.05 and F-calculated was greater than F-critical (2.2984), then the overall model was statistically significant.

Model coefficients provide unstandardized and standardized coefficients to explain the direction of the regression model and to establish the level of significance of the study variables. The results are captured in Table 4.

Table 4: Regression Coefficients

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	0.951	0.217		4.382	.000
Government policies	0.882	0.352	0.913	2.506	.014
Solar energy awareness	0.633	0.281	0.717	2.253	.026
Sociotechnical factors	0.799	0.196	0.834	4.077	.000
Economic fluctuations	0.713	0.233	0.738	3.060	.003
Environmental stewardship	0.718	0.239	0.656	3.004	.004

As per the SPSS generated table above, the equation ($\mathbf{Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \varepsilon}$) becomes:

$$Y = 0.951 + 0.882\mathbf{X_1} + 0.633\mathbf{X_2} + 0.799\mathbf{X_3} + 0.713\mathbf{X_4} + 0.718\mathbf{X_5}$$

The findings showed that if all factors (government policies, solar energy awareness, sociotechnical factors, economic fluctuations and environmental stewardship) were held constant at zero solar energy utilization in tea processing factories in Meru County will be 0.951. The findings presented also show that taking all other independent variables at zero, a unit increase in the government policies would lead to a 0.882 increase in the score of solar energy utilization in tea processing factories in Meru County. This variable was significant since the p-value 0.014 was less than 0.05.

The findings also show that a unit increase in the score of solar energy awareness would lead to a 0.633 increase in the score of solar energy utilization in tea processing factories in Meru County. This variable was significant since $0.026<0.05$.

Further, the findings show that a unit increase in the score of sociotechnical factors would lead to a 0.799 significant increase in the score of solar energy utilization in tea processing factories in Meru County since p-value (0.000) was less than 0.05.

The study also found that a unit increase in the score of economic fluctuations would significantly lead to a 0.713 increase in the score of solar energy utilization in tea processing factories in Meru County since p-value (0.003) was less than 0.05.

Lastly, the study also found that a unit increase in the score of environmental stewardship would significantly lead to a 0.718 increase in the score of solar energy utilization in tea processing factories in Meru County since p-value (0.004) was less than 0.05

Overall, it was established that government policies had the greatest effect on the solar energy utilization in tea processing factories in Meru County, followed by sociotechnical factors, then environmental stewardship, then economic fluctuations while solar energy awareness had the least effect to the solar energy utilization in tea processing factories in Meru County. All variables were significant since their p-values were less than 0.05.

CONCLUSION

The study concluded that government policies significantly influence utilization of solar energy in tea processing factories in Meru County. The study deduced that government requirement for rooftop solar heating installation for commercial establishments and that laws enacted greatly influence solar energy utilization in tea processing factories in Meru County. Furthermore, the study found that government initiatives influence solar energy utilization in tea processing factories in Meru County to a little extent.

The study concluded that solar energy awareness significantly influence utilization of solar energy in tea processing factories in Meru County. The study established that knowledge of technology benefits influences solar energy utilization in tea processing factories in Meru County to a great extent. Moreover, from the outcomes the study found that access to innovation and knowledge influence solar energy utilization in tea processing factories in Meru County to a moderate extent.

The study concluded that sociotechnical factors positively and significantly influence solar energy utilization in tea processing factories in Meru County. The study found that availability of technical services as and knowledge on solar energy influence solar energy utilization in tea processing factories in Meru County greatly. Moreover, the study established that performance of products moderately influence solar energy utilization in tea processing factories in Meru County.

The study concluded that economic fluctuations influence solar energy utilization in tea processing factories in Meru County. The study deduced that solar PV and solar hot water technologies and alternative renewable energy technologies greatly affect the solar energy utilization in tea processing factories in Meru County. The study further found that availability of solar installation technicians influences solar energy utilization in tea processing factories in Meru County to a little extent.

The study also concluded that environmental stewardship influence solar energy utilization in tea processing factories in Meru County positively and significantly. The study established that awareness of climate change and attitude towards solar energy greatly affect the solar energy utilization in tea processing factories in Meru County. The study further found that recognition of hydropower scarcity influences solar energy utilization in tea processing factories in Meru County to a little extent.

RECOMMENDATIONS

The study shown found that there is need for the training of staff on solar use and installation. The Government of Kenya and especially the Ministry of Energy need to provide training and education to increase the level of knowledge and awareness on the use of solar energy. This can be done through seminars, workshops and public barazas where members are invited for training and demonstration on the use and benefits of solar energy.

The study further found that economic fluctuations affect the utilisation of solar energy and therefore there is very low chances of accessing solar equipment. The Government should consider zero rating tax on solar equipment so as to influence lower pricing thus making it more affordable for purchase and installation of solar system. Alternatively, the government could arrange for a plan that allows industries to pay an agreeable small amount of money per month in a bid to increase the use of solar energy.

The industries use other sources of energy such as wood and coal hence affect the environment. The county councils need to get involved as energy solution providers regardless of the availability of alternative/substitute of other sources of energy. Solar power will eventually help the councils achieve better forest cover as tea industries turn to solar and use less wood-based fuel. The tea industries should be encouraged to harness solar technology since it is cheaper and easily accessible compared to other sources of energy.

The Meru County government should provide incentives such as tax waivers and import duty waivers to encourage tea industries to engage in installation and implementation of solar energy technologies hence catering for the industry needs.

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