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Promotion of PV Uptake and Sector Growth in Kenya through Value Added Training in PV Sizing, Installation and Maintenance

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Abstract

Sub-Saharan Africa, and more specifically the East African region, has the lowest rates of access to electricity in the world. On average, at most 15% of the rural population has access to electricity. Rural households and remote institutions use traditional energy sources such as charcoal, firewood, kerosene and diesel for generator sets, batteries and dry cell batteries. On the other hand, the region is one of the most promising in the world in economic development with growth levels being high and market saturation is a far away future problem. This growth has however been hampered by several factors with lack of energy being one of them. Kenya being one of the countries in the region faces a similar problem with the traditional sources of hydro facing weather related challenges. The situation is more wanting in the rural setting having only achieved electrification rates of between 5 and 10%. The rural being where the majority of low-income earning groups reside is further compounded with large geographical imbalance in electricity demand and supply. The main challenge to adopting pv utilization however, is lack of local capacity to handle the uptake all the way from solar home systems to grid connected and hybrid systems. According to Kenya Renewable Energy Association (KEREA), it is estimated that between 800 and 1000 pv technicians have been in practice since this sector started in Kenya in the late eighties, majority of them having the basic skills but no formal training to provide the service. They however have been offering necessary service to end-users and are hence an important aspect in the pv sector as a whole. Currently the pv (mainly SHS) comprise an over the counter trade system which provides loopholes when it comes to quality of products and installation. To safeguard the quality and safety of installations, formal training has to be incorporated in the system.

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1.0 Introduction

Kenya has in the past decade experienced tremendous growth in demand for electricity with the traditional sources of hydro facing weather related challenges. Reports indicate that electrification rates are between 15 and 20% nationally [1]. The situation is even more wanting in the rural setting having only achieved electrification rates of between 5 and 10%. The rural being where the majority of low-income earning groups reside is further compounded with large geographical imbalance in electricity demand and supply. This has been a major challenge faced by the rural electrification programme where markets and schools in the rural are targeted for electrification. Since not everyone in the rural resides near a market or a school, few homes have benefited in this program but the majority is still without electricity [2]. The government has adopted measures geared towards alleviating the electricity demand by incorporating renewable energy sources to boost the existing capacity, which currently stands at 1191MW against the demand of 1490MW. This demand is set rise to about 2500MW by 2015[1]. This shows that the country still faces a major challenge in meeting this demand. Some of the measures the government has adopted are to increase the capacity from geothermal and tap in the un-utilized wind and solar energy sources. As a means to conserve the environment, the government has also set 2017 to be the deadline for the country to adopt green energy sources. Solar energy being one of the green sources, it has been given a measurable stake in the provision of electricity to the country. The country has a high potential owing to long sunshine hours it receives throughout the year. This is due to its strategic location astride the equator. Kenya is well known for a large penetration of small PV systems with capacity of 12 – 50 watts power (Wp) consisting of low cost amorphous silicon modules and both mono- and polycrystalline silicon modules. It is projected that by 2020, the installed capacity of solar photovoltaic systems will reach 10MWp generating 22 GWh annually [1].

Solar electricity in Kenya is a market driven subsector unlike the national grid which is government controlled [3]. This has made solar electricity expand rapidly as the socio economic status of the majority of rural population rises. On the other hand, the government controlled rural grid electrification has had its challenges rendering it to expand at a very slow pace. The most interesting scenario is that solar electricity in Kenya has developed with very minimal direct government support until around five years back when tax waivers were introduced on solar modules. Initially support was realized mainly from international aid organizations. In its initial stages of uptake, solar electricity had been seen as having very little environmental benefits, few economic productive uses besides being sparse and worse, being seen as only for rural elite. However this thinking has changed over time with adoption of new and innovative approaches to electrification and government subsidies that have seen solar being readily accepted in the rural population. In his 2004 report, Jacobson [4, 5] noted that the solar pv ownership in Kenya was dominated by rural middle class populations; that solar pv played a minor role in supporting income generating activities but played a substantial role in supporting the use of light for key social activities like evening studies, tv watching and phone charging. A decade later that is not the case as solar electricity utilization has been identified as being environmentally friendly, supports income generating activities and is utilized by all levels of the rural population.

With the government's introduction of among other issues the licensing of pv installers through its energy policy document, challenges of availability of qualified installers have befallen the subsector that needs urgent address. The concept of training installers with an added value of cultural acceptance has been embraced by the Department of Physics under the Solar Academy series of trainings to address this challenge.

2.0 Technical Capacity Building

2.1. Solar electricity and cultural acceptance

Traditional rural household sources of energy in Kenya are wood fuel and kerosene. Wood fuel (firewood) is mainly used for cooking and a little on lighting while kerosene is mainly used for provision of lighting. There exist different kerosene lighting devices used in Kenya with the most common one being a traditional tin lamp with a capacity of 100ml and it uses a wick. Others are industrially produced wick lanterns and higher end kerosene pressure lamps. All these devices are portable and have very low conversion efficiencies compared to electric lamps. As earlier indicated, solar pv utilization in Kenya has been mainly in form of solar home systems comprising a solar panel, charge controller, storage battery and an inverter for ac systems. The loads are mainly lights and others have a tv and radio. As much as these systems are highly decentralized, they have been a challenge to the typical rural household which traditionally many have housing units in a home detached with the kitchen and children's (especially boys) sleeping cottage separate from the main parent's house. These may be separated by a distance as far as 100 feet apart but the kitchen is usually closer to the main house. This kind of set up leads to the main house benefiting from an installation but since the kitchen is traditionally active in the early evening, it implies that as much as a solar home system is installed, other sources of lighting like kerosene must complement it. This has been one of the main drawbacks besides the prohibitive cost whereby there has been a mismatch between the technology and the culture. This was realised and just like the famous African saying 'killing two birds with one stone'; innovations came up with portable lanterns which besides being affordable, are portable and closely resemble the traditional tin lamps both in application and structural. They can be used in the kitchen when it is time to prepare meals, then moved to the living room and used over dinner and evening studies thereafter can be moved to the bedroom or cottage. This has made solar lanterns widely accepted across the diverse communities in the country.

2.2. National Technical Capacity

Early pv installations in Kenya were however mainly institutional through NGOs with very few being acquired by homes. Currently still the installed capacity is dominated by the solar home systems with other applications being institutional, and the recently emerging applications in telecommunication and more recent grid fed systems (Table 1).

Table 1: PV technology adopted in Kenya with its estimated installed capacity

PV Technology	Estimated Installed Capacity
SHS	<6 – 8 MWp
Institutional & water pumping	>1.5 MWp
Telecommunication	>300 kWp
Tourism	>50 kWp
Grid-fed	570 kWp

As it can be observed in Table 1, pv application technology is evolving towards very advanced systems. On the contrary, capacity to deal with installations has not been growing in tandem with the advances in the technology. It is estimated that between 800 and 1000 pv technicians have been practicing since this sector started in Kenya. The majority of these technicians have the skills (mainly learned through apprenticeship) but have not undergone training to provide this service. They however offer necessary service to end-users and are hence an important aspect in the pv sector as a whole. Some of the technicians operate as resellers or sales agents for established importers. Currently the pv subsector (mainly SHS) comprise an over the counter trade system which provides loopholes when it comes to quality of products and installation.

2.3 PV Licensing Regulations

In order to regulate the pv sector, the government of Kenya through the Energy Regulatory Commission (ERC) recently gazetted a policy document that requires licensing of the various groups that are involved in the pv chain all the way from the manufacturer to the user. The regulations target the manufacturer, importer, vendor, contractor, technician, the pv system owner, the installation itself and the related components. This is with target to guarantee the quality of the system and their components. The regulations require that the importer or manufacturer, vendor, contractor or installer must have the certificate recommended under its category in order to be allowed to carry out the business. For one to be licensed in any of the categories mentioned above, the licensee must have acquired a basic formal training in pv system design, sizing and installation. However the regulations were effected by the government before a curriculum for the same course was put in place. The Solar Energy Group in the Department of Physics developed a short professional training in installation in order to bridge this gap.

2.4 Scope of Training

The training period is ten days, and it targets individuals with a secondary school qualification or an apprentice who has a record of experience of working with solar pv. The training comprises theory and practical sessions in basics of pv, pv mounting, pv components (modules, controllers, inverters, batteries and appliances), wiring, sizing, installation, commissioning, user education and maintenance. This scope covers the curriculum for the proposed T1 and T2 licensing certificates by the ERC. The trainees also introduced to grid tied pv systems both in theory and demonstration of the system. The course on grid tied systems, mini grids and hybrid systems is categorized as advanced (or T3) whose curriculum is yet to be developed. Since the trainees are drawn from diverse backgrounds, which include vendors and upcoming contractors, a section on entrepreneurship is included in the training. Further, in order to be in tune with the diverse culture Kenya enjoys, a section on solar lanterns has been introduced where the participants are taught the various lighting technologies with their luminance or efficiency, how to assemble and repair solar lanterns. The two extras are the value addition to the traditional pv training that is offered by a majority of trainers. The training is organized in a manner that practical sessions for each section came after the theory had been covered in class and trainees had most of their questions answered.

2.5 Trainers

The trainers are drawn from the Condensed Matter Physics and Electronics groups in the Department of Physics and prior to the training; the trainers underwent a one week training of trainers. The trainers are assisted by a team of technologists drawn from the department with a vast knowledge of electricity and electronics and are always at hand whenever the trainees needed help.

2.6 Practical Sessions

The training programme consists of five practical sessions (module mounting, solar cell/module characterization, storage batteries, system sizing, wiring, installation and commissioning) and two demonstration sessions (inverters and grid tied pv systems). The trainees are usually divided into practical groups of four to ensure teamwork as well as individual participation. The groups are allocated one hour after each practical session for discussion and presentation. The following is a summary of each practical session:

(a) pv module structures (1 hour)

The session comprises of identification of different types of mounting structures and learning how to orient the modules, inclination and the effects of the same on performance of the systems. Among the structures the trainees use are ground mounting racks for both fixed and adjustable inclination types of mounting. Others were pole mounts and prototypes for roof mounting structures.

(b) solar cells and module characteristics (6 hours)

The sessions comprises of steps one goes through in identifying the different types of modules, point out parameters that are identified with the qualities of a module, study the current voltage characteristics of the given modules under different conditions like partial shading, varied module surface temperatures, series and parallel connection. The trainees are also expected to be able to identify important module parameters like the peak operating voltages and currents as well as peak operating power of the modules.

(c) Storage batteries (2 hours theory, 2 hours practical)

The session comprises of the steps one goes through in identifying different types of storage batteries, reading the information panel, determining different battery parameters such as terminal voltage, state of charge etc.

(d) Charge controllers and power inverters (4 hours)

The session brings the trainee to knowledge of the different technologies charge controllers as well as inverters that exist. Practical demonstration of pure sine, modified sine and square wave technologies are presented as well as grid tied inverter technology.

(e) Pv system design and sizing (3 hours)

Different groups are usually given different sizing tasks where they are expected to identify the unique requirements and needs of each set up provided to them. This would then guide the trainees in going through the step-by-step procedure of sizing the modules, controllers, batteries, inverters and cable sizes. The groups are also expected to do a cost analysis in choosing important components like the modules and batteries basing on what is available on the market. The final report is supposed to be presented as a proforma invoice basing on the arguments presented in the stepwise sizing procedure.

(f) Pv wiring, installation and commissioning (3 hours)

The practical comprised of wiring techniques both for DC and AC on a model wiring board. After wiring the trainees go through the steps of system check and commission and do a presentation to other trainers.

2.7 Assessment

The training programme has a segment for assessment which comprises written examination and practical assessment. Practical assessment is further divided into group and individual assessment. The group assessment for each group is carried out by an assigned trainer with guiding parameters of workmanship, positioning of components, observation of cable sizes and polarities and confidence and correctness in presentation. The individual assessment comprises of the trainee in the presence of a trainer going through the step by step process of system check and commission and a score awarded for the correctly followed procedure.

2.8 Trainee Feedback

The trainees are provided with feedback forms where they express their views about the training with the objective of improving on various aspects of the training. A summary of their feedback parameters is provided in table 3.

Tale 3: Summary of the feedback assessment

1	Scope coverage	
2	Organisation of presentations	
3	Aspect that was not covered	
4	Most interesting session	
5	Least interesting session	
6	Preparednedd of trainers	
7	Enthusiasm of trainers	
8	Suggestions for improvement	

From the feedback views, the most interesting sessions were pv sizing, module characteristics and practical sessions in that order of reducing interest. On the other hand the least interesting session was introduction to photovoltaics.

2.9 Certificate award

The trainees were awarded certificates of participation by the Department of Physics for which they will present to National Industrial Training Authority (NITA) for accreditation. This is then presented to the Electricity Regulatory Commission for Licensing.

2.10 Participation

Being the first of its kind in the country, the training attracted over 500 prospective participants expressing interest but so far only 80 have participated in the training. The participants were drawn from all over the country and even from neighboring countries of Uganda and South Sudan. The participation included both male and female who attended from their self-interest as one was from a biological background while the other from marketing. This shows how pv can incorporate different sectors seamlessly. Table 4 below summarizes the various backgrounds and interest groups that attended the three academies.

Table 4: Summary of attendance as per area of interest for Solar Academy

Areas of Interest	**Attendance (%)**		
	1st Edition	**2nd Edition**	**3rd Edition**
Students (Technical, university etc)	5%	0%	0%
Technical Institute Tutors (TIT)	2%	13%	20%
Practicing Engineers (Registered)	0	17%	0%
Pv Installers (Freelance)	20%	22%	35%
PV vendors	5%	4%	0%
Contractors (Registered)	36%	9%	20%
Self Interest	5%	9%	10%
Government Entities (KPLC, KEBS, KAA, etc)	7%	13%	15%
Institutional (Churches, UN, NGOs etc)	10%	13%	0%
TOTAL	**41**	**23**	**20**

3.0 Impact of training

3.1 Technical capacity

Since the onset of the first academy in April 2012, three more academies have been conducted with the latest being August 2013. From the publicity the academy has gained, there is increasing demand for the training and this has led to organizations especially dealing with humanitarian activities in the region applying to have their personnel trained. Example is the World Vision who has made arrangement for a single group of twenty participants to be trained. Besides this other universities in the country have borrowed a leaf from the academy to start similar trainings. An example is the neighboring Jomo Kenyatta University who with the aid of JAICA started a similar training after conducting a learning tour to our academy. However the Jomo Kenyatta edition has targeted govern technical institute tutors by training two from each polytechnic in preparation for the roll out of the polytechnic curriculum that incorporates photovoltaics as a course. Others are private universities with support from donor institutions have also embarked on developing short courses and degree programs in renewable energy. All this put together indicates that the academy had positive impact on the development of capacity in the country not only to deal with installations but also development of curriculum and trainers in the area of photovoltaics. This does not end within the country as the two participants from Uganda developed a similar training and have been offering to participants from Uganda, Rwanda and South Sudan.

3.2 Impact on policy

As much as the government had drawn a roadmap towards utilization of green energy by 2017 and vision 2030, implementation of the same was still a challenge owing to lack of capacity. With also new county system of government in Kenya, individual county government have developed policies that include harnessing energy from primary sources and solar has been adopted in most of the counties for use such as street lighting and water pumping. Most of these adoptions have been spearheaded by the alumni of the academies since they spread across the country. Since all the participants joined an umbrella advocacy organization known as Kenya Renewable Energy Association (KEREA), there has been one voice to front for renewable energy push to the government and through the cooperation between the association and the government, a renewable energy portal was launched y the government which is a one stop site for all matters from licensing to tendering of all forms of renewable energy. This in itself shows that the government is slowly incorporating solar energy (and renewable energy as a whole) in its policy on energy.

4.0 Conclusion

Solar Academy has been a success as it has fulfilled the objectives of building capacity in pv installation and advocacy for adoption of solar energy utilization in the country. Basing on the trainees feedback, the needs of the market were well captured in the academy and as the country gears up for regulation of the pv sector, the needs and requirements laid down by the ERC will be well met by the academy. The value addition to incorporate culturally acceptable concept of solar lanterns in the training has made sure that there is capacity to transfer knowledge in maintenance of solar lanterns to the grass roots hence increasing the use of solar lanterns in the country. This has also created employment to the rural youth and also empowered women in terms of access to quality source of lighting. As indicated above the chain of impact is all the way from the participant who attended the training to the business community, education sector, government policy as well as quality standards.

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