

A collaborative solar energy platform

Alex Osunga,^{1*} Zishan Omar,¹ Christine Gitau,¹ Kimani Gitau,¹ Bernard Shibwabo¹

¹Faculty of Information Technology, Strathmore University, Nairobi, Kenya

*alex.osunga@strathmore.edu

Abstract

Energy efficiency awareness is one of the most important steps to achieving the final goal of having a sustainable environment in the country. Together with a good energy policy and regulations, this goal can be achieved as it will help consumers make more rational decisions when it comes to new technology. The main problem nowadays is the lack of awareness and strict energy policies which then gives a channel for the counterfeit products to be shipped in and sold out at low prices. This eventually leads to a very high demand in power and later a struggling economy. The current measures put in place are not vibrant and have not gotten to a large number of people. The government regulations on the other hand are not strict and this causes the inefficient appliances to find their way into the country. The proposed project aims to improve the current status by reaching out to as many people as possible and educate them on the importance of a high initial cost which eventually leads to more savings. It also aims at building a platform where customers can verify that their appliances are energy efficient. In order to have built this platform analysis have been done through research and meeting stakeholders who have provide first-hand information in order to formulate the platform. The information gathered have been used to design a platform that meets the challenges faced in renewable energy.

Background

Kenya as a country is aspiring to become energy source, with only 6% of the rural population with access to the grid electricity. The energy systems have enormous potential in meeting immediate energy requirements for isolated institutions, businesses and households in remote areas (Wanjiru & Ochieng, 2013). Kenya has a vast renewable energy resource including solar, wind, biofuel, biogas, geothermal and hydropower, the issue they are facing is that their application is limited.

The expansion of energy is being catalysed by increasing the demand and price of electricity. Biogas in Kenya makes over 70% of the total energy consumption. Petroleum and electricity account for approximately 22% and 9% respectively (Mwakubo, 2007). According to Kimuyu, Mutua and Wainaina (2012), installed electric power capacity in Kenya was 1,412.2MW as of December 2010. It has become more from year 2010 to 2017, but not that much. The installed capacity could not meet the demand; therefore, the government contracted 60MW of emergency power to bridge the deficit.

Kenya is a country that is located in East Africa with a population of 48.5 million people and a total area of 580370 km². The energy sector in the country mostly constitutes by petroleum and electricity. The informal sector, the urban poor and the rural households provides mostly of the fundamental need of energy with wood fuel. 68% of the energy consumption, in total, is from biomass (mostly wood fuel), petroleum 22%, electricity 9% and all the others explain the remaining 1%. 36% of the population have access to electricity (2017). The energy mix regarding electricity is approximately 57% hydropower, 32% thermal (fossil fuel) and the remaining is geothermal and emergency thermal power (Gitone, 2014).

Wind power and solar PV constitutes a small part of the energy sources, less than 1%. The total installed capacity in the country is 2.3 GW. The electricity capacity of the connected grid is about 1,429 MW. It costs to connect to the national grid, about 35000 Ksh (319 EUR), and after that the electricity service costs 0.1145 EUR per kWh. The costs are high; the prices make it a problem to expand the electricity connections to poor areas and smaller businesses. The rural households mostly use biomass energy resources, mainly firewood and charcoal (Energylopedia, 2017).

Utilizing of solar systems in Kenya started in the 1870s. The aim of the Kenyan government was to use solar photovoltaic systems to operate in the remote areas. The use of solar in Kenya is mainly for photovoltaic systems, drying and water heating. Photovoltaic systems are mainly used for telecommunication, lighting and water pumping (Gitone, 2014).

Nairobi has accounted for more than half of Kenya Power's sales reflecting the capital city's economic dominance over the rest of the country. According to Otuki (2018), the power distribution company shows that Nairobi has consumed 3,507 GWh last year, being 56.2% of the total power consumption compare to last year which was 55.8%. Analysts state that the uneven growth in consumption of electricity will benefit some segment of the population especially in times of economic expansions.

Kenya Power has divided the country into four regions being Nairobi, Mt. Kenya, Coast and Western. Studies have shown that the number of customers in Nairobi using Kenya Power has crossed the one million mark standing at 1,042, and while the other 3 regions have a total number of 835,202 (Otuki, 2018).

According to Kama and Kaplan (2013), lack of sufficient information and understanding on the part of consumers lead to them making irrational consumption and investment decisions and hence the need for this system. The government should also put in place strict measures and regulate the standards of the appliances that come into the country so that prices can also be affordable to all consumers.

The proposed platform will help to move the country towards utilization of energy-efficient appliances which will reduce capital investment in energy supply infrastructure, enhance national economic efficiency by reducing energy bills, enhance consumer wealth, strengthen competitive markets and meet climate change mitigation goals (Sustainable Development Goals, 2017). The platform also aims at increasing the population that is connected to solar power.

Objectives

The aim of this project was to formulate a multi-stakeholder platform for awareness of solar energy. This will bring together solar experts and solar users to help exchange their expertise in creating awareness in Kenya. The specific objectives were:

- i. To analyze current energy situation in Kenya.
- ii. To investigate measures, methods, techniques and approaches used for awareness creation.
- iii. To design a platform for awareness creation on solar energy efficiency.
- iv. To test and implement the platform.

System Development Methodology

Introduction

The methodology that has been employed throughout this project was design thinking. In design thinking the people who face the problem are the ones who hold the key to their problem's solutions. Design thinking is human-centered approach problem solving tool which emphasize on empathy, collaboration, co-creation and stakeholder feedback to unlock creativity and innovation, which devises feasible and viable idea/solutions. They main process is empathizing with the users to uncover unmet needs by understanding their beliefs, values, motivations, behavior, pains, gains and challenges and provide innovation solution concepts to create impact in the society (Leow, Lau, Ho, & Yong, 2016).

The key principles and mindset of design thinking include; human-centered, collaborative teamwork, learning by doing, embrace experimentation, understand patterns, relationships and system, and finally visualize and show. It employs the heart-on hands-on head-on approach (Leow, Lau, Ho, & Yong, 2016).

Phase I: Explore

The explore phase has been focused on reframing the design challenge into design opportunity from multiple perspectives. The explore phase has helped us, as the designers of the project, to understand synthesis analysis to gain insights on the implications and context of the design challenge, foster multiple perspectives to explore design challenge, map the activity system as the foundation model to leverage for new idea delivery, map key stakeholders to appreciate the key people who determine the success of your design challenge, frame project into design opportunity, identify, select and invite your target stakeholders for interview and finally plan the design challenge project management. The phases of design thinking overlap into other phases (Ambrose & Harris, 2010), (Leow, Lau, Ho, & Yong, 2016).

Phase II: Empathize

Empathize phase has been used in the project to understand and share the feelings of users to foster deep user understanding and be able to unearth the deep user insights and needs. The phase begun with opportunity framing that overlaps from phase one (Leow, Lau, Ho, & Yong, 2016).

According to Design Thinking Guide Book (Leow, Lau, Ho, & Yong, 2016) the methods and tools used in this phase include field observations, user interviews, needs finding and personal development. It also consists of mindset and attitudes of the people engaged. Needs finding involve a deep human process of making sense and transforming the observations and deep user interviews into usable data cluster and meaningful insights to uncover the unmet needs of the users (Vianna, Vianna, Adler, Lucena, & Russo, 2011).

Phase III: Experiment

This is the ideation phase where robust quantity of ideas was generated by brain storming used the ideation tools. The ideas that has been generated in the project have then prototyped to provide the user with ideal experience journey (Leow, Lau, Ho, & Yong, 2016).

The purpose of this phase was to brainstorm variety of ideas around user deep needs and to make ideas tangible and visible through building prototypes and visualizing the ideal user experience. The stages of this phase are ideation that also include persona development, prototyping and experience design (Vianna, Vianna, Adler, Lucena, & Russo, 2011).

Ideation techniques include ideation by SCAMPER, ideation by analogous inspiration, ideation by deconstruct/reconstruct. Prototyping is an approach that makes ideas tangible and visual as compared to written ideas (Leow, Lau, Ho, & Yong, 2016).

Phase IV: Engage

This was the fourth stage of design thinking methodology. Once the project's solution, concept and prototypes were ready, the ideas has been shared with users. This gives the users a walkthrough experience using ideal user experience journey. User feedback and comments are taken with open mind and is being received to come to a common understanding about which idea works and which does not work for the user and why. Finally the refinement of the idea was done. The methods and tools of this phase include storytelling and co-creation (Leow, Lau, Ho, & Yong, 2016), (Ambrose & Harris, 2010) and (Vianna, Vianna, Adler, Lucena, & Russo, 2011).

Phase V: Evolve

We have gotten feedback from the previous phases, in this phase we have been developing smart strategies and smart implementation plan that has delivered/achieved the big idea/solution deduced from earlier phase. It involves renewing activities and strategies, testing some of the ideas to learn what resources are needed and how to best implement in a

way that meet user needs (Leow, Lau, Ho, & Yong, 2016) and (Vianna, Vianna, Adler, Lucena, & Russo, 2011).

The methods and tools employed in this phase include concept synthesis, strategic requirement, activity system integration; 4S impact evaluation, innovation, review, quick wins and action plan.

Mind-set and attitude are key components of this phase. They include human centered, learning by doing, system thinking, collaborative team work, open mindedness and finally visual thinking (Leow, Lau, Ho, & Yong, 2016), (Vianna, Vianna, Adler, Lucena, & Russo, 2011) and (Ambrose & Harris, 2010).

Project Milestones/ Schedule

ID	Task Name	Start Date	Finish Date	Duration	Apr 2018				May 2018				Jun 2018				Jul 2018	
					4/1	4/8	4/15	4/22	4/29	5/6	5/13	5/20	5/27	6/3	6/10	6/17	6/24	7/1
1	Group formation, theme selection and challenge definition	4/4/2018	4/11/2018	1.2w	█													
2	Chapter one and two, stakeholder engagement	4/11/2018	4/18/2018	1.2w		█												
3	Chapter three and proposal review	4/18/2018	4/23/2018	.8w			█											
4	Proposal submission	4/23/2018	4/23/2018	.2w				█										
5	Methodology and stakeholder engagement	4/23/2018	5/1/2018	1.4w			█											
6	Design; Initial prototype	5/1/2018	5/9/2018	1.4w				█										
7	Design; Prototype based on comments	5/9/2018	5/23/2018	2.2w					█									
8	Testing and Implementation	5/23/2018	5/30/2018	1.2w						█								
9	Demo 1: Refine based on comments	5/30/2018	6/6/2018	1.2w							█							
10	Demo 2: Refine based on comments	6/6/2018	6/20/2018	2.2w								█						
11	Documentation writing	6/20/2018	6/27/2018	1.2w									█					
12	Progress review	6/27/2018	7/4/2018	1.2w										█				
13	Final Project	7/4/2018	7/11/2018	1.2w											█			
14	Final Project presentation	7/11/2018	7/18/2018	1.2w												█		

Figure 3.0-1: Gantt Chart

Interview Subjects

Semi-structured interviews as well as focus groups were used, as explained in the method. The interviewees were eight people with different backgrounds and professions. The first interviewee was Zachary Mikwa.

He is a Sustainability Initiatives Officer at Kenya Climate Innovation Centre (KCIC). KCIC is an organization launched by info Dev’s Climate Technology Program and funded by the Danish Ministry of Foreign Affairs and by the United Kingdom’s UKaid. Their vision is “to be the one stop shop supporting innovative climate change solutions in Kenya” and their mission is “to provide incubation, financing and awareness that empowers the private sector to deliver innovative climate change solutions” (Kenya Climate Innovation Center, 2018).

Two of the interviewees, Sheila Olga and Samuel Wanjiru, work at Strathmore University Energy Research Centre (SERC). SERC started 6 years ago with the aim to offer services to the private sector, the general public and the government in the renewable energy sector.

Except from the research they offer training, project development and international standard laboratory testing services on Solar PV components.

Their vision is “to become a leading outcome driven entrepreneurial research centre by translating our excellence into major contribution to greater adaptation and penetration of renewable energy and energy efficiency technologies in Africa” (Strathmore University Energy Research Centre, 2017). To get different perspectives some interviewees are university students. The sessions with the students were also taken as focus groups since the students and the team members shared their ideas.

One of them is Cynthia Muchiri, who is undertaking BBIT (Bachelor of Business Information Technology) and works with the Career Department in Strathmore University. Beth Mwangi is undertaking Mathematics at University of Nairobi. Lucy Njoroge pursuing BCOM (Bachelor of Commerce) and is also dedicated to environment work in her home town, she recently organized a group of people which planted trees. Strathmore University was founded in 1961, their vision is “to become a leading out- come driven entrepreneurial research University by translating our excellence into major contribution to culture, economic well-being and quality of life” (Strathmore University , 2018).

The other interview subject was Professor Izael Pereira Da Silva; he has a PhD in Power Systems Engineering from the University of Sao Paulo (Brazil), and is also a Certified Energy Manager. He started Strathmore University Energy Research Centre and is currently a professor at Strathmore University.

He was the leading force in installing solar panels at Strathmore University, which is the only university in Kenya that has solar panels. He also created the Centre of Excellence in Renewable Energy and Sustainable Development (CERESD). This was in collaboration with United Nations Industrial Development Organization (UNIDO) (Strathmore Business School, 2018).

Finally, the team interviewed Charles Kilonzi who is currently a PHD student at the University of Nairobi and previously worked at KPLC as an electrical engineer. He helped breakdown the generation, transmission and distribution process within the Kenya Power and Lighting Company.

He also said that the main sources of energy are hydro-power and geothermal, solar energy adds up very little percentage of about 0.3%. He supports the idea of having solar as a main source of energy however feels that there are some drawbacks especially on the cost of batteries. The batteries are too expensive but he added on to say that they are worth investing in especially for households that may require more energy at night when there is no sunlight.

Sample demographics

Gender

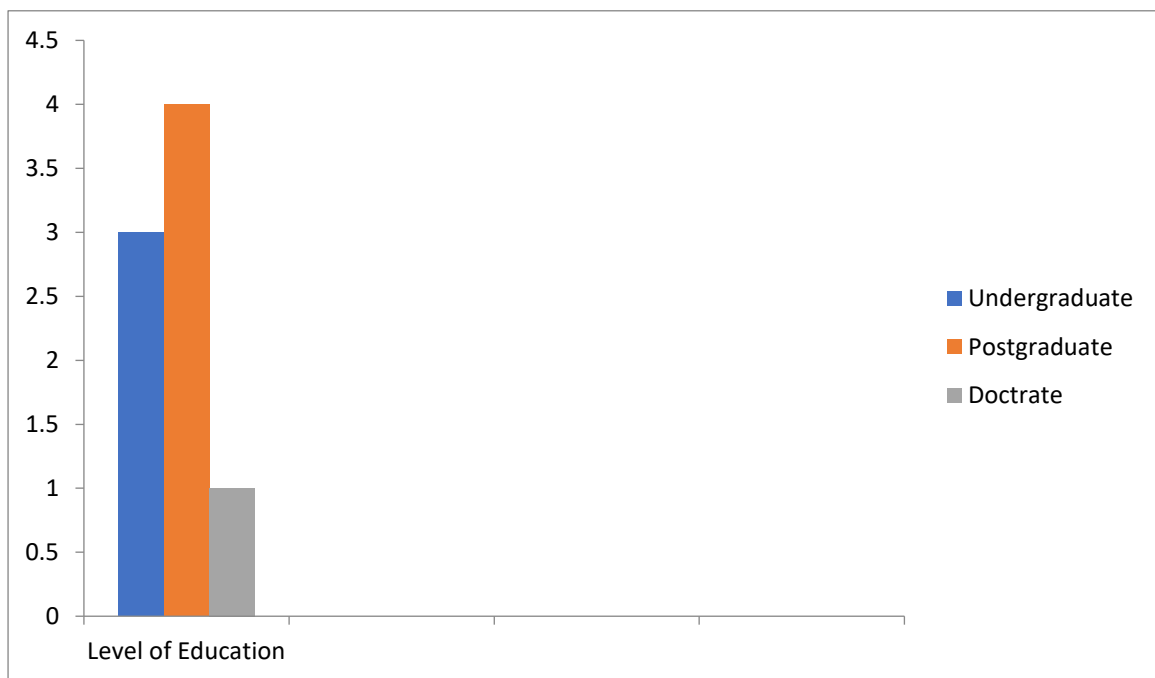
The team had several stakeholders as mentioned above and the summary of their genders is as follows:

Tool Used	Gender
Focus groups	3 females, 1 Male
Interviews	5 males, 1 female

Among all these people, they all have different capacities and therefore it was necessary to avoid gender bias in such a project. The gender also helped to get perspectives and impacts that these people have or what their visions are.

Level of education

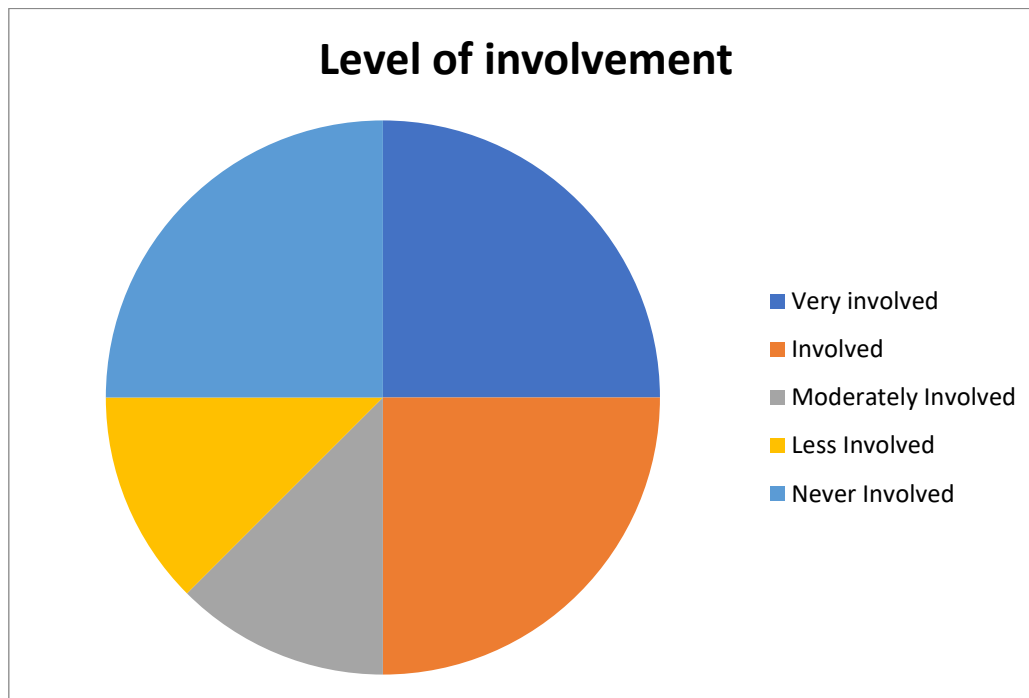
It was not a requirement for the team to talk to educated stakeholders but since the educated elite in the community is expected to give back, the team decided to talk to them. Some of them are experts in the field of solar energy and renewable energy in general while others have no idea. These helped the team understand the different perspectives about the solar energy.



Involvement in Sustainable development projects

After finding out the level of education of the respondents, it was necessary to learn how much involved they have been in the past in sustainable development projects. This being such a project the team wanted to find out how much the interviewee would be likely to take part in achieving the projects goals. Some of the most likely activities they would have been part of in the recent past would be training people on renewable energy, planting trees to be good ambassadors of environment, creating awareness about a project such as tree planting, campaigning against deforestation, launching sustainable development projects, etc.

Involvement level	Number of respondents	Rate (%)
Very involved	2	25
Involved	2	25
Moderately involved	1	12.5
Less involved	1	12.5
Never involved	2	25



Willingness to support Green Energy

From the responses received, there was evidence in interest on this project. Solar energy being readily available is a project worth a fortune. The stakeholders were all willing to take part in it be it in creating awareness or by educating the public the importance of using solar energy. The respondents having being part of sustainable development projects gave their word to spread the word and be active participants of the project.

Conclusion

In conclusion, the respondents were supportive and willing to share their ideas regarding solar energy and this gave the team hope in working on the project. The respondents showed interest in using solar energy and therefore the team believes they would be of great help in creating awareness on solar energy.

Problem Definition and Ideation

Problem Definition

The team interviewed a number of stakeholders during the empathy stage; they identified quite similar challenges/problems faced in implementing solar energy projects. Problems identified included; lack of awareness/ peoples' perception towards solar energy, Prof. Izael Da Silva mentioned that about 75% of Kenyan population is not aware (negative perception towards solar energy) about the benefits of solar energy hence the low rate of solar energy consumption in the country.

Prof. Da Silva also mentioned about shortage of solar technicians around the country due to lack of professional training to equip technicians with the much needed skills. The stakeholders talked about lack of finances as an enabler in purchasing solar equipment in the country, long processes in acquiring loans and high interest rates make it almost impossible for people to address this issue of finances.

Government bureaucracies in license application also hinder investors from putting up solar energy power plants in Kenya. The process of applying for license takes longer than expected due to corruption and many officers to approve the papers for independent power producers in the country.

Ideation

Amid brainstorming to come up with solutions to the above-mentioned problems, the team proposed the following solutions; automate independent power producers' license application process. This system is aimed at reducing the number of people involved in the application process and also curb corruption due to reduced human interaction.

License applicants will self-register in the system so that they have access to the services. Upon approval of their registration, they will fill an online form with all the required details; they will be prompted to pay license processing fee via Mpesa or any other online payment method. To approve payment, the applicant will enter payment code in case of Mpesa, and finally submit application.

The application will be verified by the receiving application verification officer for to confirm if all requirements are met as per the regulations. It will then be forwarded to final stage for approval. Applicants can either print the certificate direct from the system, or from the link sent to their email. This whole process should take at most 5 days. Investors will be required to coordinate with NEMA for environmental assessment.

However, the problem with the above solution was the level of government involvement and the government approvals that take so long to process. Due to this reason and the time limit that the team had to execute the project, the team decided on taking another idea.

The other solution proposed is awareness creation platform that will consist of banking module, experts' module and solar dealers' module. Community members can come together to have a small power plant for at least 50 households. They will put together all the required

documents then proceed to the platform to fill in the required details and finally submit for processing.

Pay a small processing fee upon approval of their request, if accepted the listed banks will be notified, the first bank to accept the offer will verify the documents and the feasibility of the project. If approved, bank offers loan and finally link them to the listed solar dealers in the system to supply them with solar equipment, the bank will pay the dealers for upon verification of the delivered equipment.

The platform will list various solar technicians who will be selected by the group to do the installation and payment to the technicians done by the bank once the work is completed. Households will pay monthly electricity bills direct to their group bank account; monthly deductions will be done for loan repayment. The remaining amount will be used for maintaining the system. The system will be fully owned by them group upon settling their loan. Money earned after settling loan will be used for development activities in the community.

The problem with this solution was mainly the fact that the team will eventually have no use in the system as the bank will probably take up all the mandate of getting the solar experts and creating awareness.

Prototyping and Testing

Prototype

Prototype Narrative

The solution agreed on was an awareness creation platform that will consist of the following actors; customer, solar expert, solar dealer and system manager. All actors will register as users of the system to be able to interact with the system. Once they are registered, the system manager will approve all registrations for authenticity. All details entered in the system will be stored in a data store for ease of retrieval.

The customer will have to request for an installation of a solar system on the platform. The customer will then put together all the required documents then proceed to the platform to fill in the required details and finally submit for processing. If in the process the customer cannot afford the installation the platform will suggest to them a SACCO or a Bank that can give them a loan in which they can pay within a certain duration. The system manager will then verify the submitted project for approval. In case the project is rejected, the customer will make corrections and resubmit the request for approval.

If project is approved, the system manager will prepare a quotation with the solar experts for the customer. The quotation will be sent to the customer for approval. If the customer is comfortable with the quote, the solar expert and the system manager will have a contract agreement for the installation. After the contract agreement between the system manager and the solar expert the system manger will then check the supplier's items to check if the supplier has the equipment in stock. After identifying the supplier the system manager will then place an order for the equipment. When the system manager receives the equipment he

will then deliver it to the solar experts who will then proceed for installation. After installation the customer will then be able to give feedback to the system.

Testing

Due to the time constraint that the team experienced, the entire system was not tested by the stakeholders in the rural areas. However, the stakeholders mentioned in chapter 4 of this document gave their views on the proposed system and gave their honest reviews. There was positive feedback and they promised to take part in the final implementation of the system towards a sustainable plan.

Discussion of Results

The team was able to analyse the current energy situation in Kenya and found out a very little percentage of solar energy is used with hydro power and geothermal being the most depended on. The team also found out that the main challenge the country is facing and hence not able to use solar energy is because people lack the required knowledge about solar energy. Government regulations and long processes are a major challenge to those investors trying to invest in solar production plants. The other main challenge is finance where the solar equipment is too expensive and majority of Kenyans lack the finances to acquire such equipment. High interest rates in banks make it almost impossible for people to acquire loans for purchase and installation of solar panels.

On the methods and techniques used for creating awareness, the team researched and found out that the media is used for creating awareness and that impressive advertisements attract customers/users. Giving incentives also helps attract users and prospective customers. On building the system, the team was able to come up with a system with some functionality on the system manager. The system manager could login, view and verify all the registered users as well as give them different rights such as solar expert or household. He could also create accounts for those users who needed help as well as delete unused accounts. The platform used to come up with the system was Laravel.

The prototype was taken to some of the named stakeholders and they were satisfied with the progress and made some recommendations as the team continued to work on the system. Suggestions were made for the team to meet stakeholders from rural areas as well as approaching SACCOs to help them finance households that would be interested in the project.

MKOPA Solar is one projects that aims at encouraging the use of solar however it mainly focuses on the lighting rather than educating. The proposed solution therefore has an advantage as it will help educate people on solar energy and eventually increase the number of people who embrace renewable energy. The main limitation of the proposed solution is the fact that there is need for good network connectivity and location detection as the experts need to know the exact location of the household which may be impossible in areas such as north western part of Kenya.

Conclusion

In conclusion, all functionality of the system was not completed however the system is still being built. The users of the system will be able to view all uploads from the experts and do everything as presented on the data flow diagram and use case diagram.

The team recommends a mobile application for easy access to the system. For locations that are harder to access, regular updates on locations may be recommended. Another recommendation is coming up with SACCOs that work purely on solar energy projects.

This will bring together more households and encourage people to take up solar energy projects. We also intend to incorporate IoT platform for interaction between energy professionals as well as a learning/training portal to ensure that we get more manpower in solar energy field.

The team hopes to meet more stakeholders especially from the rural areas especially because they are the main beneficiaries of the project. The other future work that will be done is to add an e-learning platform on the system to help people learn about solar equipment and installation process as well as share ideas on solar in general.

The team also hopes to partner with Strathmore Energy Research Centre as well as Kenya Climate Innovation Centre since they are more experienced in the field of renewable energy and solar energy in general. This project will also be presented during the Research and Innovation Conference to be held at Strathmore in October 2018.

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