A study on cost analysis and implementation of solar power systems for rural development in Namibia: Case study - Onaushe village, Oshana Region in northern Namibia

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ABSTRACT

In most developing countries, especially in rural and remote communities, lack of access to light energy is an obstacle to development. This paper presents a cost analysis study for the implementation of solar power systems in rural Namibia. The study mainly focuses on the contemporary cost for different lighting sources currently employed and compares it with the possible cost of a basic solar system being utilized. The data collected was obtained through a field survey with structured interview questions in Onaushe village, Oshana Region, northern Namibia. The results revealed that 87% of the sampled homesteads had no access to electricity and relied on traditional energy sources such as torches, candles, cellphones and firewood to meet their lighting needs. The study further found that solar power system has high initial cost compared to the lighting sources being used in rural areas. Recommendation for some relevant strategies that may enable the implementation of solar power systems are discussed.

1 Introduction

The use of renewable energy technology such as solar power system to meet the basic light needs for rural communities with no access to electricity has been promoted for many decades by the United Nations Sustainable Developmental Goals (UN SDGs) as a feasible and cost effective alternative for the basic electrification of rural households [1, 2]. The provision of energy services has often been justified on the basis that it results in economic and/or social development. For this reason, the increase in per capital energy consumption has been regarded as a measure of economic development in developed countries [3].

In most developing countries (especially in rural and remote communities), lack of access to light energy is one of the biggest obstacles towards development. Thus approximately over the past three decades, many developing countries, including Namibia, have attempted to sustain and improve their energy services through a number of approaches such as the introduction of modern forms of energy supplies, restructuring power utilities and educating communities about energy supply systems. In countries with adequate solar radiation, solar power system technologies have been chosen as an energy alternative for areas that are not connected to power grid electricity [3].

Access to reliable electricity is one of the major factors that allow opportunities for the development and operation of many enterprises. The access to energy has proven fundamental to economic growth and a catalyst for alleviating poverty. However, supplying electricity by grid in small and geographically remote and isolated

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rural areas is often nearly impossible and not cost effective. A number of successful Solar Home Systems (SHSs) pilot projects received widespread attention such as the Bangladesh SHS project [2]. After these success stories, SHS gradually came to be adopted as a viable option for rural electrification.

Even though Namibia has great potential when it comes to renewable energy resources in particular solar energy, the vast majority people in rural areas live in the dark, because they are have low income and in remote location to be reached by grid electricity. It is estimated that 63% of the Namibian population live in rural areas and only 19% of these homesteads have access to electricity [4]. Namibia is known to have the best sunlight energy (solar energy) in the world with an average direct insolation of $2000\,kW/m^2$ per year, while in certain areas it is about $3000\,kW/m^2$ (solar radiation data) per year, with minimal cloud cover, as well the potential of power generation capacity for more than 250 000 MW (megawatts) [5].

The ever-increasing energy source prices, insufficient electricity supplies, and the dependency on foreign energy sources pose significant risks, not only to the Namibian people and economy, but also to the development of the country. If Namibia is determined to achieve the development goals stipulated in the Vision 2030, sustainable energy supplies are necessary cornerstone underpinning that vision. Sustainable development can only be safeguarded if the country's energy supplies are sustainable. This paper presents a study on the cost analysis and implementation of solar power systems for rural development in Namibia.

2 Methods

The data were obtained through conducting a field survey with structured interview questions during the month of July 2016. The following questions were asked during the interview:

Group 1: Non electrified houses

a) What do you use to light up your house? Firewood, Candles, Paraffin, Lamps, Torches, or Other(s) (Specify).....

b) How much do you spend on your light sources per month? .....?

c) How long does that light source last.....?

d) What is the household monthly income....., and source.....?

e) Why is your house not electrified.....?

f) Do you know what solar power system is? Yes / No

g) If yes, what do you think about the implementation of solar power system for lighting up rural areas? .....

Group 2: Electrified houses

a) What was the total cost of the installed system.....?

b) For how many hours do you use Solar light..... ?

c) What was the motivation for installing a solar power system.....?

d) What benefits have you encountered with the solar power system.....?

e) What problems have you encountered with the solar power system.....?

f) Will you recommend solar power system to be used for lighting up rural areas? Yes/ No?

g) If yes, what is your suggestion on how solar power system can be implemented for lighting up rural areas.....?

Participants were divided into three groups and in group 1 (non-electrified homesteads) participants were interviewed in order to obtain the percentage of village dwellers that do not have access to electricity, the light source items they are using, the cost and period of time they can last. The participants in group 2 (electrified homesteads with solar power system were asked to provide the information on actual experiences with solar power system, the money spent on solar power system and the period of time solar power system can last and in group 3 (electrified homesteads) village dwellers that have access to grid electricity were interviewed to provide information of the percentage of village dwellers who have access to grid electricity. The targeted population of the study was 72 houses in Onaushe village. All the samples selected for inclusion in the study were taken from Onaushe village located in the northern part of Namibia, of which 55 houses were visited and interviewed. Respondents participated voluntary and the researchers informed consent and maintained anonymity and confidentiality.

2.1 Procedures for data collection

The data were collected by visiting and interviewing rural houses in Onaushe village, Oshana Region in northern Namibia. A total of 55 houses were visited one at a time and a short interview was conducted with the household owner or any elder who was in charge of the house at that time.

2.2 Data analysis

The data were analyzed using qualitative content analysis with the approach of summative content analysis. The data were further classified, presented in tabula and graphical forms. Finally they were interpreted, discussed, and compared.

3 Results

3.1 Demographic profile of the participants' houses

Participants from 55 houses took part in this survey by completing structured interview questionnaires of which 7 houses were electrified and 48 houses were not electrified. Figure 1 depicted below indicates the percentage of electrified and non-electrified houses where 87% of rural dwellers homesteads of Onaushe Village don't have access to electricity and only 13% have access to electricity.

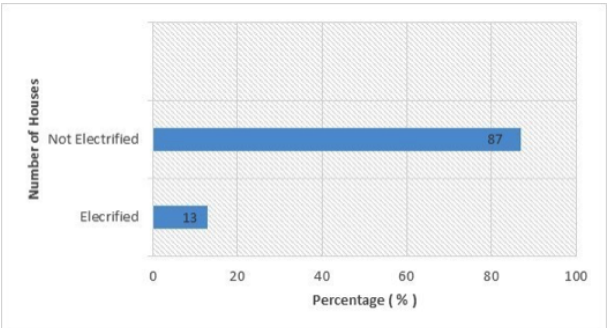

Figure 1: The percentage of electrified and non-electrified houses in Onaushe Village.

3.2 Light source items used in rural houses in Onaushe village, Oshana Region in northern Namibia

The study found out that the majority of homesteads in the Onaushe village were not electrified and depend on unclean and unsustainable energy sources such as candles for their lighting needs. The study further found out that 54% of these people depend on small torches, 21% depend on candles, 12.5% depend on cellphones lights/touches and 12.5% depend on firewood as shown in Figure 2 below. Figure 2 shows that majority of the Onaushe village dwellers relied on torches, followed by those using candles. The number of houses using cellphones and firewood for lighting were equal.

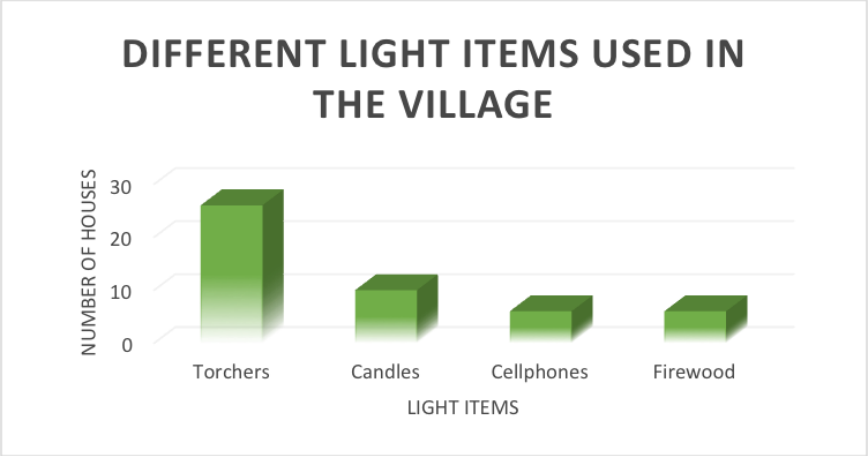

Figure 2: The different sources of light items used in the Onaushe village.

3.3 The cost of different sources of light items

Different sources of light items cost differently depending on where they were bought. The authors verified the prices by visiting the shops at a complex where the participants normally buy them from. Torches batteries cost roughly $N\$1.00 - N\$2.00$. Table 1 below shows the cost for different sources of light items each household spent. Table 1 indicates that light source items have low initial cost and only 6 houses do not spend any money on lighting.

Number of Houses that use Torches	Torches Prices N$
1	12.00
8	35.00
2	10.00
5	25.00
1	300.00
5	20.00
2	15.00
2	35.00
Number of Houses that uses Candles	Candles Prices N$
6	5.00
2	3.00
1	4.00
1	3.50
Number of Houses that uses Cellphones for lighting	Cellphones Prices N$
3	200.00
2	250.00
1	300.00
Number of Houses that uses Firewood for lighting	Firewood Prices N$
6	0.00

Table 1: Cost of prices of different sources of lights

3.4 Current cost interpretation

The cost of lighting items varies for different time range from minimum to maximum time an item can last as shown in table 1 below. It is evident that households spend more money on the lighting items that do not last long and spend less on the items that last long.

3.5 Relationship between cost of light items and time

There is a linear relationship between the independent (time) and dependent (light sources cost) variables and it is shown in Figure 3. The graph for cost versus minimum time range is steeper than the graph of cost versus maximum time range. This implies that the shorter the light item can last the more money spend on replacing it. The regression lines for both scattered graph is defined by the first order differential equation. This implies that one can predict the cost at any given time. R-squared is a statistical measurement of how close the data is to the fitted regression line. In all the graphs, R-squared is equal to 1 or 100% and it indicates that the model explains all the variability of the response data around its mean.

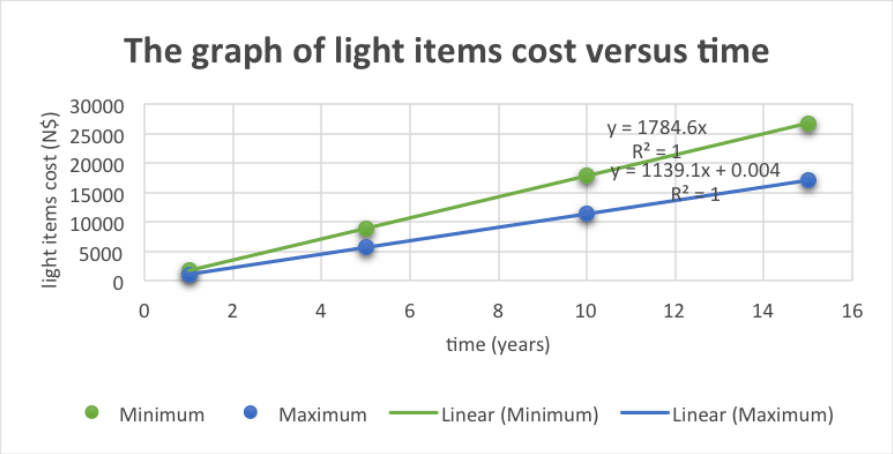

Figure 3: The relationship between the sources of light and time

3.6 Solar Power Systems

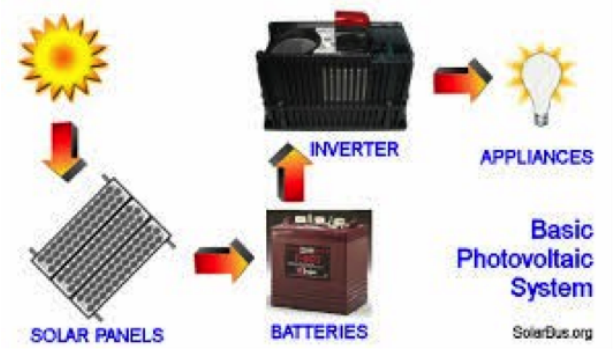

Figure 4: Schematic diagram of the basic solar system. Source: `solarflux.org`

Participants using solar power system stated that a small basic system cost roughly $N\$400.00$ to $N\$550.00$. Basic system consists of a small solar panel, a battery, an inverter, and a universal outlet for charging cell-phones or other small appliances as shown in the Figure 4. The cost of a solar panel is determined by its capacity (in Watts), the physical size, the brand, quality of materials, the durability / warranty period and any certification the solar panel might have. Generally, the more modules in a solar system, the less the cost per unit. The inverter last for about 10 years, while the solar panel can last for approximately 25 years [8]. But in general a solar panel is expected to last for approximately 40 years without major decay. The lifetimes of batteries varies considerably from project to project, from less than 1 year to more than 4 years [7]. The lifetime of batteries is determined by the size of the battery, size of PV module, and battery maintenance.

4 Discussions

The study revealed that 87% of the Onaushe village homesteads do not have access to electricity. They relied on unsustainable energy sources such as torches, candles, cellphones and firewood for their lightning needs. The cost of the light source items varies and this can be attributed to the fact that participants bought the light

sources in different shops. Different light items last for different time ranges, depending on how many people are using it, who is using it and if proper maintenances were taken. The less people using a certain lightning item, the longer an item can last. This implies that the number of people using the light sources item is indirectly proportional to the period of time light sources item can last. Majority of village dwellers have low households incomes, thus they cannot afford electricity on their own. Furthermore, 81% of people in the Onaushe village are aware of solar power system technology, thus they have positive thoughts with regards to the implementation of solar power system.

Solar power systems have high initial cost, but lasts longer. The present light sources items used in the village have low initial cost, but last for a short period of time. Thus, their expense is more expensive in the long run compared to the solar power systems' costs. Switching to renewable energy sources for generation of electricity provides beneficiary management strategies from the economic point of view. In many situations, solar power system proves to be a highly effective means of meeting essential needs such as lighting for homes. At the domestic level it can improve individual and family productivity and lessen the burden of many domestic tasks. These technologies can also contribute to reduce the country's electricity supply gap. Additionally, the use of solar power systems has been proven to reduce the risks of fire burns, indoor air pollution, compromised visual and visibility health and maternal health issues caused by the use of unsafe lighting sources such as candles and firewood [9, 10].

There are many advantages of using solar power system such as: low maintenance requirement, low operational cost, and long life expectancy, environmentally friendly, highly portable, and easy integration with small appliances. On the other hand, solar power system have some disadvantages for instance: high initial cost, limited power supply, power availability depends on external conditions, and expensive energy storage devices [6]. Although the solar energy solution is not perfect, its advantages arguably outweigh its disadvantages for rural areas usage.

5 Conclusion and Recommendations

Understanding the cost of different light items being used is the biggest concern for development. This study specifically analysed the cost of different sources of light items used in the rural community of Onaushe village and compared it to cleaner and reliable alternative source, that is solar power system(s). In reality, solar power alone is not an answer to the world's energy challenge due to the technological limitations of solar power technology. However it has been proven to be one of the best solutions for rural areas electrification. Therefore to solve the lighting need for low income rural communities, the government should understand rural dwellers' needs, preferences, and capacity to pay before making decisions. Furthermore, the study found out that solar energy is the most practical and economical way of bringing power to the poor people in rural areas and remote communities and thus suggesting that awareness should be spread to the Namibian rural people regarding policy initiatives such as the National Renewable Energy Policy of Namibia which enables access to modern, clean, environmental, sustainable and affordable energy services for all Namibians which eventually leads to the improvement in the quality of the Namibians lives. Since there is no shortcut to rural development, policy makers should always take into account the overall cost of solar power system(s), and implement them in order to meet the lighting needs of people in rural areas.

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