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The Cost and the Cost-Effectiveness of Renewable Energy in Rural Areas

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Abstract: *Use of renewable energy will enable the rural area to get out of its isolation and have its energetic autonomy. However, the development of the latter is subject to the high costs of equipment, limited financial capacity of rural areas, lack of information, and finally a lack of a structured market. Furthermore, the development of renewable energy requires capital resources, raw materials and space. In spite of all this, we have conducted a study that focuses on the analysis of equipment costs and profitability. We studied in particular the use of photovoltaic equipment in rural areas based on the results of a survey conducted in the rural town of Sid Taibi.*

Keywords: *Renewable Energy, rural area, financial capacity, development, equipment costs.*

1. INTRODUCTION

Africa is experiencing a period of increasing population growth. By 2050, the continent will have a population of at least 2 billion people (twice of what is now), 40% of it are in rural areas.[1]

In developing countries, the issue of energy is not only linked to the economy and the environment, but it is also related to improvement in the quality of life since over three billion people are dependent on traditional biomass such as coal used especially used for cooking and heating. One and a half billion people lack access to electricity; although modern energy services are available, they are still too expensive for millions of people in economic difficulties (UN, 2012). [2]

Nearly 60% of energy is consumed by only 20% of the world's population according to the latest figures provided by the nongovernmental organization Practical Action in the study "Poor people's Energy Outlook 2012" (Guinebault 2013).[2]

Access to energy will increase productivity, improve competitiveness, economic development as well as the living standards of the people.

In Morocco, the population is of 32.95 million inhabitants as of 2013. Nearly 19,513,000 inhabitants (59.37%) live in urban areas and nearly 13,437,000 inhabitants (40.63%) live in rural areas. [3]

The rural population remains the most vulnerable segment of the Moroccan population: 72% of the poor reside in rural areas. A huge gap exists between the development in cities and in countryside.[4]

Solving the energy imbalance from which poor Moroccan people suffer by providing them with access to reliable electricity, adapted by the production of green energies, are priorities for the country.

In Morocco, energy is a key factor for development, more than that, it is necessary for the survival of people in rural areas (for cooking, water pumping, heating, etc.).

Moreover, in a context where poverty is prevailing, many barriers often limit meeting basic needs, which hinders local development.

Morocco has favorable natural resources for the development of renewable energy, which need to be exploited. From the perspective of using large-scale renewable energies, the rational exploitation of

them must be based on the principles of energy conservation, energy efficiency and environmental friendliness. [5]

In this article, we will analyze the cost of electricity production essentially as renewable energy, based on the results of a survey in a rural community in particular using photovoltaic energy.

2. SITE OF THE STUDY

The village of our study represents an example of rural villages that use natural resources, especially the sun, to produce energy in the absence of the local network. The inhabitants of the village have invested in photovoltaic kits to replace the traditional tools used as gas bottles, candles ... etc.

2.1 Data About the Village

Number of inhabitants: 25005 inhabitants
Number of households: 4612 households
Age of the sample: 20 years to 50 years
Geographic situation: North west of Rabat city, 24,8 Km of Kenitra city
Poverty rate: 20% of the population
Education level: 43,16% of the respondents did not have access to any formal education, 29,56% did not go beyond primary school education and 16,20% secondary level education
The monthly income ranges from 1000 to 2000 MAD (≅ 100 to 200 €).
Renewable energy is the primary source energy for 60% of the households in the village compared to 11% in 2004, which is an increase of 49%.
Primary jobs: workers, artisans, farmers or traders.
Primary sources of energy: • ONEE Network: 37%, • Gas bottles and candles: 2,50% • ONEE network and renewable energy: 10, 40%. • Renewable energy: + 60% of which 99,59% of energy is photovoltaic

3. OBJECTIVES

The main objective is to study the cost of renewable energy in rural areas and the opportunities to encourage people to use them.

Finally, the results from the survey will enable the analysis of rates and proposals in order to adapt them to the financial capacities of citizens in rural areas.

4. RESULTS AND DISCUSSION

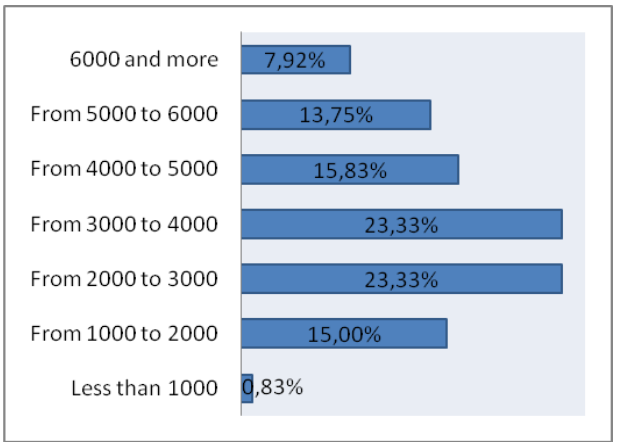
4.1 Results

In this part, we will present statistics from the processed data of the questionnaires through the SPHINX software.

4.1.1 Cost of Photovoltaic Kits

According to the participants, the average price of a photovoltaic kit is 3448.65 MAD (≅350 €) (graph 1), this price includes the price of the plate, the controller and the battery.

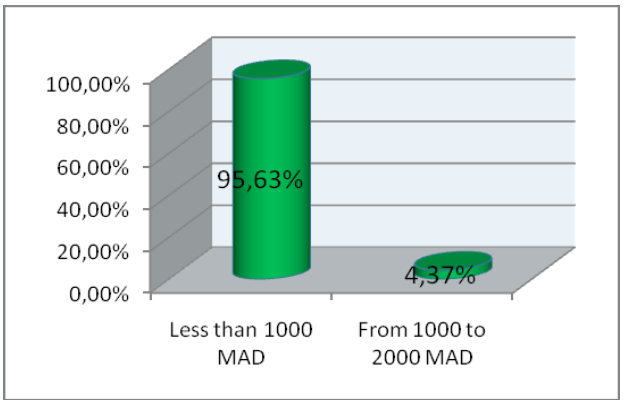
The cost of equipment varies according the strength of the equipment and quality of the battery. Some people bought old equipment with a price not exceeding 1500 MAD.



Graph1: *The cost of the photovoltaic panels*

4.1.2 The installation cost of the photovoltaic panels

The installation is done either by the person himself or by a technician; some of the respondents mentioned that they ask help from a neighbor or family member. The cost of installation is shown in the graph below:



Graph 2. *The installation cost of the photovoltaic panels*

4.1.3 Plates sale price

According to sellers, plates prices varies between 800 and 2200 MAD see table below:

Table 1. *Plates prices (in MAD)*

Strength in watt	Price in MAD
50	800
60	900
70-80	1000
185	1500
230	1750
280	2200

4.1.4 The power of panels:

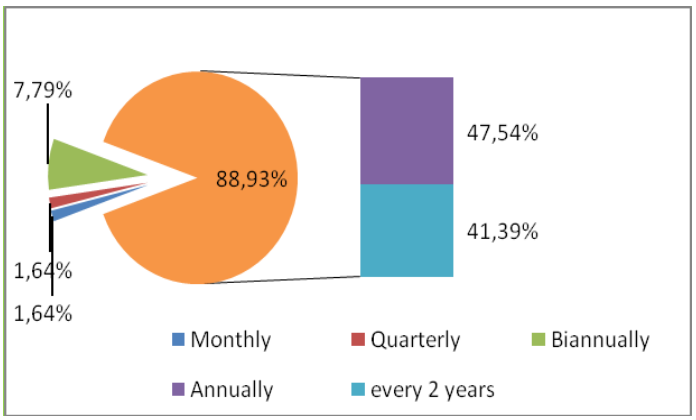
The average installed capacity in the village is of 150 Watts (see Table 2):

Table 2. *Strength of the panels (in watt)*

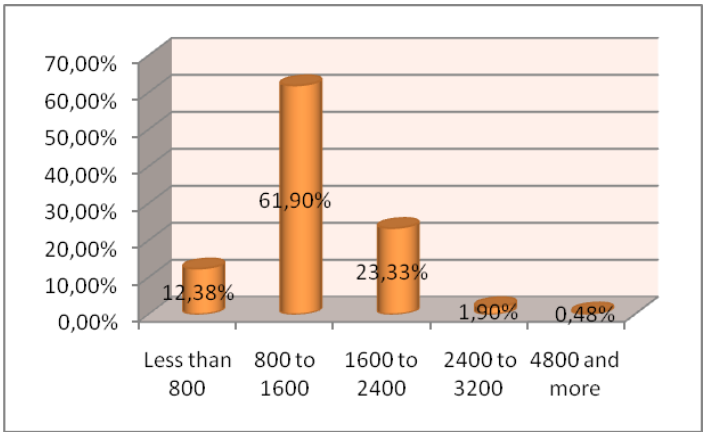
Strength in Watt	%
Less than 100	33,04%
From 100 to200	39,73%

From200 to300	24,55%
From300 to 400	2,23%
600 and more	0,45%

4.1.5 Frequency of the failures and the cost of reparation



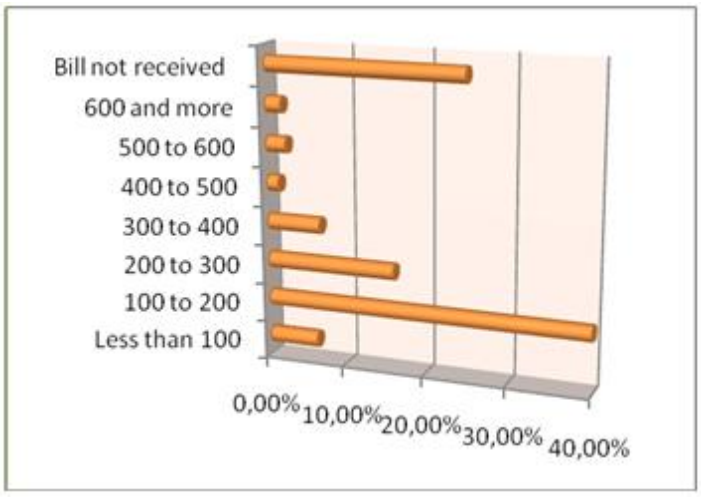
Graph 3. *Frequency of the failures*



Graph 4. *Costs of reparation*

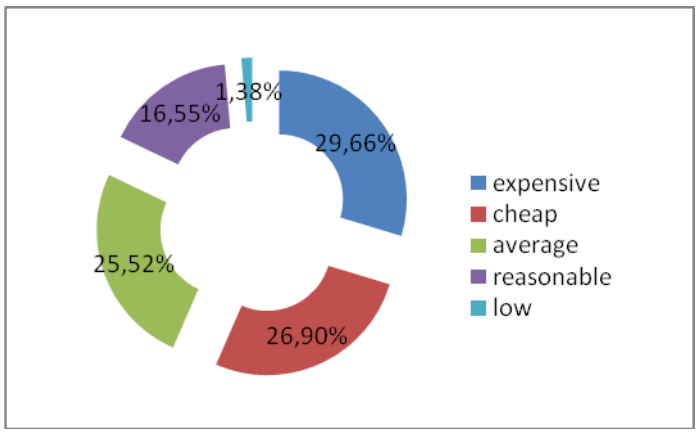
4.1.6 Cost of electricity bills

Below you find the amount of the electricity bill, 24.87% of households have not yet received their bills as they have just been connected to the ONEE network.



Graph 5. *Total monthly electricity bill in MAD*

The satisfaction and dissatisfaction about the electricity bills varies from a person to the other; this depends on the income of the household and the use of electricity.



Graph 6. *Satisfaction about the electricity bills*

4.2 Discussion

Statistical analysis of the survey reveals that today about 60% of households in the village of Sid Taibi, produce electricity for domestic use through solar equipment, which allowed the population to overcome their energetic isolation. Shops (coffee...), and schools are also lightening with renewable energy.

About 10% of the village population that is already connected to the network uses the solar energy in parallel with the local ONEE network because solar energy is only used for lighting. The objective of this mixture of energies is to reduce electricity bills and be able light up in case of any potential loss of electricity especially in the newly connected areas where power cuts often occur.

However, the results showed that there are still residents using traditional means (candles, gas bottles...) for lighting and cooking. The amount of the monthly electricity bill for those who are already connected to the ONEE network is between 100 MAD and 600MAD with an average of ≈ 192 MAD per month, the average annual cost is $ 2,304 MAD.

The satisfaction about the electricity bills varies from one household to another, the results showed that about 60% consider the electricity bills expensive or even very expensive, others consider that it is reasonable for their consumption and income especially those that use electricity for water pumping.

Regarding the cost of equipment, whole photovoltaic kits are sold in the village with a price that range between 800 and 6000MAD which is an average of 3448.65 MAD. (See graph 1) This price varies from one area to another and depends on the household power of purchase, the age of the equipment and also the terms of purchase. At that price the cost of installation, which differs from one household to another is added. According to the results, that price depends on the person performing the installation and the availability of on-site technician. On average, the cost of installation does not exceed 340 MAD.

If we calculate the average price of a photovoltaic kit:

Panels price + battery + controller	*3450 MAD*
Installation fees	340MAD
Total	3790 MAD

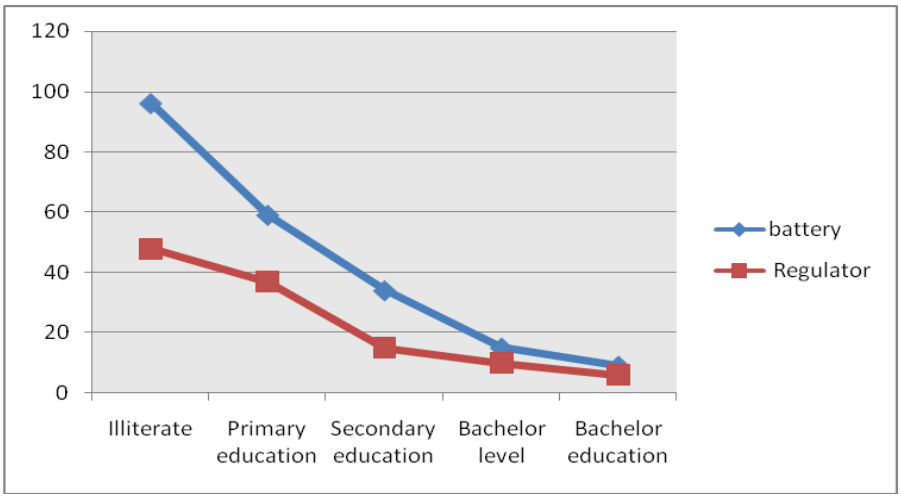
The average price of a kit is MAD 3790 and the average income is of no more than 2,000 MAD. In order to buy the equipment, people may have to take credit either from funding institutions or from the vendors themselves.

The connection costs are often higher. The wealthiest households are the first connected. A study in Bangladesh mentioned above (Barkat et al., 2002) compares the households connected and the ones non-connected to the local electricity network in a village. The authors found that connected households have an income of 126% higher than non-connected households.

With the initial investment, other additional costs are generated by the installation of kits and are costs fault repair and maintenance. Statistics show that in the village of our study over 30% of households do not want to keep the solar panels because of the high cost incurred in the regular battery failures.

The battery is often the critical element of a solar installation. Indeed, it is an expensive item, it has a relatively limited life, and above all, unpredictable quality.

The price of a new battery is an additional burden that the people in rural areas cannot stand. The cost of a new battery varies between 800 MAD and 2400 MAD depending on the brand and the quality.



Graph 7. *Relationship between failures and the level of education*

From the graph below, we can see that there is a relationship between the level of education and the batteries' failures. Some failures, like overcharging, are due to the lack of information on the use of the equipment

5. CONCLUSION

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Generally a non-electrified rural household spends on average between 120 and 150 MAD / month while a home with electricity, which consumes an average of 70 Kwh, has a total bill of about 80-100 MAD. Thus, the electrification grid connection costs less than traditional means of electrification, without considering of course the comfort and well being of citizens.

However, access to energy cost has become a constraint to households. In the case of centralized systems, the connection costs including the cost of indoor facilities are inadequate to the financial capacity of households with low income. It is the same for decentralized renewable energy technologies including initial costs that remain relatively high.

When solar equipment is installed, the proportionate cost is almost zero: Energy is generated for free but the investment represents a significant expenditure. The photovoltaic industry has experienced a significant decline in investment and operating costs since 2010, mainly due to lower module prices, which alone accounts for nearly half of the expenditures.

Furthermore, the option of the installation of individual photovoltaic systems, as in the case of our study, is the most common for decentralized rural electrification options. It is also valued for its modularity, reliability of components and the ease maintenance.

However, the energy produced is limited, which implies a necessary management of electricity consumption. People can only buy small electric equipment to meet the electricity shortage.

The establishment of community facilities will produce electricity in large quantities which can reduce the cost of the initial investment and can be adapted to limited income of citizens who cannot acquire photovoltaic kits with great power.

The results of the survey confirm the importance of providing financial incentives to invest in renewable sources of energy in rural areas with low income. The cost of installation (with public support to investment) and its operation is accessible for a rural household that spends 15-20% of their income in purchasing energy.[6]

Barriers to developing renewable energies are not merely technological but organizational, institutional and financial. The government should intervene to facilitate access to modern energy services for disadvantaged populations.

A very considerable improvement has been noticed in recent years, in rural areas of Morocco through the Global Rural Electrification Program (PERG). However, the situation of Moroccan rural areas concerning the availability of energy is critical

There is always a lack of energy, with population growth and the harsh winter weather, especially in mountainous areas; the demand for energy is increasing.

The implementation of renewable energy projects, in particular photovoltaic, is required to gradually reduce the imbalances in regional development and promote social inclusion of rural populations.

The Moroccan government should encourage research related to the exploration of new technologies, the support and promotion of training and research in the field of energy.

Encouraging Moroccan companies to engage in science and technology partnerships is necessary for the development of renewable energy.

Sensitizing Moroccan citizens of the importance of renewable energy and provide information on the operation of equipment.

The definition of incentive tariffs and regulatory conditions that will allow managing the market of equipment sales and structuring it is a way of inciting citizens to invest in community facilities.

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