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25 Years of Operation of the "Santa María De Loreto" Photovoltaic Plant, Cuba

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Abstract

The work addresses the main socio-technological aspects of the electrification process with photovoltaic solar technology , during 25 years of exploitation, in the rural community "Santa María del Loreto" and its necessary relationship with its beneficiaries, where participation, training and the use of resource rules such as those main variables that favor the assimilation of this technology, modifying habits and customs of the users in terms of energy consumption in a collectivist manner, which have allowed the promotion of endogenous capacities for the community appropriation of photovoltaic technology in substitution of a Diesel Generators, as an electrification route.

Introduction

An option for rural electrification in Cuba of some settlements has been the use of Diesel Generators, without clutching the damage to the environment caused by gas emissions and fuel and lubricant spills in fragile ecosystems, mountain areas, are evident, they also face the problem of high fuel costs and the difficulties of transportation and stable distribution of the same, all this imposes the need for generation for a few hours a day, not fully satisfying the needs of users, also reinforces costly maintenance needs.

A solution to the lack of energy in isolated rural areas is the increasingly frequent use of Renewable Energy Sources, of which the most widespread currently in the country is Solar Energy, in particular photovoltaic (Pv) technology, which appears in two main variants for electrification: decentralized and centralized.

The latter, among other advantages, allows a significant reduction in costs for installation, maintenance and repair (Ramos et al., 1998). However, for there to be a greater probability of success in rural electrification with photovoltaic technology, at least the demand for Pv electrification must be the result of a participatory prioritization process from the base.

Development

Characterization of the Rural Community "Santa María Del Loreto"

The rural community "Santa María del Loreto", is a settlement that emerged at the beginning of the last century, due to the arrival of people of Spanish origin or descent, interested in buying properties to dedicate them to agricultural production, basically to cultivation coffee, and others in search of employment that this economic activity generates as a result.

It is located at the following coordinates: Latitude 20.075616º and Longitude -75. 555550º, in the "Sierra Maestra" mountain range, 650 meters above sea level, Ti Arriba Popular Council, Songo La Maya Municipality, Santiago de Cuba Province. She is distant approximately 60 km from the provincial capital. Access is through a difficult mountain road of approximately 11 km to the Santiago-Guantánamo highway through which the National Electroenergetic System passes.

This community before the electrification with photovoltaic solar energy, in 1997, was made up of about 30 houses where about 121 people lived (López et al., 2000). Its fundamental activity was reduced to agricultural production, its main line being coffee and fruit trees (Jenny et al., 2007).

The population of the community had only two lights on average per dwelling (the majority being incandescent or of low efficiency), there were 6 radios, 8 high-consuming B/W televisions (only 4 in operation) and two domestic refrigerators, which could barely function. They did not have the possibility of using free time at night, the Family Medical Office lacked elementary equipment due to lack of stability in the electrical service, the primary school lacked computer equipment and means, limiting the actions of improvement of the children and a null improvement night for the workers, as well as poor access to the main media, radio and TV.

As part of the socio-demographic diagnosis stage, the community map was prepared, which allows us to know the location and order of the dwellings, the distance between them (Camejo Cuán et al., 2013), which can indicate the level of grouping or dispersion of the settlement, as shown in Figure 1.

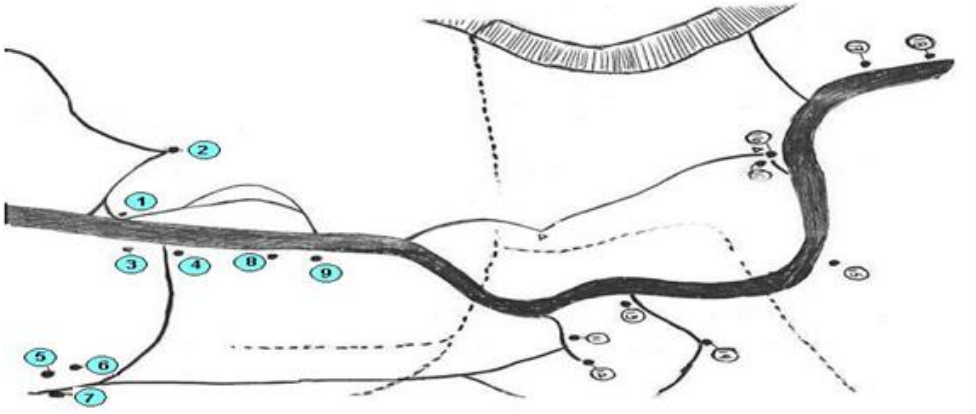

Figure 1. Location and order of dwellings, community map

When we think of electrifying communities with centralized photovoltaic systems, we have to stop at the disposition of their inhabitants before the possible cooperative or selfish nature of users in the use of energy, for this reason we include in the questionnaire a question referring to this topic where it is reflected that in this community (Camejo Cuán & Ramos Heredia, 2013):

Through the processing of a question from the applied questionnaire, where the neighbors are asked about the way they use the resource, with the possible answers (1 sometimes), (2 never), (3 always), we are interested in knowing the disposition of the neighbors in relation to the cooperative or individualistic character in energy consumption and as can be seen in the response graph, Figure 2, most of them would like to maintain an energy consumption behavior that does not affect the needs of the other neighbors , which shows a positive level of cooperation with respect to the use of a resource for collective use, in this case electricity.

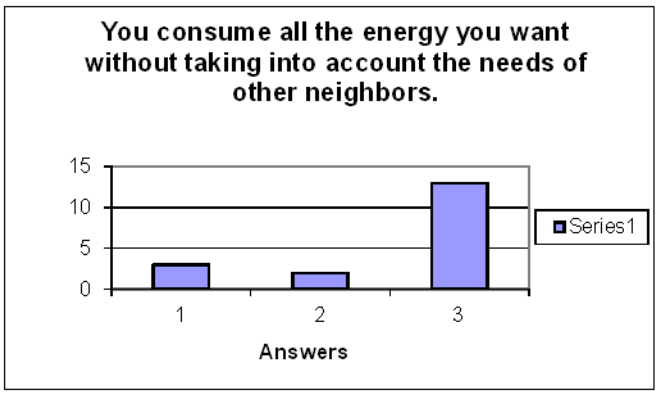

Figure 2. Result of the question

To guarantee the appropriation of the centralized photovoltaic technology, the social participation channel was used in the project from the beginning, throughout the community, for this purpose the installation of the centralized photovoltaic system from the beginning, guaranteed the incorporation of the neighbors to the construction and assembly works, as well as the contribution to the logistical attention to the technical team in charge of the installation, in the same way a neighbor was trained, from the beginning, to fulfill the functions of technician in operation and primary maintenance, who also performs the functions of local administration (Camejo & Hechavarría, 2011).

Technical Characteristics of the Proposed Photovoltaic Installation

The proposed installation, a centralized photovoltaic system (Figure 3), has a total power of 14.55 kWp and works at an input voltage of 48 VDC from the PV generator and an output voltage to the user of 120 VAC and 60 Hz, characteristic of the National Electroenergetic System of Cuba.

Figure 3. Santa Maria del Lotero Photovoltaic Plant

The PV installation is made up of two independent systems. Circuit 1, with the highest consumption, with a generation power of 7.5 kWp and Circuit 2 with a power of 7.05 kWp. Each system is made up of a 48 VDC and 1080 Ah battery bank, with a 5 kW DC/AC inverter, which pays its energy independently to each circuit.

Results and Discussion

Community Behavior after Electrification with Photovoltaic Technology

As a consequence of the improvements in the quality of life of the residents, there are now 48 homes in the community, 12 refrigerators, 31 televisions, 11 blenders, 12 fans, radios, among

other appliances, and optimal lighting in the homes, elements that illustrate the quality of life of its inhabitants.

Consequently, access to community information was increased through TV and radio, new activities were incorporated such as a collective laundry service, a collective 24-hour telephone communication service, contributing to community development and improving the quality of life of men and especially of women (given that in the community they are mostly in charge of carrying out domestic tasks).

The improvement of the quality of life of the residents benefited the production of food, fruits and vegetables for community self-consumption, also encouraging the production of milk and the harvest of coffee in the community area.

The results of the investigations have allowed the formation of a Doctor of Science, two Master's in Science and undergraduate theses. Regarding the informative and training work, different didactic and informative materials have been prepared for the radio, written press and television, where the scientific results and impacts achieved in the project and the degree of satisfaction of the beneficiary population are exposed.

All this gives an example of the intense scientific, technical and social work carried out over more than 25 years of uninterrupted operation to demonstrate the sustainability of photovoltaic technology.

The "Santa María del Loreto" community has shown significant population growth, Figure 4, we must note that in 1997 30 homes were electrified, grouping 121 inhabitants, 37 (0-5 years old), 37 women and 47 men, at year of being electrified, 1998, the population increases to more than 150 inhabitants due to the increase in the birth rate.

The number of electrified homes is increased to 41; from 2000 to 2004 the population grew by 164 inhabitants with 43 dwellings, from 2004 the population began to have a decreasing mobility behavior due to migrations with a peak in 2012 of (-39) people, product of the destructive effects on housing caused by Hurricane Sandy, in a population also with a significant weight of older adults who have been migrating to areas closer to specialized health services. As of 2014 and after compensating for the damage to homes caused by Hurricane Sandy, the population returns to the community.

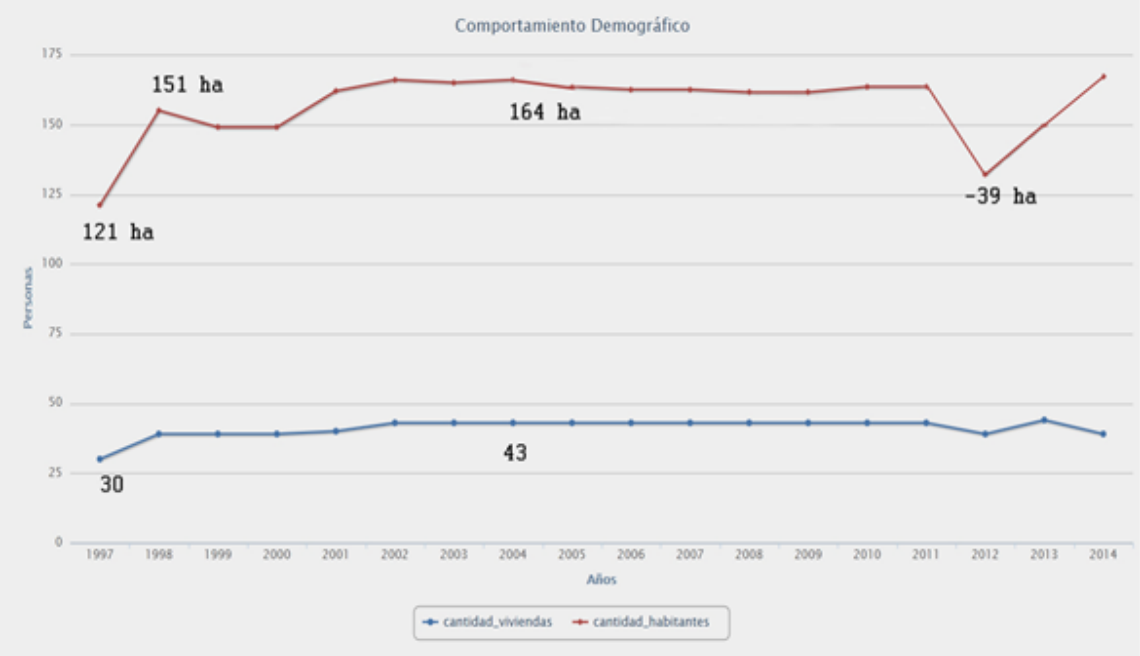

Figure 4. Population behavior and number of dwellings

Electrical appliances have had a significant growth with a growth rate per year of 2.29 units, Figure 5, showing characteristic features of its inhabitants, where the most significant is the increase in the acquisition of TV, refrigerators and blenders, which represents most of the installed power in the growth of consumption in the residential sector.

In relation to the above, there has been an increase in family income of 30%, where 90% are workers who depend on their productivity and the coffee harvest, the landowners with their productions.

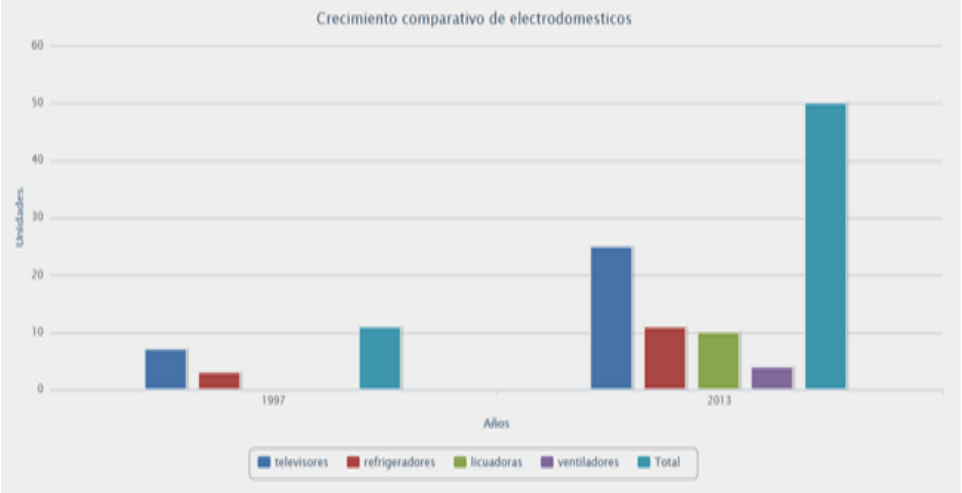

Figure 5. Behavior of electrical appliances

From a technical point of view, the photovoltaic installation has achieved a performance level of 88%, in accordance with the internationally established parameters (80 to 85%), basically achieved due to the existence of the local technician, his level of training and permanence in the community, as well as the cooperative nature of the community members in the use of energy resources, which has been promoted in the community.

Despite the fact that, from the beginning, a partial charge for the electricity service provided was established jointly with the local authorities and the community, in order to cover part of the maintenance costs and promote greater responsibility in the actors and a culture of energy saving and rational use of the resource, is still not enough.

Preliminary studies of electricity consumption in the rural community "Santa María del Loreto", developed by CIES between the years 2018-2021, made it possible to monitor the changes that are taking place in the life habits of the rural population as a result of electrification , which leads to a series of important elements for demand load management studies, taking into account an accelerated increase in consumption, where the residential sector uses the largest amount of total energy produced by photovoltaic plant, with 76 %.

The photovoltaic plant represents an important step in community development, but this photovoltaic system has its limitations like all energy sources, for example, inclement weather affects the operation of the plant, electrical discharges have caused failures in the system, being the inverters the most affected components, because they are the most fragile in this type of system. The photovoltaic modules are approaching the end of their useful life (25 years maximum), they present a high level of degradation compared to when they were new. That is why there are consumption regulations such as; (1) Limited number of devices per household; (2) High consumption equipment such as electric ovens and all high consumption resistive equipment cannot be used.

It is to be expected that the future growth of electrical appliances will take place in those homes with a low completion of electrical appliances (87%) with their respective regulations due to the degradation of the installed equipment and the largest consumers (13%) must have

concluded their Provision of equipment so that the use of the electrical energy resource has an equitable meaning.

The current rate that is applied for the collection of electricity produced by the photovoltaic plant is linear at 0.19 cents per kWh without taking into account the staggering of consumption, so that in order to contribute more effectively to the savings of those who consume the most, It is proposed that the collection from now on be made by applying the following rate, see Table 1.

Table 1. Collection rate proposal according to consumption levels

Monthly Consumption	Cost ($)
0-24 kWh	0,9 cent
25-50 kWh	0,15 cent
51-79 kWh	0,25 cent
+ de 80 kWh	0,40 cent

High consumption homes (5) are in a range of 51-80 kWh, those with medium consumption between 25-50 kWh (26) and those with very low consumption between 0-24 kWh (14).

Taking into account the accelerated growth of consumption, it is proposed to restrict the acquisition of new consumers of significant power, and to enforce the rules of common or collective use among users.

Despite this, we can affirm that the technological substitution has produced important changes in the community, the surveys carried out on 52 people who represent 62% of adults, reveal a high acceptance of PV technology and a high assimilation by the inhabitants. The interviews carried out show that the change in the quality of life of the community is identified, rising by more than 60%, new sources of employment have been created (Jardín de Flores, Cafeteria del Círculo Social and Telephone Agent Center, among others).

Social impacts of electrification

(1) 100% of the homes maintain high-quality lighting; (2) Improves the quality of the domestic atmosphere due to the non-use of kerosene burners for night lighting; (3) 27.5% of homes have domestic refrigerators for food storage; (4) 62.5% of homes have a TV for entertainment and information of the population; (5) 25% of households use blenders to make smoothies and juices; (6) It contributes to the training and retention of essential human resources in the community, currently a doctor and two teachers, which enhances the quality and stability of two basic services prioritized in the program of the revolution, health and education.

Conclusion

The processes of active participation and training have allowed the promotion of endogenous capacities for community appropriation of photovoltaic technology in the "Santa María del Loreto" community. The electrification of the rural community "Santa María del Loreto", with Photovoltaic Solar Energy, has had a wide social repercussion and significant achievements have been obtained in health, education, and economic development, as well as in the cultural heritage of the population, for more than 25 years of exploitation. It was shown that the success factors of the photovoltaic installation of the rural community "Santa María del Loreto" were due to the fact that the project was viable from the beginning and is based on the collectivist sentiment of the inhabitants, the existence of the local technician and its high level of training, as well as a high level of appropriation of the technology by users, all this has allowed the community to achieve local administration of the resource, a crucial aspect when it comes to centralized photovoltaic solar systems.

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