Sustainable Architecture from Proper Recycling: Renewable Energy Integration and Housing Automation

Diego X. Morales, Julio Berzosa, and Santiago Moscoso

Abstract

The increase in energy consumption from non-renewable resources causes large amounts of polluting gases, which ones are emitted into the environment, in addition, it is known that low-income people have serious complications to access their own home and basic services that guarantee a decent lifestyle, which is why this work presents a proposal that seeks to change certain paradigms with the introduction of alternative energies, with the implementation of self-sustaining homes that can supply their consumption by significantly reducing the costs of buying electricity. On the other hand, the cost generated during construction can be reduced by using recycled plastic for the manufacture of masonry blocks, also the first results of the automation carried out inside the house are presented, whose function is to regulate the temperature.

Keywords

Sustainable architecture • Solar panel • Telegram • Automation • Recycled plastic

1 Introduction

Energy from fossil resources needs to be replaced with renewable and inexhaustible resources to meet future energy demand. Ecuador has places that are privileged in terms of a resource for electricity generation (Neira González & Velecela Zhindon, 2014). Therefore, the efficient use of energy is one of the most important technological options to face the future, which is not a new theory, since in the early 1970s, the vast majority of industrialized countries adopted energy rationalization policies, to deal with severe increases in oil prices (Ulloa Arizaga, 2015).

Similarly, another great problem in society is related to the difficulty of accessing decent and affordable housing. Hence, the design of this house is oriented to confer a high degree of self-sustainability, capable of meeting the basic needs of the inhabitants autonomously and uninterruptedly, which implies that it contains the necessary resources to generate its energy and the subsequent disposal of waste generated by the fact of inhabiting it (Hodosi & Losada, 2016).

2 Case Study

The house under study is located in the postgraduate headquarters of the Catholic University of Cuenca located in La Estancia Luis Cordero in the city of Cuenca. See Table 1.

Figure 1 depicts the location of the home and a quick view of the campus.

2.1 Materials and Methods

A very efficient technique in obtaining data is observation. "It is a technique that allows obtaining information by registering the characteristics or behaviors of a group of individuals or elements without establishing a communication process and therefore without the need for collaboration by the analyzed collective" (Giler Chango, 2018). As well as the approach and combination of various technologies apply the automation of housing to contribute to improving the housing efficiency parameters. A bibliographic review will

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Table 1 Location of the house

Coordinates	−2.872	−78.918
Elevation	2508 msnm	

Fig. 1 Geographical location of the home

also be carried out, which will serve to make an adequate selection of criteria that will serve in the sizing and choice of solar panels. Subsequently, the information will be obtained from the solar radiation of the area and the estimated consumption (kWh) of the house, and information collected from the official pages of the Empresa Eléctrica Regional Centrosur S.A. See Fig. 2.

For a home to be self-sustaining, it must be designed and built considering respecting the standards of comfort and quality, it must be practical and economically viable, in addition to having characteristics that respect the environment. To this end, solar technology will be used, considering that it is consolidated worldwide and in Ecuador the solar

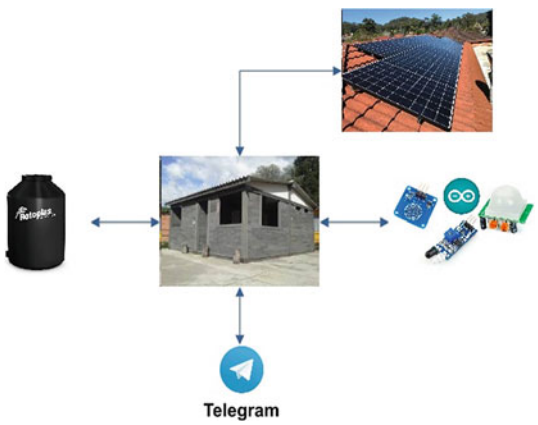

Fig. 2 Proposal for the integration of renewable energy and automation

resource is abundant. According to Sánchez Quiroga (fig), a solar panel is "an electronic device that allows transforming the luminous energy into electrical energy, through the photoelectric effect. The union of these cells gives rise to a photovoltaic panel". The origin of solar radiation can be defined as "it originates from the fusion of hydrogen in the core of the sun, and this causes radiation to spread in all directions without the need for a physical medium for its propagation" (Romero Crespo & Flores Peralta, 2017). The unit is the W/m^2.

2.2 Obtaining Solar Radiation Information

Ecuador is in a privileged geographical position so most of the year there is the presence of solar radiation, the solar rays affect perpendicularly on the surface, allowing the use of the resource for power generation. With the help of PHOTOVOLTAIC GEOGRAPHICAL INFORMATION SYSTEM (PVGIS) software, you can obtain radiation and temperature information in the area of influence. This data obtained will be useful in the calculation of the panels that are required to meet the demand of the home. It is necessary to take into account the historical temperature values of the city of Cuenca, and Fig. 3 shows the historical temperatures.

2.3 Panel Calculation

To calculate the solar system, the technical and constructive parameters of the solar modules must be taken into account, see Table 2, in the same way, the climatic conditions of the place where the house is located should be considered.

Table 3 gives the estimated energy consumption in housing built from recycled plastic.

Taking into account the information in the table above, it is determined that the number of panels required is 2. Table 4, you can see the calculations made.

3 Home Automation

For the implementation of the home automation system (see Fig. 4), it is necessary to consider the following criteria.

- Design elaboration: For the elaboration of the design, which is considered the necessary components as well as a strategic location in the house. For this study, the sensors were located in windows, roofs, and the main door.
- Mounting sensors and actuators: The components are placed taking into account the design. ¨Devices used by the centralized control system, to modify the status of certain equipment or installations In some cases, the

Fig. 3 Table of historical temperatures and radiation values for July in the city of Cuenca (es.climate-data.org)

Table 2 Panel and inverter technical data

Solar Best SE-P230-60	230	W
Voc	36.6	V
Isc	8.42	A
V_{MPP}	29.5	V
I_{MPP}	8.7	A
β%	−0.28	%
δ%	−0.37	%
γ%	0.04	%
Inverter sungrow	300	W
Voc	40	V
Vmin	30	V
Varranque	30	V
V_{MPP}	36–50	V
Imax	7.5	A

Table 3 Calculation of housing consumption

Household appliances consumption	Power (W)	Quantity	Hours of use	Energy (Wh/day)	Energy (kWh/year)
Fridge	60	1	12	720	
Laptop	65	1	4	260	
PC	50	1	5	250	
Lighting	72	1	4	288	
Fans	40	2	3	240	
Total	**287**			**1758**	**641.67**

sensor and actuator are integrated into the same device" (Rodriguez & Fernández, 2012).

- Design: The programming that activates the sensors. In this step, we will select the necessary commands and programs that will serve for the activation of the sensors and components of the circuit, for we will use the Telegram application that will fulfill the messaging function; together with Arduino which is the program selected to execute the different commands.
- Technical test: Multiple tests were conducted to verify the proper functioning of the components in their different applications.
- Low environmental impact system (LID) is a technique that bases its operation on rainwater collection through

Table 4 Panel number

Month	July	February
Temperature	8	21.3
Hour	7:00	13:00
Irradiance (W/m^2)	53.19	682.34
T Panel °C	9.46	40.06
V_{OC}	38.08	36.60
N_{MAX}	1	1
V_{OC} max	38.08	36.60
V_{MPP}	30.69	28.34
N Panels	1	2
V_{MPP} max/min	30.69	56.69
I_{MPP}	8.66	8.74
P_{MAX} Panels (W)	460	

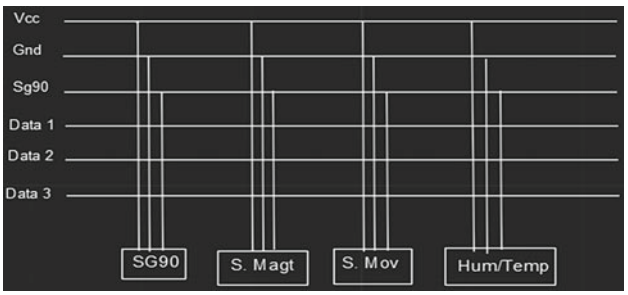

Fig. 4 Automation diagram

calculation processes, roof extension, and the storm level of the area. The collected water is stored in a reserve tank and through a pumping system is distributed to the sanitary batteries and gardening irrigations, optimizing water consumption in the medium and long term.

4 Results and Discussion

The following graphs show the behavior recorded by the temperature and humidity sensors inside the house (see Fig. 5), which will allow us to operate the ventilation and heating mechanisms, allowing us to balance the thermal conditions contributing to a stable environment in temperature and humidity.

As you can see there is a stable temperature behavior on each day of the week. At noon, you can see temperature spikes (about 32 °C) and at night, a drop below 16 °C. It is important to note that the fan installed inside the house is configured to turn on by exceeding 25° to maintain acceptable levels inside the house.

In Fig. 6, you can see how the house is controlled from the Telegram app, in the same way, the daily report generated, the temperature at any time of consultation, and movement alerts.

4.1 Energy Supplied to the House

The house has two solar panels connected in series with an active power of 230 W every one, the energy they deliver to the house is in the order of 839.5 kWh/year, and the consumption of the house is 641.67 kWh/year. That is, there will be a surplus of energy that can be injected into the distribution network to improve economic income. See Table 5.

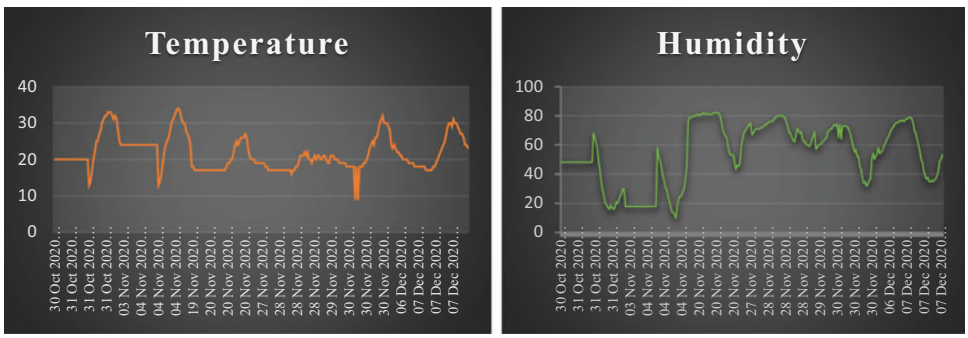

Fig. 5 Temperature and humidity values inside the house

Fig. 6 House sensor control program

Table 5 Data on energy consumption and supply in the home

Home consumption	641.67	kWh/year
Power supplied by the panels	839.5	kWh/year

4.2 Finished House with Panels, Inverter, and Automation

Figure 7 shows the location of the panels (left corner), as well as the arrangement of the automation system inside the house, which consists of a lighting system, humidity and temperature control, window drive mechanisms, and motion sensors.

5 Conclusions

The implementation of self-sustaining housing initially should be focused on low-income people who cannot access their housing and rural sectors where the conventional electricity grid does not have access so that service costs become high. For this reason, an economical, easily accessible, and technologically equipped housing alternative is proposed to minimize construction costs and reduces the negative impact on the environment with the emission of polluting gases.

Today the increase in electricity consumption in households has led to the relentless search for alternatives that suggest savings it, with the advancement of technology in different electrical, electronic devices, and the reduction in cost makes possible the implementation of various automata systems that guarantee a high rate of safety and control of buildings through applications that allow real-time visualization from anywhere in the Internet access is available.

Based on the climatic conditions of the city of Cuenca, it is determined that it is possible to develop sustainable housing in terms of energy, by combining various energy sources, as well as the use of raw material that usually ends up polluting rivers, broken or sent to landfill. The housing proposal has a positive impact, as it raises the level of comfort and safety allowing people to access and monitor

Fig. 7 Main facade and inside view of the house

the different parameters of the house from an application known as a Telegram.

From the first data of temperature and humidity, it can be concluded that the house is comfortable to be inhabited, in the same way, it offers advantages in terms of the cost of construction since savings of up to 30% can be achieved concerning conventional construction systems. Emissions to the interior of the home will be measured in the next phase of the project, and sismoresistence conditions will be checked.

It is necessary to collect data for a longer period and integrate the energy delivered by the solar panels into the monitoring system. Similarly, evaluate energy performance.

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