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Load Analysis to Solve the Daytime Demand in a House that is Located in "La Armenia Urbanization" with a Sizing of Photovoltaic Cells Connected to the Grid

Juan Xavier Guerrero García[a], Andrea Katiushka Loor Calderón[b], Guillermo Antonio Loor Castillo[c], Wilber Manuel Saltos Arauz[d], Lenin Agustín Cuenca Alava[e]

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Corresponding Author [a]

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solar energy;

Abstract

In this article a load analysis is carried out that is capable of solving the daytime demand for a home in the La Armenia urbanization of the Conooto parish belonging to the Quito canton, with the sizing of photovoltaic cells connected to the grid, seeking to reduce the environmental impact and the cost in terms of electricity generation. The sun is considered as the main resource that contributes to the generation of electricity, since the sun spills enough energy on the planet, if it is used efficiently, we could produce 400 times more than what is currently generated. The sector in which the study is carried out generates 4.16 kWh of solar energy on a daily average, with the use of this energy we could satisfy the daytime consumption of the house; A design of a grid connection photovoltaic generation system will be carried out in the form of distributed generation to satisfy the demand of the house during daytime hours. In carrying out this research, bibliographic resources from studies previously carried out as theses similar to the proposed project, scientific articles, catalogs, web pages, engineering books, and software such as PVGIS were used where radiation and temperature data (monthly, annual) were obtained to carry out the sizing of the photovoltaic system, also PVSYS that simulates the photovoltaic system, evaluating its operation in a certain time, measuring the efficiency with which the system works. For the design and implementation of the photovoltaic grid connection system, 4 solar panels connected in series are required, with a total power of 1.28 kwp. The inverter power is 1.2 kW, thus obtaining a photovoltaic system that supplies a daily demand of 90% without any problem according to the simulations carried out in the PVSYS software.

[a] Universidad Técnica de Manabí, Portoviejo, Ecuador
[b] Universidad Técnica de Manabí, Portoviejo, Ecuador
[c] Universidad Técnica de Manabí, Portoviejo, Ecuador
[d] Universidad Técnica de Manabí, Portoviejo, Ecuador
[e] Universidad Técnica de Manabí, Portoviejo, Ecuador

Contents

1 Introduction

Human beings to satisfy basic needs have destroyed the planet, being affected by overpopulation, even more since industrialization arose with greater demand for electrical energy. The progress of Humanity, particularly in the last two centuries, has been closely linked to energy consumption. Technological development and social welfare imply greater energy consumption, so it is obvious to ask ourselves, in what sense will this relationship evolve? The answer is trivial. The ever-increasing consumption of energy will not be able to be satisfied by the so-called traditional sources based on fossil fuels: coal, gas, and oil, so these sources must be gradually replaced by other sources, which in turn are renewable (Hernández, 2006; Jiayi et al., 2008).

According to Santamarta (2004), Under the name of renewable, alternative, or soft energies, a series of energy sources are included that are sometimes not new, such as firewood or hydroelectric plants, nor renewable in the strict sense (geothermal energy), and that is not always used in a way soft or decentralized, and its environmental impact can be significant, such as reservoirs for hydroelectric uses or monoculture biofuels. They currently supply 20% of world consumption (statistics do not usually reflect their real weight), their potential being enormous, although difficulties of all kinds have delayed their development in the past. Except for geothermal energy, all renewable energies derive directly or indirectly from solar energy.

In the book by Murcia (2008) he states: Solar energy is the radiant energy from the sun received on earth. It is an energy source that has several important advantages over others and that, for its use, also presents several difficulties. Its advantages include its inexhaustible, renewable nature and its pollution-free use. But, for its use, it is necessary to take into account its intermittent nature, its variability beyond the control of man, and its low power density. These difficulties then entail the need to transform it into another form of energy for storage and later use. The low power density results in it being an extensive source: for higher power, a larger range of conversion equipment. Solar engineering is precisely concerned with ensuring the reliable supply of energy for the user taking into account these characteristics.

In recent years, Ecuador has seen an increase in energy demand due to the increase in users of industrial and domestic applications (Jiménez et al., 2017; Green & Prodanović, 2007). In recent years, Ecuador has established the need to achieve the diversification of the national energy matrix traditionally based on conventional energy sources, for one that can be sustained using indigenous renewable resources (water, solar, wind, biomass, and geothermal (Peralta et al., 2013; Arauzet al., 2016). The country, becoming aware of the electricity deficit in certain areas where there is greater demand, seeks alternative energies, as in this project, which aims to provide a solution with load analysis to solve the daytime demand of a house, with a dimensioning of photovoltaic cells connected to the grid.

The province of Pichincha is a large province with and a large population that has a high demand for energy consumption, especially during the day, for which a load analysis will be carried out in the Urbanization "La Armenia" of the parish of Conoco and provide a solution with photovoltaic cells that connect to the network, thus solving or the daytime demand. After the existing problems, the objective is to provide a solution to sectors with daytime demand, with alternative energies that are friendly to the environment, in this case with photovoltaic cells with connection to the grid, considering the Urbanization "La Armenia" located in the rural area of Cantón Quito, an ideal sector to carry out the project with the help of practical methodologies and some programs that help simulate the project.

2 Materials and Methods

To define this project, the research modalities are used which will allow obtaining optimal results to design the photovoltaic generation system for connection to the grid, starting with bibliographic research to have an overview of the existing systems in the world, to then determine the requirements of the system and start sizing, to finally evaluate the performance of the photovoltaic system. The project to be developed begins with the compilation of information in bibliographic materials, one of the main pillars of the research are the theses that have similar characteristics to the proposed project that are handled in the approach of photovoltaic installations of connection to the network and those that have with an accumulation of electrical energy, in the same way with the help of scientific articles, catalogs, web pages, and engineering books, obtaining important information for the design and development of the photovoltaic generation system for connection to the grid with storage.

The research is focused on the design of a grid-connected photovoltaic generation system, taking as base demand power that of a house in Quito, to size the system with its respective elements: inverter, photovoltaic modules. Using the PVGIS software we obtain radiation and temperature data (monthly, yearly) to be able to carry out the sizing of the photovoltaic system and the PVSYS software we can simulate the photovoltaic system to be able to see its operation in a certain time and measure the efficiency with which the system works (Lalouni et al., 2009; Kobayashi et al., 2006; Sidrach-de-Cardona et al., 1999).

3 Results and Discussions

Photovoltaic solar

Photovoltaic solar energy is a technology that generates direct current (power measured in watts or kilowatts) using semiconductors when they are illuminated by a beam of photons; While the light falls on a solar cell, which is the name given to the individual photovoltaic element, electrical power is generated, when the light is extinguished, the electricity disappears; Solar cells do not need to be charged like batteries. Some solar cells have been in operation on land or in space for 30 years (Horikoshi, 2009; Insa, 2015). Photovoltaic solar energy has both technical and non-technical advantages and disadvantages, often, the advantages and disadvantages are opposed to those of conventional fuel plants, for example, fossil fuel plants cause dangerous emissions for the environment, use source limited, their cost tends to grow and they are not modular, that is, small plants cannot be made, photovoltaic solar energy does not have any of these problems, on the contrary, they have the disadvantage of being difficult to store, finally, they coincide in being both very reliable technologies (Telecommunication, 2002). Table 1 shows the advantages of solar energy.

Table 1
Advantages of solar energy

Advantages	Disadvantages
Clean, renewable, infinite, silent	Large investment
Economically rewarded for grid production	Difficult storage
Subsidies	Complex and expensive module manufacturing process
Short payback of energy	Not competitive with other energies at present
No modular moving parts	Variable production according to weather and time of year

Source: (Telecommunication, 2002)

Available solar resource

The energy we receive from the sun is more than enough to cover the world's energy demand, in reality, the energy we receive is 10,000 times the current energy consumption in the world. It is defined as the amount of kWh that can be generated about solar radiation in 1 square meter (Abella, 2005; Arencibia, 2016). The irradiation is distributed equitably over the surface of the earth, firstly due to the shape of the earth, the areas around the equator receive more solar energy than elsewhere, secondly, to the differences in the humidity of the air, clearance of the sky, and cloud cover, there are variations from country to country, even if they are at the same altitude. On a clear day, the energy is distributed throughout the day in a kind of Gaussian distribution (bell shape) (Chávez, 2013; Dincer, 2000). In figure 1 we can see that it can be seen that in the province of Pichincha there is average radiation of 5.5KWh/m^{2}day.

Measurement of solar radiation

Whenever you want to make use of solar energy in a place or region, it is necessary to know the characteristics of solar radiation and the influence on its climatological, geographical, and atmospheric effects, as well as the amounts of radiation incident on the solar collectors, to optimally size any system. The most used instruments to measure solar radiation are pyrheliometers, which are used to measure the radiation of normal incidence; pyranometers that measure global radiation (and diffuse radiation when a shadow band is incorporated) on both horizontal and inclined surfaces; and insolation recorders that measure the hours of sunlight. For this last type of measurement, heliographs are used, which are based on a very simple principle: a spherical lens concentrates the sun's rays on a mobile strip of photosensitive paper, causing burns when there is direct radiation greater than 210 W/m^2. These measurements have been used to estimate daily irradiation values (Rodriguez & Vázquez, 2018; Panwar et al., 2011). Figure 1 shows the average annual global potential of Ecuador in 2019.

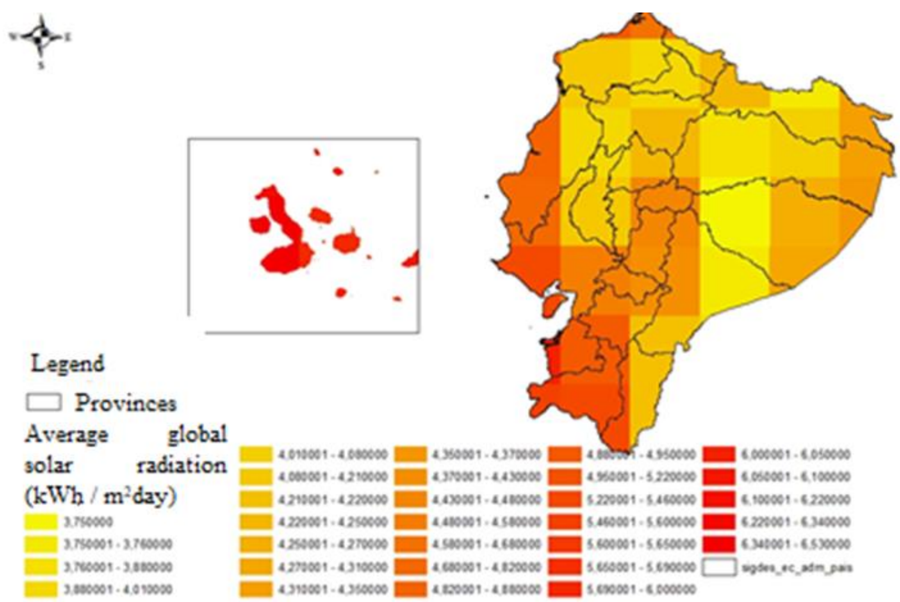

Figure 1. The average annual global potential of Ecuador in 2019

Temperature is a factor that intervenes in the performance of solar modules. Table 2 shows the radiation and temperature values of the La Armenia urbanization.

Table 2
Monthly measures radiation and temperature

MES	Irradiation (kw / hm2)	Temperature (°C)
January	175.24	03.14
February	178.78	13.9
March	162.92	14.1
April	166.71	14.3
May	165.83	14.1
June	183.42	13.9
July	170.44	13.7
August	194.23	14.8
September	195.53	15.6
October	166.99	14.9
November	167.07	14.4
December	198.05	14.5

Source: (Cattaneo, 2018)

Energy consumption in the home, average demand in daytime

The demand was determined according to the schedule, being 6,850 kW, The sizing will be obtained from the load consumed in the daytime from (6:00 a.m. to 6:00 p.m.), observed in figure 2.

Figure 2. Consumption in daylight hours

Photovoltaic solar generation system connected to the Grid

The photovoltaic systems connected to the electricity grid also have as their main objective annually the production of electrical energy that is injected into the grid. The main applications of these systems are for:
Roofs in homes (integration in buildings), in which the installation is physically located in a building that is usually located in an urban environment.
Power generation plants (photovoltaic plants), in which the PV installation works like a conventional power generation plant in the sense that it injects all the electricity production into the grid.

However, there are also other types of applications in which photovoltaic modules are used as constructive elements in various urban environments such as sound barriers on highways and train tracks, pool covers and parking lots, etc. In addition to the annual maximization of the energy generated, other aspects must also be taken into accounts, such as architectural integration and integration with the environment, possible shading losses, which are difficult to avoid in many of the systems integrated into buildings, safety, and quality aspects. of energy generated as well as the absence of effect of disturbances of the electrical network.

Calculation of installed power

To size the photovoltaic generation system connected to the grid, 208.89 kWh / month is established, the consumption demand in the home during the daytime.

$$\text{Capacidad Instalada} = \frac{\sum_{i=\text{mes }1}^{\text{mes }12} \text{Emensual}_i(\text{kWh})}{\text{Factor}_{\text{planta de diseño}} * 8760\ (\text{h})}$$

$$208{,}89\frac{\text{kWh}}{\text{mes}} * \frac{12\ \text{meses}}{1\ \text{año}} = 2506{,}68\frac{\text{kWh}}{\text{año}}$$

$$\text{Factor}_{\text{planta de diseño}} = \frac{\text{HSP}}{24\ \text{h}}$$

Where:

$$HSP: \ Peak\ Sun\ Hours$$

$$HSP = 5\ hours\ for\ the\ city\ of\ (Quito, Conocoto)$$

$$factor_{Design\ plant} = \frac{5\ h}{24\ h}$$

$$factor_{Design\ plant} = 0.28$$

$$Installed\ Capacity = \frac{2506.68\ kWh\ /\ year}{0.28 * 8760\ (h)}$$

$$Capacity\ Installed = 1{,}021\ kW$$

Simulation Pvsyst

To check the sizing of the system, the Pvsyst software was used, in which the data of the project location, horizontal irradiation, average temperature, height of the area, the inverter data, the data of the photovoltaic panel. To perform the simulation in a calendar year, the results of Table 3 were obtained, in addition to the performance of the system, with 82.2% and the energy produced in the order of 2,200 kWh/year with an angle of 15 degrees and without shadow obstacles that affect to the system.

Table 3
Simulation results

New variant of simulation, balance and main results

	GlobHor kWh/m²	T Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray kWh	E_Grid kWh	EffArrR %	EffSysR %
January	175.2	14.30	154.6	148.3	174.9	163.1	14.57	13.59
February	178.8	14.00	164.0	158.1	184.9	173.1	14.52	13.60
March	162.9	14.10	158.8	153.0	181.5	169.5	14.73	13.76
April	166.7	14.40	171.1	166.1	192.7	180.2	14.51	13.56
may	165.8	14.20	178.0	172.8	200.5	187.4	14.51	13.57
June	183.4	14.00	202.6	197.4	226.9	212.7	14.43	13.52
July	170.4	13.80	185.1	179.8	209.0	195.6	14.55	13.62
august	194.2	14.80	203.8	198.2	227.7	213.4	14.40	13.49
September	195.5	15.70	194.8	189.1	215.5	201.8	14.25	13.35
October	166.9	15.00	157.3	151.5	177.7	165.9	14.55	13.58
November	167.1	14.50	150.1	144.0	170.2	158.8	14.61	13.63
December	198.1	14.49	169.9	162.6	191.1	178.6	14.49	13.54
Año	2125.0	14.44	2090.1	2020.7	2352.5	2200.0	14.50	13.56

Legend:
GlobHor Horizontal global irradiation
T Amb Room temperature
GlobInc Global incident in the receiving plane
GlobEff Global cash; corr for IAM and shaded
EArray Effective energy at the generator output
E_Grid Energy injected into the grid
EffArrR Efficiency Esal field / gross area
EffSysR Efficiency Esal gross area system

Source: (PVSYST, 2014)

The Pvsyst program generates the following report of the "Urbanización Armenia" project where it offers the location of the area, the angle of inclination of the modules, their number, the type of connection, and other parameters of interest. For an angle of inclination of 15 degrees, the performance factor shown in figure 3 was obtained

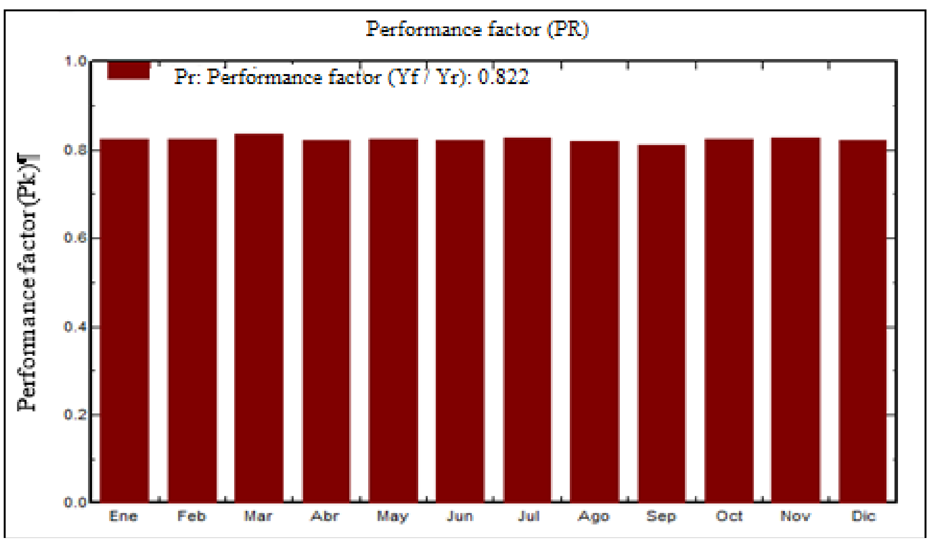

Figure 3. Performance factor
Source: (PVSYST, 2014)

In figure 4, the normalized production per kWp in salado is shown, with a nominal power of 1280 Wp.

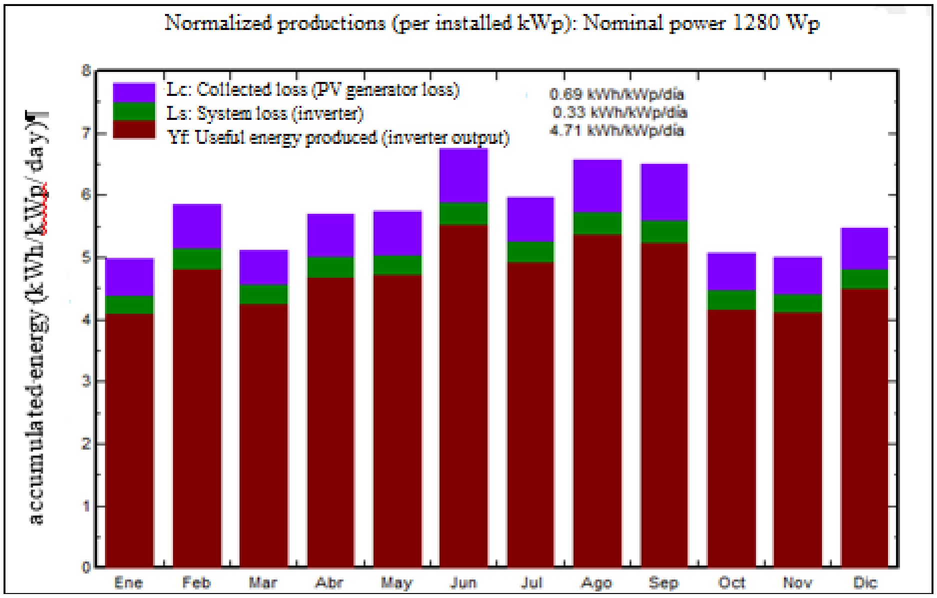

Figure 4. The normalized production per kWp in salado
Source: (PVSYST 2014)

The system offers a report of the losses during the year studied, shown in figure 5.

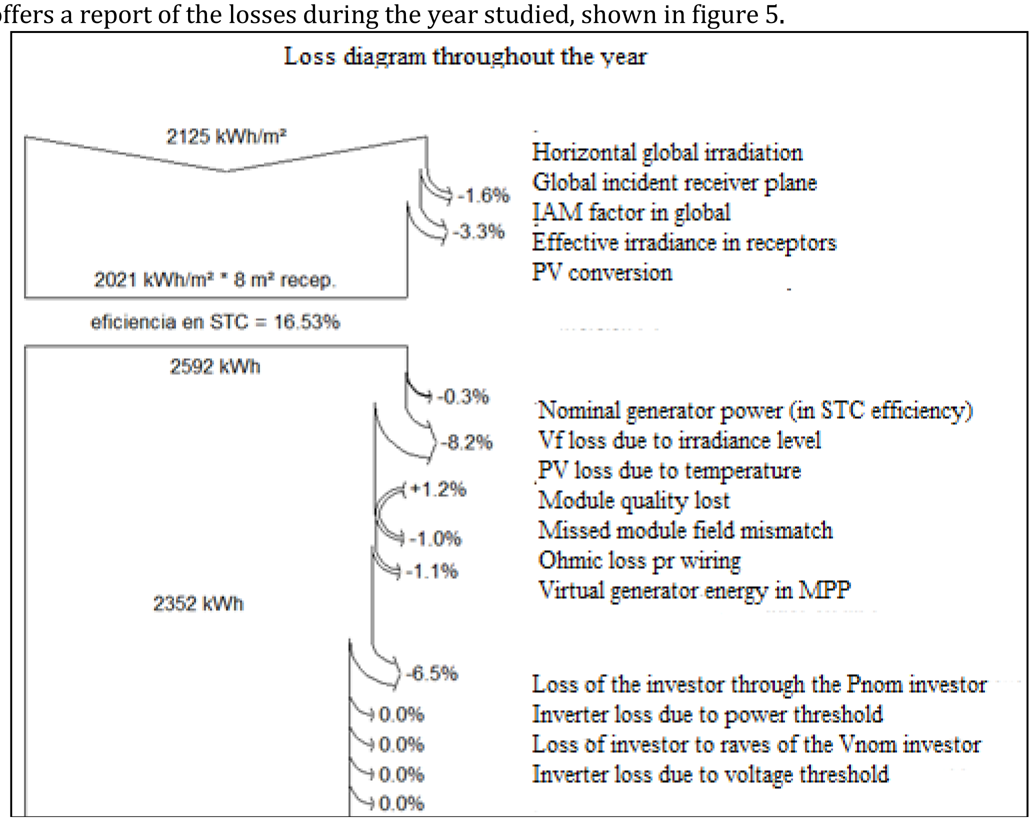

Figure 5. Report of the losses during the year studied, shown

As can be seen, the values of global horizontal irradiance, the global incident and other values of losses of interest are shown. they must be taken into account for the development of the project. As the sun is a source of free energy, it is very profitable to use solar panels to generate electricity for homes, as well as being environmentally friendly. The power of the inverter is 1.2 kW, the inverter is in charge of transforming direct current into alternating current to supply the daytime demand in the home.

Ecuador is in an enviable geographical location for the production of solar energy since the solar rays fall perpendicularly towards the surface of the earth and consequently have in the city of Quito 5 peak solar hours of maximum performance for the dimensioned photovoltaic system. The correct dimensioning of the PV system will reduce the losses in it since the elements work with their maximum performance. In the sizing, a PV system connected to the grid was obtained that can supply the daytime demand by 90% annually without any problem according to the simulations carried out in the software (PVSYT)

4 Conclusion

A photovoltaic grid connection system was designed consisting of 4 solar panels connected in series with a total power of 1.28 kWp. After studies carried out in the country, the recommended inclination for the best reception of solar radiation is 15 degrees, this helps to improve the cleaning of the panel and better efficiency of the photovoltaic system. It was obtained that the performance of the system is 82.2% and the energy produced 2200 kWh / year according to the simulation in the software (PVSYT).

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Biography of Authors

Juan Xavier,
Engineering student in electricity
Email: jguerrero6765@utm.edu.ec
https://orcid.org/0000-0001-9494-7526

Andrea Katiushka,
Engineering student in electricity and civil engineering.
Email: katiushkaloor@gmail.com
https://orcid.org/0000-0001-5533-978X

Guillermo Antonio,
A graduate of Electrical Engineering at the Universidad Técnica de Manabí (UTM), Portoviejo, Ecuador. Master of Educational Management. Assistant Department of Electrical and deputy dean of Electrical Engineering at the Faculty of Mathematics Chemistry, Physical in the UTM, Portoviejo, Ecuador. Professor, currently she is working on her doctoral work on the topic of smart grids for efficient application to university facilities.
Email: galoor@utm.edu.ec

Aspiring Doctor of Technical Sciences, Electrical Engineer, Has worked in various research primarily directed to the use of microgrids with renewable energy sources, it has participated in scientific events as the author of several currently working on the issue of the use of renewable sources in form of distributed generation through microgrids that enhance power quality and decrease environmental impacts.
Email: wsatos@utm.edu.ec

Graduate of Electrical Engineering at the Universidad Técnica de Manabí (UTM), Portoviejo, Ecuador. Master in Educational Management. Assistant Department of Electrical and coordinator of the School of Electrical Engineering at the Faculty of Mathematics Chemistry, Physical in the UTM, Portoviejo, Ecuador. Professor currently working on his doctoral work on the topic of artificial intelligence for efficient application to university facilities.
Email: lcuenca@utm.edu.ec.