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Design, Dimensioning, and Installation of Isolated Photovoltaic Solar Charging Station in Tungurahua, Ecuador

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Abstract- In this article the process of design, sizing and installation of the first solar photovoltaic electric vehicle charging station isolated from Ecuador is described. The construction of solar electric vehicle charging station is framed within the concern of the Ecuadorian State to promote the integration of renewable energies in urban transport and in isolated areas of the country. In this sense, the electric vehicle charging station is revealed as a prototype that been allowed the standardization of the technical characteristics of solar photovoltaic materials to be used in a set of photovoltaic isolated rural projects in different provinces of country. In addition, an optimized design of this solar photovoltaic electric vehicle charging station can be installed in the Galápagos Islands, allowing address the problem of land transport in the islands with the use of massified renewable technologies currently technically and economically very competitive.

Keywords photovoltaic solar, electric vehicle charging station, inverter.

1. Introduction

Ecuador is one of the countries with the highest dependence on exports of oil and oil products. 89% of its primary energy is associated with the production, export and refining of oil [1]. In the future, 90% of primary energy from Ecuador could depend on a resource that the country will no longer have. The sector of the Ecuadorian economy with the highest energy consumption is transportation, equivalent to 101 million barrels of oil. In 2014, 42% of the total consumption of final energy in Ecuador corresponded to transportation [2].

The practical implementation of a sustainable strategy to reduce oil dependence of transportation would mean the beginning of a profound transformation of the current energy model inherent in any modern society. Transport is one of the most pressing and critical issues to be addressed by various states - regardless of the level of human development - and involves developing and implementing a long-term comprehensive strategy of transformation of the transport system for people and goods, adjusted to a process of transformation of the energy model. The pedestrian, the cyclist and the public transport should be the central elements of a comprehensive strategy for sustainable mobility **[3].**

The emerging yet developing countries have a system of transporting people and goods with a disorganized, inefficient, chaotic and intermediate level of development. Transport systems with an intermediate level of development allow ample action for the establishment of an orderly, efficient and sustainable growth in the transport sector. This statement implies that if the process of transforming the energy model starts as soon as possible, these states won't need expensive, deep and traumatic changes, like those currently experienced by most industrialized countries with a more crowded private transport and large volumes of merchandise **[4].**

The vehicle electrification entails numerous challenges, such as the range as charging times, which limits mobility. The energy storage systems usually need more than one hour of charging time. At the present, a storage system cannot be "filled up" link tank of vehicle powered by a combustion engine. One option for battery charging could be a widespread network of connection points so called electric vehicle, EV, charging station. EV can be connected with the grid while parked, which is typically 70-80% of a day. This makes it possible to use a vehicle's storage capacity to store excess energy from the grid or to supply energy to the grid for so-called network services [5]. In this context, the main objective of the paper is to describe the design, sizing and installation of the first isolated photovoltaic solar EV charging station of Ecuador, built at the Technical University of Ambato. The EV charging station permitted the definition of the basic technical characteristics of the solar facilities for their implementation in remote rural areas of Ecuador and the Galapagos Islands. The photovoltaic facilities in the communities of the Ecuadorian jungle will provide energy for domestic use, while in the Galapagos Islands they will take advantage of the outstanding solar resources to replace the use of oil derivatives and supply solar energy to electric vehicles that will replace the current fossil combustion vehicles.

The experience gained in the process of building the first solar EV charging station in the country and the steady decline in prices of photovoltaic modules and solar equipment as well as the evolution of photovoltaic technology invites the people to optimize the design presented to improve the energy performance and features of the solar EV charging station **[6].**

This paper is organized as follows: in section 2, a description of the elements of the EV charging station is presented. The calculation of energy consumption in the EV charging station is presented in Section 3. Section 4 presents the databases of solar radiation in the city of Ambato. In Section 5, the design and dimensioning of the elements of the EV charging station are developed. In section 6, the economic cost of the installation and commissioning of the EV charging station is described. Finally, section 7 presents conclusions and some recommendations for the optimization of the design process, dimensioning, construction, installation and commissioning of the first isolated photovoltaic solar EV charging station in Ecuador, and the Andean region.

2. Description of the Elements of the EV Charging Station

Figure 1 presents, in a schematic form, the elements that conform the isolated solar EV charging station installed on the Technical University of Ambato campus.

- Metal support structure of the solar modules.

- Solar conversion system – photovoltaic modules

- Regulation, control and adaptation system – regulator and inverter/charger.

- Accumulation system – stationary batteries.

- Electrical Vehicle Charging Station

Figure 1. General scheme of elements of solar electric vehicle charging station

2.1. Metal support structure

The metal support structure of the photovoltaic modules covers a total of two parking spaces and serves as a solar protection, since it gives shade to vehicles and reduces degradation of materials in an area of high exposure to sunlight. In the design of the metal support structure the weight of photovoltaic modules and wind overloads were considered. The geographical location of solar EV charging station, 1.28 ° south in latitude, allows the metal support structure to not have any inclination. However, an inclination of 10 ° of the metal support structure was considered, which allows proper evacuation of rainwater and avoids stagnation of rainwater.

2.2. Photovoltaic generator

The photovoltaic modules are grouped into two subfields, independent photovoltaic solar modules, placed on the metal support structure that form the photovoltaic installation**.** Each solar photovoltaic subfield consists of 8 SunPower photovoltaic modules of the E20 series of black monocrystalline silicon, connected in series-parallel. The EV charging station is located in a specially designated area of the existing outdoor parking in the Huachi campus of the Technical University of Ambato. The space allocated to the location of the metal structure is owned by the university, avoiding the payment of rent. Figure 2 shows schematically the connection of photovoltaic modules for each photovoltaic field.

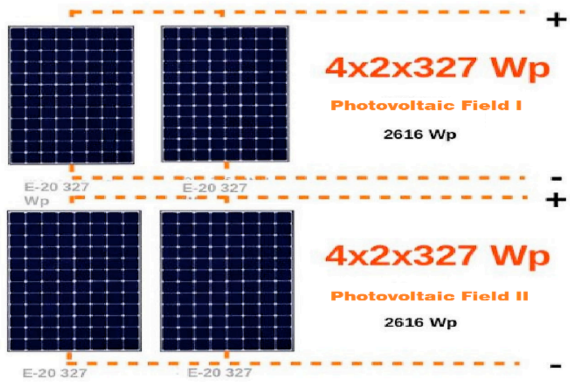
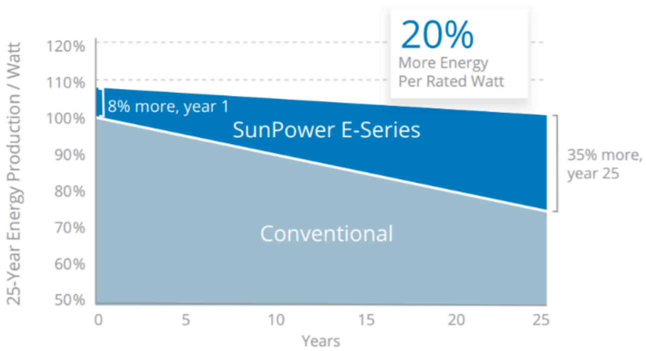


Figure 2. Parallel connection of photovoltaic modules of photovoltaic fields I and II, respectively.

Each photovoltaic panel has a peak power equal to 327 Wp. Each photovoltaic subfield will have a total installed power equal to 2616 Wp, respectively. Therefore, the photovoltaic system has a total installed power of 5,232 kWp. In Figure 3, the distribution of photovoltaic fields I and II on the metal structure are presented schematically.

Figure 3. Distribution of photovoltaic subfields I and II on the metal support structure of solar Electric Vehicle Chargers.

The primary objective in the process of multi-criteria comparative selection of photovoltaic modules was to obtain maximum energy production with the lowest amount of surface and weight for the structure. The tilt and orientation of the metal support structure have the optimum values suitable to maximize production based on geographical and topographical conditions of the location. The factor of existing shadows and maximum use of the surface have been the most dominant criteria in selecting the orientation and tilt of the metal structure. The efficiency of the photovoltaic panel SUNPOWER E20 series is equal to 20.4% which corresponds to the highest efficiency values on the market for photovoltaic modules. Maximizing energy production requires the use of high-efficiency photovoltaic modules, since the available space is limited. The panel efficiency is a determining factor in the final price of the photovoltaic installation.



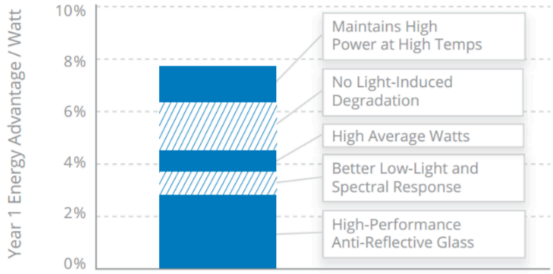


Figure 4. Comparison of energy production from a PV panel SUNPOWER and a conventional photovoltaic panel.

SunPower E20 Series modules, due to their high efficiency, convert more sunlight into electricity. According to the technical characteristics of the manufacturer they produce 36% more power per panel and 60% more energy per square meter over 25 years than conventional brands. High performance during the first year offers 7-9% more energy per nominal watt. This advantage increases with time, producing 20% more energy throughout the first 25 years. Figure 4 demonstrates a comparison of the energy generated over a period of 25 years for a 327 Wp E20 SUNPOWER photovoltaic panel and a conventional photovoltaic panel. Also Figure 4 shows the comparative advantages of the 327 Wp SUNPOWER E20 panel during the first year of performance.

The dimensions of the photovoltaic modules are 1.6 meters long and 1.05 meters wide. The surface area of 1.6 square meters is relatively small compared to several models of other manufacturers. The size of the modules is ideal for roofs and structures of small size, since it allows optimization of the available space. These photovoltaic modules have a weight of 18.6 kilograms compared to the 24 to 25 kilograms that standard modules with that level of electrical power normally weigh. The weight of the modules is especially important to avoid overloading the metal structure.

2.3. Regulation, control and adaptation system

The system of regulation and conversion of the photovoltaic installation consists of a device that includes two elements in an integrated solution: a regulator and an inverter/charger. In Figure 5, a representation of the basic scheme of the inverter/regulator/charger device is presented. It also incorporates a battery charger, which lets you connect the isolated system to an external power source. This device is suitable to cover the total demand for isolated facilities such as homes, farms, shelters, etc., being of special importance for EV charging stations, in case of adding an extension and including an additional small wind turbine.

The isolated charging station will use two devices, a regulator and an inverter/charger, in an integrated solution called Flexpower TWO of the American manufacturer of solar equipment, OutBack Power. The chosen MPPT Regulator model is called FLEXmax80, whereas, the model of the chosen inverter/regulator is called FXR 3048A.

The integrated solution Flexpower TWO contains the chosen Regulator and Inverter/Charger devices - FLEXmax80 and FXR 3048A - respectively, and are designed for use in isolated solar facilities which operate at a designed voltage of batteries equal to 48V.

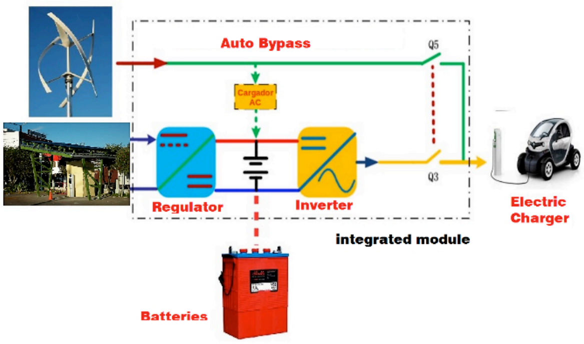


Figure 5. Basic diagram of a controller and inverter / charger device isolated a photovoltaic system.

The chosen equipment includes in one device the following elements: a battery charge regulator with a maximum current of 80A; a pure wave inverter of 3000VA, respectively, with instant peaks of 6000VA, and a battery charger from an external source with a selectable maximum intensity of 35A.

2.4. Accumulation System

In isolated photovoltaic systems, the photovoltaic solar modules, once installed, are always available to generate electricity. However, the amount of solar radiation received is usually variable, subject to the daily cycle of day and night, to the annual cycle of the seasons and to the random variation of the state of the atmosphere with its clear, cloudy or stormy days, etc. The accumulation system, consisting of storage batteries, stores energy and is able to transform the potential chemical energy into electrical energy, performing the following functions [7, 8, 9]:

- provide energy regardless of the instant electricity production of the photovoltaic modules, allowing the supply of the necessary power to the loads for several days.

- maintain a stable level of tension, providing a constant voltage within the predetermined allowable range.

The accumulation system for each of the photovoltaic subfields of the solar energy plant consists of open heavy load solar batteries of lead-acid. The individual cells are mounted on a resistant external deposit with a removable cover. Battery modules with a voltage of 6V and storage capacity of 600Ah will be used. The design voltage set for the accumulation system of the photovoltaic system is equal to 48V. Since the modules of the selected batteries have a voltage of 6V, it is necessary to connect the modules in series until the predetermined design voltage is obtained. The serial connection must connect 8 6V batteries to store the energy from the photovoltaic modules in 48V installations. Deep cycle batteries offer an extremely high cycle to deep discharges. The batteries provide 1500 cycles for a discharge of 50%.

The EV charging station has two blocks with a serial connection of 8 6V batteries with 600Ah of capacity providing a total capacity of 600Ah and 48V for each block. To perform this type of connection you have to connect the positive pole of a battery to the negative pole of the other. The remaining poles will serve as a point of connection of the positive and negative wires coming from the charge regulator, figure 6.

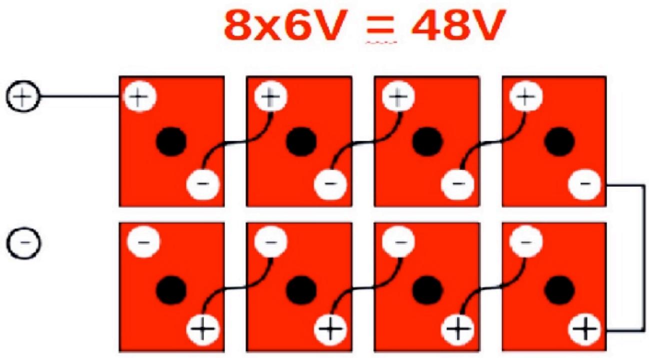


Figure 6. Series connection of batteries 6V for obtaining an accumulation system 48V and 600 Ah.

3. Estimate of the Energy Consumption Solar Manager Platform Structure

The electric charges of the EV charging stations include the following:

- 2 vehicles Renault Twizy 5 Cv Urban 45

- 10 LEDline type lights of 9.6 W

The Renault Twizy electric vehicle presents a 58Wh consumption per kilometer and a range of 80/100 km. The car battery has a capacity of 6,1kWh. Since it is intended that the electric vehicle battery will be charged at night and discharged during the day, a power consumption of 6.1 kWh/day will be implemented for each electric car. The LEDline type lights will work for twelve hours a day consuming a total of 960Wh (10x9, 6Wx1Oh 960Wh). The auto-consumption losses of the Regulator and Inverter/Charger together will be 72Wh (24hx3W 72Wh). The total energy consumption is 6652Wh, associated to each photovoltaic subfield corresponding to the consumption of an electric vehicle, 5 luminaires and of 9,6W and the auto-consumption of the Inverter/Regulator, Table 1.

Table 1. Estimation of energy consumption associated with each photovoltaic subfield.

Unity	Load	Unitary Power, W	Daily Hours of Operation	Total Energy, Wh	Total Energy, correction factor, Wh
1	Electric Vehicle	2033,33	3	6100	7320
5	LED Luminaires	9,6	10	480	576,0
	Consumption	3	24	72	86,4
Total				6652	7982,4

In the last column of Table 1, to the average daily consumption, a correction factor of 20% has been applied, corresponding to a recommended safety margin. This safety margin is justified due to the performance losses in the battery, regulator, inverter/charger and wiring. The performance values for the different elements of a solar photovoltaic installation are: battery equal to 95%; inverter/controller equal to 90%; conductor performance equal to 99%. The overall performance of the battery-inverter/regulator-wiring is 84,65%.

4. Solar Radiation in Ambato

The average solar radiation data from the geographical area of implementation of the project can be obtained from different sources. Horizontal radiation data from the city of Ambato are obtained using the RETScreen International software, figure 7. According to the annual information provided by the NASA RETScreen International software, in Ambato, the average daily solar radiation is equal to 4,48 kWh/m2 day. June is the least favorable in solar radiation with a monthly daily average of solar radiation equal to 4,23 kWh/m2 day.

The University of Massachusetts has solar irradiation values of annual and monthly averages for Ecuador. The data is corroborated up to 25 years of measurements in some places, table 2. According to information provided for Ambato, the annual daily average of solar radiation is equal to 4,55 kWh/m2 day. June is the least favorable month in solar radiation, with a monthly daily average of solar radiation equal to 3,97 kWh/m2 day.

With the minimum value of solar radiation, the production of photovoltaic solar energy in the worst cases can be calculated. The solar charging station presents an inclination angle β=10°, in relation to the horizontal position in the N-S direction. For an inclination of 10° it presents an irradiation factor that practically does not change the values presented of horizontal solar radiation presented in the previous figures and tables.

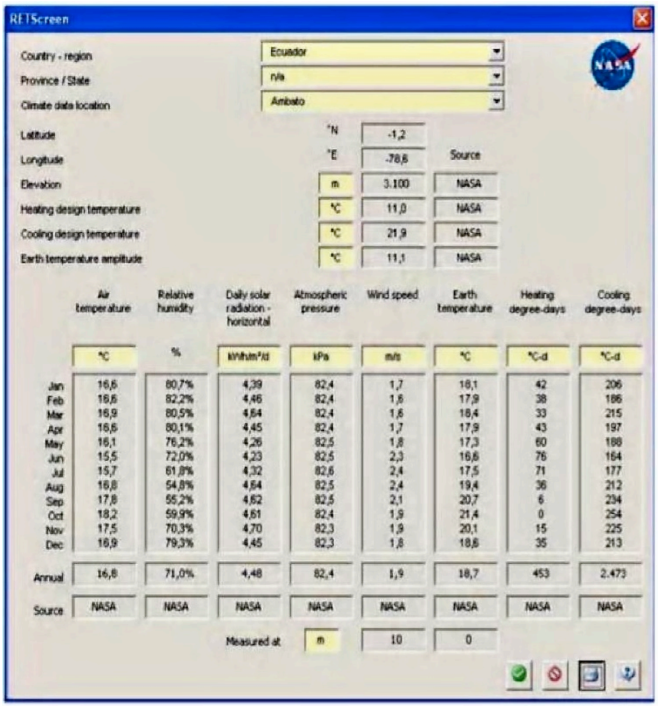


Figure 7. Facts horizontal solar radiation in Ambato, RETScreen International NASA.

5. Design and Dimensions of the Elements of Photovoltaic Energy Plant

5.1. Multi-criterial comparative analysis of the photovoltaic modules

The selection of photovoltaic modules is usually done based on the supplier's existing stock of solar material and the lowest price per panel Wp. In the design process of the charging station the procedure was to select the photovoltaic modules based on the criteria of efficiency, a smaller surface, a lower weight and voltage level. Thus, various types of photovoltaic modules, above 200W, from 10 different manufacturers were compared based on the previously mentioned criteria [4].

Table 2. Facts horizontal solar radiation in Ambato city, University of Massachusetts.

Values in kWh/m^2 day

Place	Latitude	Length	Elevation	Years readings	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec.	Prom.
Ambato	1.28 S	78.63 W	2540	18	4.64	4.56	4.56	4.42	4.39	3.97	4.28	4.5	4.5	4.97	5	4.81	4.55

Table 3. Multicriterion Comparative analysis of different photovoltaic modules.

	PV Modules manufacture	Country	Cell Type	Cell number	Maximum Efficiency	Maximum Power, W	Power/Surface, W/m²	Power/Weight W/kg	Power Tolerance
1	Trina Solar	China	Monocrystalline	72	16,80%	270	139,15	9,78	0-3%
			Polycrystalline	72	16,20%	310	159,76	11.23	0-3%
2	Yingli Solar	China	Monocrystalline	72	17,10%	280	143,56	10,77	0-5%
			Polycrystalline	72	15,90%	310	158,94	11.92	0-5%
3	Canadian Solar	Canada	Monocrystalline	72	16,50%	270	140,71	12,27	0-5%
			Polycrystalline	72	16,42%	310	161,55	14,09	0-5%
4	Jinko Solar	China	Monocrystalline	72	16,23%	315	159,76	11,69	0-5%
			Polycrystalline	72	16,23%	315	159,76	11,69	5-3%
5	Ja Solar	China	Monocrystalline	72	16,77%	325	159,92	11,92	0-3W
			Polycrystalline	72	16,51%	320	159,92	11,92	0-5W
			Monocrystalline	60	18,04%	295	180,41	16,2	0-5W
6	Sharp Solar	Japan	Monocrystalline						
			Polycrystalline	72	15,30%	300	153,12	13,21	0-5W
7	Renesola	China Malaysia Poland	Monocrystalline	60	16,90%	275	169,03	14,47	0-5W
			Polycrystalline	72	16,20%	315	159,76	11,48	0-5
8	First Solar	EEUU							
9	Hanwha solarone	South Korea	Monocrystalline	60	16,00%	265	160,41	12,92	0-5
			Polycrystalline	72	16,10%	3152	158,46	13,19	0-5
10	Sunpower	EEUU	Monocrystalline	96	21,50%	345	190,1	16,66	0-5%
			Monocrystalline	96	20,40%	327	180,2	15,79	0-5%
11	Kyosera	South Korea	Monocrystalline						
			Polycrystalline	80		330	102,55	8,18	0-5%

The photovoltaic modules SUN POWER 327W and 345W presented the best efficiency values, 20.4% and 21.5%, of power per square meter, 180.2 and 190.1 W/m^2, and for power per kg, 15,79 W/kg and 16,66 W/kg, respectively. Better efficiency means less surface area and less weight, significantly reducing the costs of the metallic support structure. Likewise, the voltage level of the selected modules is far superior to that of other modules. High levels of battery voltage are assumed.

5.2. Calculation of the number of photovoltaic modules

To calculate the number of photovoltaic modules the minimum value of monthly average irradiation in the city of Ambato will be used. Thus, the calculation was performed when the relationship between energy consumption and the available irradiation was maximum. Therefore, ensuring the power supply, even if it means an oversizing for the remaining months [5, 7].

To calculate the number of photovoltaic modules it is necessary to introduce the concept of "Peak Sun Hours" or PSH. The "Peak Sun Hours" can be defied as the number of hours available for a hypothetical constant irradiance of 1000 W/m2. In this sense, a peak solar time "HPS" equals 1kWh/m2. In other words, it is a way of accounting for the energy received from the sun grouping them in packages, each "package" of 1 hour receiving 1000W/m2 [5]. In the case of the city of Ambato, as indicated above the worst month is June. In June, the daily average solar irradiation value is 3.97 kWh/m2 or 3.97 PSH. Calculating the total number of photovoltaic modules is determined by the equation.

$$N_T = \frac{P_{Charger}}{P_{nominal} * HSP * PR} \quad (1)$$

$P_{Charger}$ is the energy consumption, defined in Table 1, which equals 7982.4 Wh/day. $P_{nominal}$ is the power peak of the module under standard conditions, 327 Wp. PSH are the peak sun hours of the worst month. In the case of the city of Ambato, the most unfavorable irradiation corresponds to the month of June, 3.97 PSH. PR in Anglo-Saxon terminology, Performance Ratio, defines the overall performance of the photovoltaic system and varies between 0.65 and 0.90. The most common value in isolated photovoltaic systems is equal to 0.8. Therefore, replacing the formula (1) is [10]:

$$N_T = \frac{P_{Charger}}{P_{nominal}*HSP*PR} = \frac{7982{,}4\ Wh}{327Wp*3{,}97h*0{,}8} = 7{,}69 \cong 8\ modules \quad (2)$$

In total, the isolated photovoltaic installation must have 16 327 Wp photovoltaic modules to supply energy consumption associated with loads of the charging station. The power loads for each subfield is greater than 2000W, therefore, a voltage was adopted on the DC side of the photovoltaic system equal to 48V, table 4. The voltage of the photovoltaic modules provides a voltage level above the nominal battery voltage. The defined voltage reduces the current required to power the battery storage system. A high voltage level reduces losses from the Joule effect on the board of the installation. Additionally, the risks of material damage and human losses, in case of errors from a short circuit of the system, are reduced.

Table 4. DC voltage depending on the power of the electric charges of the PV system.

Power Demand per watts W	Working voltage, V
Less of 1.5000	12
1.500-5.000	24 ó 48
More of de 5.000	120 ó 300

5.3. Dimensioning of the battery capacity

The accumulation system dimensioning was done in function to the autonomy of the system. The dimensioning of the accumulation system in lead-acid batteries requires the following considerations [11, 12]:

- The maximum depth of discharge, which is the highest level of discharge allowed to the battery before disconnection of the regulator, to protect its overall duration.

- The maximum depth of discharge usually considered for a daily cycle (maximum daily depth of discharge) is around 50-60%.

- In the case of the seasonal cycle, which represents the maximum number of days that a battery can be discharged without the modules receiving sufficient solar radiation, are around 3-10 days and a depth of sporadic discharge of about 90%.

- In photovoltaic systems aggressive discharges aren't sought, but rather progressive ones. The batteries to be used typically have discharges of 100 hours, C 100, then the more intense the discharge of a battery is, the less energy is able to be supplied.

The nominal capacity of the batteries is calculated depending on the depth of daily and seasonal discharge and the number of days of autonomy with help of the following formulas [7, 10]:

$$C_{Nom.sea} = \frac{P_{Charger}}{D_{max,d}*F_{CT}} \quad (3)$$

$$C_{Nom.sea} = \frac{P_{Charger}*N_a}{D_{max,sea}*F_{CT}} \quad (4)$$

$D_{max,sea}$ is the maximum depth of seasonal discharge, it is often having a value of 0,90. $D_{max,sea}$ is the depth of maximum daily discharge, it depends on the type of battery, in the case of stationary lead-acid batteries it is 0,5-0,6. N_a is the number of days of autonomy, a minimum autonomy will be considered at three days N_T is the temperature correction factor equal to 1. The highest value obtained will be selected, otherwise a seasonal or daily accumulation system failure could incur. There is the possibility of installing a small wind turbine of 0.5-1 kW which will increase the life of the accumulation system. Replacing the values in formula (3), the following is obtained:

$$C_{Nom.Sea} = \frac{P_{Charger}}{D_{max,d}*F_{CT}} = \frac{7982{,}4\ Wh}{0{,}3*1} = 26608Wh \quad (5)$$

$$Q_{Nom.Daily} = \frac{C_{Nominal.daily}}{Vcc} = \frac{26608Wh}{48V} = 554{,}33\ Ah \quad (6)$$

$$Q_{Nom.Sea} = \frac{P_{Charger}*N_a}{D_{max,sea}*F_{CT}} = \frac{7982{,}26608Wh*3\ days}{48\ V} = 26608\ Wh \quad (7)$$

For each photovoltaic field it is possible to choose a battery of 600 Ah, as observed in the equation number (8). The stationary lead-acid batteries Surrette ROLLS of the 4000 6V 5-605 series present capacity values of 600 Ah. In this project, the serial connection of 8 batteries of 600Ah in capacity and 6 volts will give as a result an accumulation system with a total of 600 Ah of capacity and a nominal voltage of the direct current system equal to 48V [13].

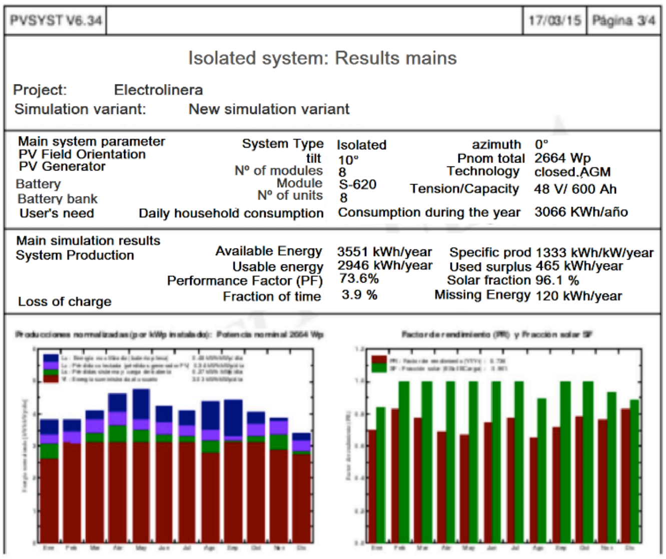


Figure 8: Energy production of a subfield of using the software Electric Vehicle Chargers PVSYST [8].

5.4. Energy Production of the photovoltaic solar charging station

The calculation of the energy production has been done with the help of the computer program PVSYST [8]. The energy production of a photovoltaic subfield of 8 modules of 327 Wp has been calculated, due to the fact that the energy plant consists of 2 identical photovoltaic subfields. Figure 8 presents the obtained results of a subfield of the charging station. It is observed that the annual energy available at the location of the charging station is equal to 3551 kWh/year. Meaning, each subfield could produce 9729 Wh as a daily average, almost 1700 Wh/day more than the load demands, allowing to have a greater availability of energy to increase the electric charge.

6. Economic Cost of the Isolated Solar Charging Station

In this section, the final budget is presented of the purchase of the photovoltaic equipment, transportation, installation and commissioning of the isolated solar charging station, tax included, built in the Technical University of Ambato, table 5. The total cost of the photovoltaic solar charging station was equal to 38,724 dollars. When dividing the cost of the solar energy plant between the installed power of the inverters, 6000 W, it is possible to determine the value of investment per kW installed. The cost per kW installed in the charging station of the TUA is 6454 $/kW, a value much less than the average cost of the isolated photovoltaic solar facilities. Likewise, depending on the investment, the cost of operation and maintenance, as well as electric power expected to generate in the 25-year life span of the solar installation it is possible to estimate the cost per kWh generated. The cost of solar power generated by the charging station equals 25 c$/kWh.

Table 5. Budget Solar Electric Vehicle Chargers Isolated.

Items	Description	Cost Unitary, $ USD	Cost Total, $ USD
1	16 photovoltaics modules SUNPOWER E20-327W	372,00	5232;00
2	1 Inverter/Regulator/Load LEX POWER TWO FRX/3048	6900,00	6900,00
3	16 Battery ROLLS SURRETTE S-620 6v	375,00	6000,00
4	1 String Box FlexWire PV 12	120,00	120,00
5	DC fusil protection 10A	3,50	28,00
6	DC Disconnector 32A	25,00	50,00
7	16 Connection Bars + Bolts	20,00	320,00
8	2 Cables Flex Power- Battery 10 pies	110,00	220,00
9	32 Insulating Polos Battery	9,50	304,00
10	2 AC switch25A	30,00	60,00
11	1 EV Charge Station Circuitor Mod. RVE-2 COM	4650,00	4650,00
12	Transport Miami-Guayaquil	2340,00	2340,00
13	Metal structure	2871,00	2871,00
14	Installation and commissioning. Grounding, wiring and small electrical equipment	5480,11	5480,11
15	IVA		4149,0132
TOTAL			38724,12

7. Conclusions

In this article the process of design, dimensioning, installation and commissioning of the first solar photovoltaic charging station of Ecuador, built in the Huachi campus of the Technical University of Ambato, is described. The photovoltaic facility has an installed nominal capacity of 6000 W and an annual power generation potential equal to 3551 kWh/year. The installation cost of the solar charging station was 38,724 dollars, including transportation, installation and commissioning of the metal structure, of the photovoltaic system and of the charging station for electric vehicles. The charging station has the capacity to feed two small electric vehicles, with an energy consumption of 6.1 kWh for a range of 100 kilometers, and some electric bikes. The cost per kW installed in the charging station was 6454.0 dollars and the estimated price of the generated energy is equivalent to 25 c$/Wh. The design and dimensioning of the first isolated photovoltaic solar charging station from Ecuador will serve as a prototype for similar facilities to be installed in rural areas of the Amazon rainforest and the Galapagos Islands.

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