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Solar Charging Station for Electric Vehicles in Shopping Malls

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Abstract

Design, dimension and model the photovoltaic system connected to the grid to provide the energy required to charge electric vehicles. Evaluate the technical and economic feasibility of the solar charging station for electric vehicles in shopping malls.

In this article, we present the design, sizing and modelling of a grid-connected solar charging station for recharging electric vehicles in shopping malls. The applied method consists of an analysis of the solar resource available at the location of the shopping mall, as well as the analysis, evaluation and selection of the components of the grid-connected photovoltaic system with the support of simulation software such as PVsyst and Helioscope, as well as analysis, evaluation and selection of the components of the charging points of electric vehicles and finally the economic analysis of the solar charging station in the shopping mall.

The specific output photovoltaic energy where the shopping center is located is 1,435 kWh/ kWp, the optimal inclination of the photovoltaic modules is 12°, the month with the lowest irradiation is the month of July and peak solar hours (HSP) equals 4.24. The plant factor is 17.32%, the energy produced is 135,675 kWh and the specific production 1,443 kWh/kWp. Eight 11 kW Wallbox chargers are considered for charging electric vehicles. The energy consumed since 9:00 a.m. until 06:00 p.m. equates to 576 kWh, while the energy consumed since 06:00 p.m. until 09:00 p.m. equals 192 kWh. The photovoltaic system connected to the grid provides 50% of the energy consumed during 09:00 a.m. until 06:00 p.m. which is equivalent to 288 kWh. The energy consumed in the course of the day is estimated to be 768 kWh. 03 photovoltaic generators with individual power of 31,350 Wp will be required. Considering 330 Wp polycrystalline photovoltaic modules, each one will be made up of 95 photovoltaic modules, distributed in 5 chains of 19 photovoltaic modules. 03 three-phase inverters for grid interconnection of 27 kW-380/220 VAC are required, with their respective Smart Meter 50 kA-3. The conventional three-phase substation for grid connection must have a 250 kVA-10-22.9/0.38-0.22 kV encapsulated dry transformer. For the analysis, the inverters are considered as a load, and a power factor of 0.85. The annual energy produced amounts to 142,708 kWh.

Keywords: Helioscope; Photovoltaic energy; Solar charger; Greenhouse

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Introduction

In this article, we present the design, sizing and modeling of a grid-connected solar charging station for recharging electric vehicles in shopping malls. The applied method consists of an analysis of the solar resource available at the location of the shopping mall, as well as the analysis, evaluation and selection of the components of the grid-connected photovoltaic system with the support of simulation software such as PV syst and Helioscope, as well as analysis, evaluation and selection of the components of the charging points of electric vehicles and finally the economic analysis of the solar charging station in the shopping mall. Below we provide an certain methodology and survey which is conducted by our team. This study provides brief on solar charging station for electric vehicles to mitigate greenhouse gas emissions which is harmful for our sustainilibilty day by day [1-7].

Literature Review

The proposed methodology follows the following steps

• Description of the study area

• Estimation of the available solar resource

• Calculation of the energy consumed by charging electric vehicles

• Calculation of the power of the photovoltaic generator and selection of protection devices

• Requirements for network connection

• Economic evaluation

• Simulation with PVSyst and Helioscope software

• For the study analysis, the "Molina Plaza" Shopping Center was selected, located in the La Molina district, Lima province, Lima region, Peru.

• The Molina Plaza shopping centre was selected for two reasons. The first is that it is located in an area of considerable solar radiation during the year. According to the Global Solar Atlas, the specific photovoltaic energy output is 1,435 kWh/kWp (Global Solar Atlas, 2020). And the second reason is because the residents of the district have enough purchasing power to buy electric vehicles.

• With the geographical coordinates and using the NASA Power Data Access Viewer application, the monthly global horizontal mean irradiation is obtained from the NASA (1983-2005) and NASA (1984-2013) databases **(Table 1)**.

The optimal inclination of the photovoltaic modules is approximately 12°, using NASA's Power Data Access Viewer application the monthly mean global irradiation on a surface inclined at its optimum angle, oriented towards the North **(Table 2)**.

The month with the least irradiation according to the previous table is the month of July (González Pinzón, Ponce Corral, Valenzuela Nájera, and Atayde Campos, 2013). If the irradiance is considered equal to 1,000 W/m2, then the peak solar hours (HSP) equals 4.24 h.

To perform the simulation in the PVsyst software, the Typical Meteorological Year (TMY) was selected, which the software obtains from the data of the PVGIS platform. The PVGIS platform works with the 2005-2015 databases, provided by the National Renewable Energy Laboratory (NREL). The main parameters of the simulation system with the PVsyst software are the following **(Table 3).**

Table 1: Monthly meteorological values from NASA (kWh/m^2 day).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Monthly Mean global irradiation at an angle of 12°	6.6	6.33	6.79	6.62	5.87	4.53	4.24	4.37	4.90	5.84	6.41	6.72	5.77

Table 2: Monthly average global irradiation on a 12° inclined surface (kWh/m^2 day).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Monthly mean global irradiation at an angle of 12°	6.6	6.33	6.79	6.62	5.87	4.53	4.24	4.37	4.90	5.84	6.41	6.72	5.77

Table 3: Main parameters for the PVsyst simulation.

Main parameters for PVsyst simulation	
Orientation PV fields and inclination	Azimuth 0° and 12° inclination
PV modules	Model AS6P33-330 Pnom.330 Wp
PV set	285 modules Pnom total 94.05 kWp
Investor	Model Fronius Eco 27.0-3-S
Number of investors	3 unid. Pnom. Total 81 kW AC

• With reference to the materials, among the main ones we have:

• 03 photovoltaic generators whose power each amounts to 31,350 Wp. Considering 330 Wp polycrystalline photovoltaic modules, from the manufacturer Amerisolar (Amerisolar, s.f.). Each one will be made up of 95 photovoltaic modules, distributed in 5 chains of 19 polycrystalline photovoltaic modules of 330 Wp.

• 03 three-phase inverters for grid interconnection of 27 kW-380/220 VAC, from the Fronius brand (Fronius International, 2014), with their respective Smart Meter 50 kA-3.

• In each string box and for each string there must be two 16 A (gR) fuses with a rated voltage of 1,000 VDC 10 x 38 mm cylindrical. One will be connected to the positive pole and the other to the negative pole of each chain.

• The conventional three-phase substation for connection to the grid must have a 250 kVA encapsulated dry transformer 10-22.9/0.38-0.22 kV.

• For the analysis, the inverters are considered as a load, and a power factor of 0.85.

Discussion

In Peru there are more than 1,200,000 old vehicles, the average age of the cars is almost 14 years, in the city of Lima the particulate matter in the air is four times that recommended by the World Health Organization, a situation that requires special attention in the short and medium term, since air quality is one of the significant factors for an adequate quality of life in our cities.

In this context, there are two alternatives to mitigate greenhouse gas emissions, the first is the electrification of transport and the second is the generation of electricity through renewable energies (photovoltaic systems), alternatives that contribute to decarbonisation, diversification and decentralization of the energy matrix.

It is important to consider that the shopping center that is taken as a reference is located in an area of considerable solar radiation during the year and the residents of the district have sufficient purchasing power to purchase electric vehicles.

This article develops a methodology for the design of a solar charging station for electric vehicles in shopping malls, which consists of the design, dimensioning, evaluation of the solar resource available in the place where the shopping center is located, the selection of the components of the photovoltaic system connected to the grid and the modeling of the photovoltaic system with the support of simulation software such as PVSyst and Helioscope; The analysis, evaluation and selection of the components of the infrastructure and the charging points of electric vehicles is also carried out, and ends with the analysis and technical-economic evaluation of the proposal.

The specific output photovoltaic energy where the shopping center is located is 1,435 kWh/kWp, the optimal inclination of the photovoltaic modules is 12°, and the month with the lowest irradiation is the month of July and peak solar hours (HSP equals 4.24. The plant factor is 17.32%, the energy produced is 135,675 kWh and the specific production 1,443 kWh/kWp. Eight 11 kW Wallbox chargers are considered for charging electric vehicles.

According to the simulations and calculations carried out, the proposed solar charging station covers the energy required to charge electric vehicles.

The interconnection inverters will be configured so that they do not inject energy into the public grid and are only used for self-consumption.

The interconnect inverter will stop working if there is a disconnection from the grid. It is because the inverter needs to synchronize with the frequency of the public power grid.

With this project, 1,111.35 tCO_2 would stop being emitted, contributing to the environment and demonstrating that the use of renewable energies and electromobility contribute to the reduction of greenhouse gases.

The results obtained indicate that the project is technically and economically (NPV and IRR) viable.

Finally, current technology would allow the development and execution of this project, with the added value of presenting high replicability.

Conclusion

The project is economically viable, since the NPV and the IRR obtained are viable. The project is technically feasible, since current technology would allow this project to be carried out and it is highly replicable. With this project, 1,111.35 tCO_2 would stop being emitted, contributing to the environment and demonstrating that the use of renewable energies and electromobility contribute to the decarbonisation, diversification and decentralization of the energy matrix.

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