Evaluation of 300 WP Solar Photovoltaic Panel Performance for Electric Vehicle Charging Station

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Abstract—Conventional transportation methods result in the release of harmful greenhouse gases into the environment. Electric vehicles offer an alternative to mitigate this environmental harm. Electric Vehicle Charging Stations (EVCS) are crucial infrastructure components for supporting electric vehicles. Photovoltaics represents a facet that can be integrated into EVCS to improve eco-friendly power generation. Various factors, including temperature, humidity, and light intensity, influence electricity generation in photovoltaic (PV) systems. This research examines the consequences of temperature, humidity, and light intensity fluctuations within EVCS. During the system integration testing conducted between 09:00 and 16:00, it was noted that there is an inverse relationship between air humidity and temperature; when air humidity increases, temperature decreases, and vice versa. The solar panel exhibits its highest sunlight intensity reception between 09:30 and 15:30. The peak power output from the solar panel was registered at 13:00, with an air temperature of 40.40°C, air humidity at 35%, and light intensity at 54.61 Cd, resulting in a solar panel power output of 146.1 Watts. Conversely, the lowest power output from the solar panel was observed at 16:00, with an air temperature of 31.80°C, air humidity at 54%, and light intensity at 39.39 Cd, leading to a solar panel power output of 107.36 Watts. Anticipated findings from these analyses are expected to contribute to future technological advancements, enabling the creation of competitive products in the market.

***Keywords—* Electric Vehicle Charging Station (EVCS), Photovoltaic, Performance, Electric Vehicle (EV)**

I. INTRODUCTION

In the contemporary era of human civilization, the availability of electricity is considered a basic entitlement for all individuals. Numerous sources, including fossil fuels, biogas, geothermal energy, nuclear power, oil, wind, and solar energy, have the capacity to produce electrical power [1], [2]. Renewable energy holds significant promise, with solar power being a prime example. It involves capturing sunlight and transforming it into electrical energy through the utilization of solar panels [3], [4]. Nonetheless, harnessing this energy resource is not without its drawbacks, which are linked to weather patterns and environmental elements. These factors can affect the sunlight absorption capacity of solar panels. Hence, it is crucial to evaluate the level of light intensity in the vicinity where solar panels are to be positioned when calculating the power generation system's capacity [5].

The power produced by solar panels relies not solely on the level of incoming radiation but also on the rising temperature of the solar panel's surface, which has the potential to diminish the voltage level. Changes in temperature affecting solar panels are attributed to both the surrounding environmental temperature and the silicon material itself. When the surface temperature of the solar panel rises, it leads to a reduction in power output, while greater radiation levels result in higher power generation by the solar panel [6], [7]. The main issue with solar energy is the instability of power output from solar panels as it heavily relies on the received sunlight intensity. The amount of sunlight received by solar panels can be optimized by installing them at the correct tilt angle, ensuring maximum power output (Hariningrum & Artikel, n.d., 2021). Air humidity is a term that refers to the moisture content present in the atmosphere. High humidity levels lead to the condensation of pollutant particles, preventing them from rising into the atmosphere. As a result, the atmosphere maintains high clarity, allowing sunlight to reach solar cells unobstructed. This phenomenon is one of the effects that reduce the absorption of solar energy by solar panels [9], [10].

The current trend is a growing interest in electric vehicles, which will lead to a significant surge in demand in the Indonesian automotive market. Undoubtedly, the demand for electric vehicle charging infrastructure will also continue to grow. There will be a substantial need for Electric Vehicle Charging Stations, sparking competition among governmental, private, and corporate stakeholders [11], [12]. As Electric Vehicle Charging Stations evolve in the future, it will inevitably be influenced by a range of competitive factors, including product quality, pricing, service, and other related aspects [13].

Considering these challenges, this research aims to concentrate on the examination of environmental temperature and humidity, which represent significant obstacles in the solar energy-based electricity production process. It is anticipated that the findings from these analyses will play a role in advancing this technology in the future, leading to the creation of a product that can compete effectively in the market.

II. METHODS

A solar cell is a device that transforms sunlight into electric power by utilizing the photovoltaic phenomenon, which is why it is commonly known as a photovoltaic cell. These solar cells are semiconductor instruments with the capacity to directly convert sunlight into direct current (DC) electricity, employing thin silicon (Si) crystals. The solar panels employed in this study have specific characteristics: two 150wp Mono Crystalline Solar Panels, capable of producing a maximum voltage of 18.3 V and a peak current of 16.26 A [14], [15].

ISSN 0216-8685 (print); 2528-6889 (online)

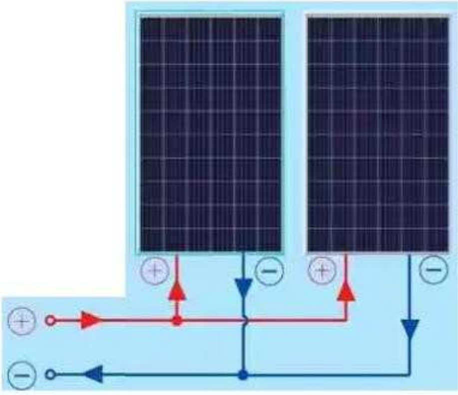

Fig.1. 300 WP Photovoltaic connected into parallel

DHT11 sensors are instruments utilized to gauge heat levels by transforming them into measurable electrical parameters, allowing for the assessment of the heat's extent. The DHT11, on the other hand, is a sensor that measures both temperature and humidity. It generates a digitally calibrated signal based on a sophisticated temperature and humidity sensor. The DHT11 is renowned for its exceptional precision and straightforward design, especially in comparison to alternative temperature sensors is depicted in Fig 2 [16].

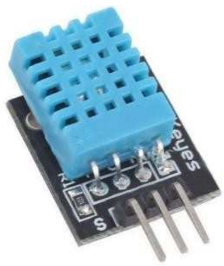

Fig.2. DHT 11 Sensor

The BH1750 sensor is a module created for measuring fluctuations in light intensity is depicted in Fig 3. Its purpose closely resembles that of a lux meter, which quantifies light intensity in lux units. In its calculations, 1 lux (lx) corresponds to 1 lumen per square meter (lm/m2) or 1 candela per steradian per square meter (cd·sr/m2). To put it simply, if you concentrate 1000 lumens of light into a 1 square meter area, it will result in an illumination level of 1000 lux. This sensor operates within a voltage range of 3-5V and utilizes I2C communication. The BH1750 sensor is capable of measuring light intensity with a resolution spanning from 1 to 65535 lux and has physical dimensions of 13.9 mm × 18.5 mm on its board [17].

Fig.3. BH1750 Sensor

The block diagram illustrates an electricity generation system that makes use of solar cells as its energy source is depicted in Fig 4. It is equipped with monitoring capabilities and has the primary objective of charging electric vehicle batteries. This system is commonly known as an Electric Vehicle Charging Station (EVCS). The main emphasis of this system lies in analyzing the consequences of various environmental factors. These factors encompass temperature, signifying how solar energy affects the solar cell surfaces and the heat conditions they experience. It also encompasses humidity conditions, which relate to the moisture levels in the surrounding air due to water vapor presence. Furthermore, the system considers the influence of the solar panels' tilt angles, impacting the absorption of solar energy on their surfaces. The block diagram description reveals that environmental factors exert the most substantial influence on electricity generation, before subsequent processing by other devices.

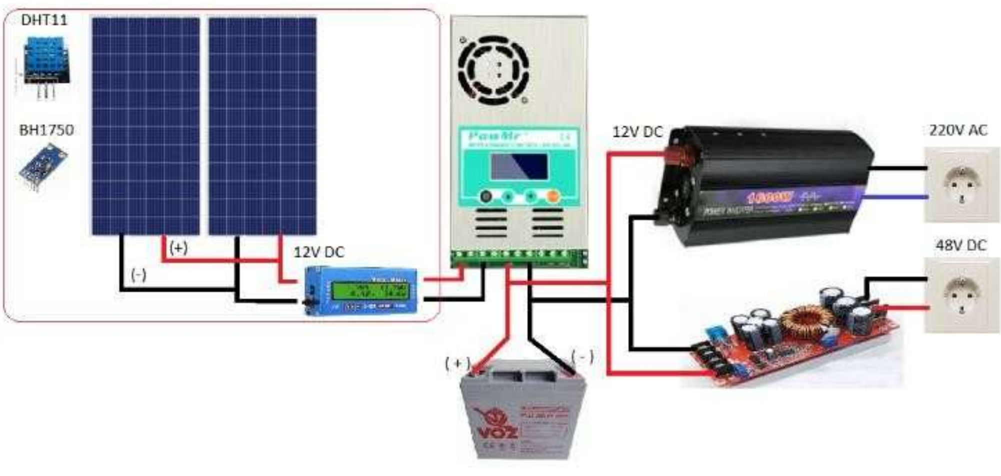

Fig.4. Block Diagram System

ISSN 0216-8685 (print); 2528-6889 (online)

Within this electricity generation and monitoring system, there are humidity sensors and light intensity sensors affixed atop the solar panels. These sensors are responsible for detecting atmospheric moisture levels in RH% (Relative Humidity) and the brightness of sunlight, quantified as Lux. These sensor units are employed to collect comparative data in relation to energy measurements generated by the solar panels, encompassing Voltage (Volt), Current (Ampere), and Power (Watt).

The power generation system at the EVCS is augmented by an MPPT (Maximum Power Point Tracking) or solar charger component. Its primary function is to charge the battery by harnessing solar panel-derived energy for storage, particularly during nighttime when sunlight is unavailable. The energy stored in the battery is then utilized to provide power to connected loads. In the SPKL system, two distinct load voltage systems are present: a 220V AC system achieved through the conversion of voltage from 12V DC batteries using a power inverter unit, which transforms 12V DC into 220V AC, and a 48V DC load voltage system attained by converting 12V DC into 48V DC via a DC-to-DC power inverter. To facilitate the connection of loads at any preferred time, power socket outlets are provided. Each load can be powered with a capacity of up to 1000W for AC and 500W for DC loads.

III. RESULTS AND DISCUSSION

The process of introducing a solar panel system to the EVCS unit starts with a sequence of steps as follows: initially, creating the foundational unit frame or EVCS frame, which is subsequently followed by building the support structure for the solar panel, considering the panel's surface area, and finally, proceeding to the fabrication of the EVCS frame. This system derives its power from solar energy, which is transformed into electricity by solar panels and subsequently stored in a battery using either a solar panel charger or MPPT (Maximum Power Point Tracking). The voltage, current, and power levels transferring from the solar panel to the solar panel charger system can be observed and tracked using a power meter. The battery's stored energy will be channeled to the DC-AC inverter for the purpose of powering electric vehicles that operate on an AC voltage input source. Furthermore, the energy stored in the battery can also be utilized to charge electric vehicles that rely on a DC voltage input source.

Fig.5. Implementation System

Table 1. Integration data results

No	Time	Temperature (^{0}C)	Humidity (RH%)	Light Intensity (Cd)	PV Voltage (V_{DC})	PV Current (A_{DC})	PV Power (Watt)
1	09.00	33.2	42	40.345	12.8	8.7	111.33
2	09.30	34.2	39	50.369	13.96	9.86	137.66
3	10.00	35.5	37	50.287	14	9.82	137.5
4	10.30	36.4	40	50.463	14.05	9.81	137.85
5	11.00	37.2	41	50.687	14.11	9.8	138.3
6	11.30	38.5	36	51.004	14.16	9.81	138.93
7	12.00	39.1	35	50.648	14.47	9.55	138.27
8	12.30	40.5	36	52.158	14.77	9.56	141.28
9	13.00	40.4	35	54.612	14.67	9.96	146.1
10	13.30	37.8	42	54.466	14.41	10.12	145.79
11	14.00	36.4	40	53.362	14.04	10.23	143.56
12	14.30	35.6	39	50.826	14.01	9.89	138.57
13	15.00	34.8	45	50.657	13.99	9.88	138.23
14	15.30	33.8	48	50.558	13.97	9.88	138.03
15	16.00	31.8	54	39.396	12.45	8.62	107.36
	Average	36.35	41	49.99	13.99	9.7	135.92

ISSN 0216-8685 (print); 2528-6889 (online)

The testing procedure for the components concludes with the gathering of data from each individual part. This data collection phase includes the temperature and humidity sensors, specifically the DHT11 sensor, the light intensity sensor employing the BHT1750 sensor, as well as voltage, current, and power measurements taken using a digital watt meter. Additionally, the manual determination of the solar panel tilt angle is part of this process. The data collection occurred on Saturday, July 23, 2023, commencing at 09:00 AM local time and concluding at 04:00 PM local time. It involved the acquisition of data related to temperature, humidity, light intensity, solar panel tilt angle, voltage, current, and panel power.

During this phase, the researcher opted to test a 0-degree angle, conducting data collection at 30-minute intervals from 09:00 AM to 04:00 PM local time. Following this, the researcher evaluated how this angle affected energy-related parameters like voltage, current, and power. Additionally, the researcher assessed the impact of environmental factors, such as temperature, humidity, and light intensity. The data collected is presented in Table 1 below. It's worth noting that the weather conditions during the research remained partly cloudy until late afternoon.

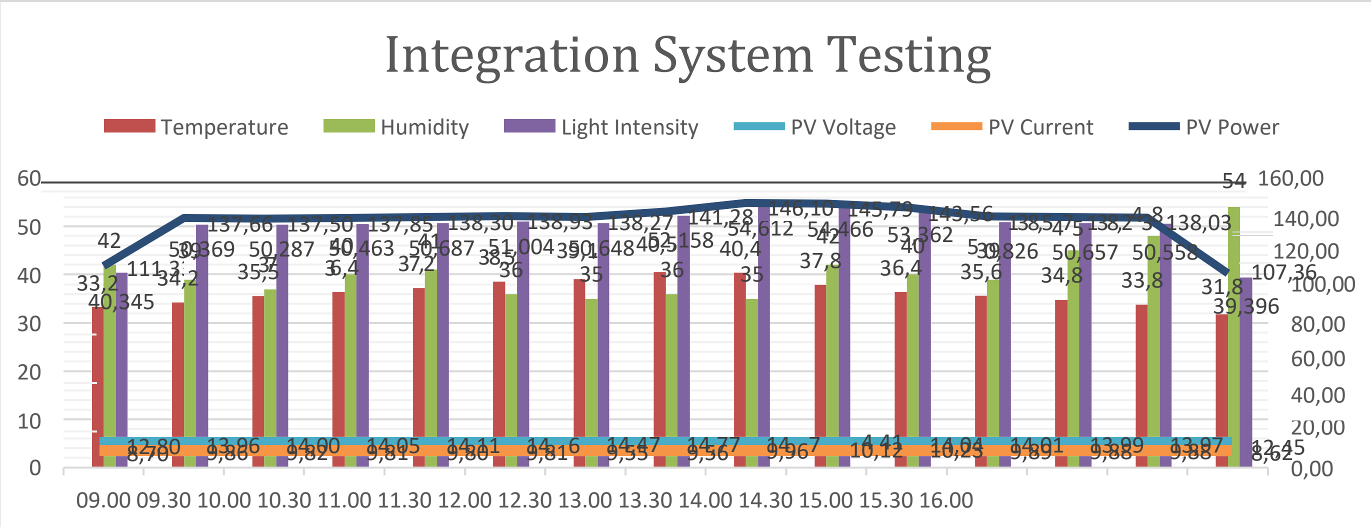

Fig.6. Integration system graphic results

Referring to Figure 6, which illustrates the environmental factors affecting the EVCS (Electric Vehicle Charging Station) and their impact on voltage, current, and solar panel power generation, the chart highlights that the peak power output from the 300 WP photovoltaic system is observed at 13:00, reaching 146.1 Watts. During this period, the light intensity is at its highest, measuring 54.61 Cd, while the temperature is relatively high at 40.4°C, and the humidity is at its lowest, recorded at 35%.

IV. Conclusion

The examination of the environmental data provided by Electric Vehicle Charging Station (EVCS) leads to several noteworthy conclusions:

1. Peak power output from the 300 WP photovoltaic system is observed at 13:00, reaching 146.1 Watt. The peak light intensity is 54.61 Cd, the temperature is high at 40.4°C, and the humidity is at 35%.
2. Lowest power output from 300 WP photovoltaic system is observed at 16:00, reaching 107.37 Watt. The peak light intensity is 39.396 Cd, the temperature is low at 31.8^{0}C, and the humidity is at 54%.

Acknowledgment

The authors thank Electric Vehicle Charging Station (EVCS) members for supporting this research.

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ISSN 0216-8685 (print); 2528-6889 (online)