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Charging Quality of 100 Amper-hours Battery Using a Silicon Photovoltaic at Different Altitude in Semarang Region

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***Abstract*— Currently automotive battery technology evolve rapidly. The reasons stated are environmentally friendly because they do not produce carbon dioxide such as ICE. One form of battery power supply is from a solar power source. This paper discusses the charging of batteries with a capacity of 100 AH which are sourced by solar cell power (PV). The type of solar cell uses a 100-watt solar cell type silicon mounted on a portable basis and parallel connected. The position of solar cells are installed in three different areas in different around Semarang city. The altitude of each region is 0 - 7.5 m, 350 - 450 m and 600 - 800 m above sea level. Battery charging duration of three altitudes has different time range. These condition are caused by the quality of light intensity that reaches the solar cell. At higher altitude has a relatively fast charging rate compared to lower positions due to a higher intensity. This information is used to determine the required solar cell panels on the vehicle to charge the vehicle battery and battery charging time.**

Keywords—automotive, battery, solar panel, amper-hour

I. INTRODUCTION

The transportation industries are influenced by the human population. The Indonesia populations in 2015 and 2017 were 254.5 million and 261.9 million respectively. The population increased by 2.8% for two years. The sold manufacturing of cars in 2015, 2017 were 238601 units and 280504 units. The car productions are increased by 17.6 % over two year [1]. The increasing of the cars will produce CO_2 due to the cars still used the ICE (internal combustion engine) system. The EEA (European Environment Agency) reported the production of CO_2 around 1,205Mt CO2 equivalent [2]. This condition would affect the air environment especially the greenhouse effect [3]. Several attempts were made to reduce the production of CO2 in the air. Some activities are carried out by diversifying renewable energy so that the use of fossil fuels decrease. Several renewable energy include solar-thermal plant, onshore wind worldwide, hydropower, nuclear and geothermal, and solar photovoltaic [4]. In the field of transportation, the use of electric cars has been developed to reduce exhaust emissions. Some countries have produced electric cars with mature technology such as the United States, Japan, Germany, South Korea, United Kingdom, China, Norway, Sweden [5]. The companies from their countries have been successfully to build an lectric car and have sold in the market. The companies include GM, Ford, Chrysler, Tesla (USA), Toyota, Honda, Mitsubishi, Nissan (Japan), BMW, Daimler Benz (Germany), BYD (China), Think (Norway), Hyundai (South Korea) [6]. The power of the battery cars can be obtained by charging of the electric power that can be done by fuel cell [7], ICE [2], nuclear power plant [4], hydroelectric power plants, wind power water [8] and photovoltaic power plants [9-10]. Indonesia has the potential to develop a solar power plant due to located in the equatorial region. Sunlight shines throughout the year which can be used as an alternative power source through photovoltaic technology. This technology is ready and has been used in various fields. One of its uses is for battery charging.

This paper discusses the photovoltaic technology used for battery charging. The type of battery is type 100 AH, and the photovoltaic is a monocrystalline type. Photovoltaic equipment is installed in three different areas with altitudes from 0-7.5 m, 350-450 m and 600 - 800 m. The chosen place is around the city of Semarang.

II. METHOD AND EQUIPMENT

The specification of the photovoltaic (PV) shown in TABLE I. The auxiliary equipment includes solar charge controller (SCR), Battery Valve Regulated Acid (VRLA), Digital multimeter, Thermohygrometer, DC clamp meter, Irradiance meter. SCR is used to control the current entering the battery and the power supply breaker from PV when it was full. Thermo hygrometer was used to measure the air humidity and temperature surrounding PV. Irradiance meter

was used to measure the sun radiance that hit the PV. Fig. 1. shows the diagram of circuit PV. The circuit consist of the PV panel, SCR, Battery 100 AH, 12 V and load.

TABLE I. PV SPECIFICATION

No	Type	Note
1	Photovoltaic	Monocrystalline silicon
2	Maximum Power	100 W
3	Voltage at Pmax	18.1 V
4	Current at Pmax	5.5 A
5	Open-circuit voltage	22.2 V
6	Short circuit current (Isc)	6.00 A
7	Dimension surface	1020x670 mm2
8	Operating temperature	45-80 C

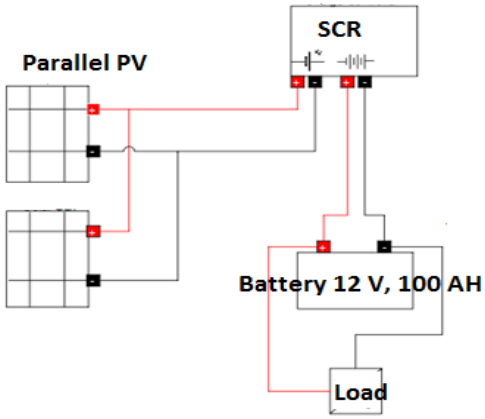

Fig. 1. The circuit PV which connected by the battery.

III. RESULT AND DISCUSSION

The result of intensity measurement of sunshine and current from PV are presented in the table as follow. TABLE II shows the intensity from time 08.00 until 16.00. The PV was intalled by a single panel at Marina beach. The altitude of the Marina Beach is around 7.5 m above sea level.

TABLE II. Intensity and current of single PV at Marina Beach

Time	Irradiance (W/m^2)	T PV. C	T Amb	Humidity	PV to SCR			SCR to Battery			SOC
					V V	I A	(watt/h)	V V	I A	(watt/h)	
08.00	441.7	37.0	29.6	70%	12.0	2.4	28.6	12.0	2.3	27.2	28%
09.00	729.0	40.8	32.7	69%	12.3	3.1	37.7	12.2	3.0	36.3	38%
10.00	880.5	44.3	33.4	66%	12.4	4.3	53.1	12.3	4.2	51.4	46%
11.00	876.0	45.3	33.5	63%	12.6	4.7	59.0	12.5	4.6	57.3	57%
12.00	788.3	43.2	33.8	61%	12.6	4.5	56.8	12.5	4.4	55.2	67%
13.00	632.5	40.6	34.5	59%	12.7	3.8	48.2	12.6	3.7	46.6	73%
14.00	503.0	36.8	34.2	59%	12.7	2.9	36.4	12.6	2.8	35.0	75%
15.00	296.5	34.5	34.2	59%	12.6	2.4	30.0	12.5	2.2	27.6	75%
16.00	263	33.2	32.8	61%	12.64	1.4	17.7	12.51	1.3	16.3	75%

The Fig. 2. shows the graph of relation SOC and time charging at the three different locations for single panel PV. The Marina beach, Tembalang, and Bandungan area have altitude around 7.5 m, 450 m and 700 m above sea level respectively. Single panel PV was capable of charging 100 % capacity for the battery of 65 AH, 12 V. It needs about 5 hours charging while the battery of 100 AH, 12 V can be charged around 75 % of full capacity for 8 hours. The single panel of 100 Wp monocrystalline PV can't charge the full capacity the battery of 100 AH, 12 V.

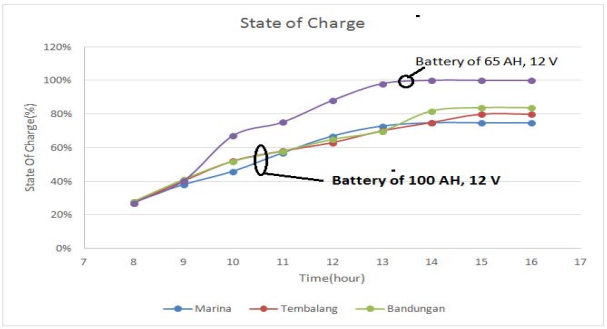

Fig. 2. SOC of the battery 12 V, 65 AH and 100 AH charging using single panel PV.

For capacity charging the battery of 100 AH at different position altitude for Marina beach, Tembalang and Bandungan are 75 %, 80 %, 85 % of full capacity respectively. The highest charging capacity is at Bandungan region. It appropriate that a higher intensity of sunshine will produce a higher current of PV [10-11].

TABLE III. shows the PV parallel and SOC of the battery of 100 AH, 12 V at Bandungan. The two panels of 100 Wp were installed parallel and connected to 100 AH, 12 V battery. The highest intensity of sunshine at 11.00 am. The panel can produce electric current of 12.0 A . The 100 % SOC battery can be achieved at time of 13.00 or 5 hours panel exposure to sunshine

Table III PV Parallel and SOFC Battery 100 AH, 12 V at Bandungan

Time	Irradiance (W/m^2)	T PV	T Amb	Humidity	PV to Controller			Controller to Battery			SOC
					V	I, A	(watt/h)	V	I,A	(watt/h)	
8.00	524.3	36.6	24.8	70%	12.3	7.1	87.1	12.3	7.0	86.0	28%
9.00	754.3	43.2	27.1	72%	12.8	9.3	118.8	12.7	9.2	116.2	42%
10.00	973.8	40.6	27.6	68%	13.3	11.3	159.3	13.2	11.2	157.1	78%
11.00	1000.3	42.6	27.8	67%	13.5	12.0	152.8	13.4	11.9	150.1	88%
12.00	889.3	43.8	28.9	63%	13.6	10.8	146.5	13.5	10.7	144.1	96%
13.00	498.8	38.1	30.0	59%	13.4	6.5	86.7	13.3	6.4	84.5	100%
14.00	533.8	36.6	29.2	60%	13.4	6.6	88.9	13.4	6.5	87.4	100%
15.00	547.8	38.5	29.2	60%	13.6	6.6	88.9	13.5	6.5	87.1	100%
16.00	336	34.7	28.1	64%	13.5	5.3	71.6	13.4	5.2	69.7	100%

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Fig. 3 shows the graph of SOC Battery of 100 AH, 12 V at three different altitudes, Marina Beach, Tembalang and Bandungan.

The higher sunshine intensity occurred at 11.00 am and the lowest at 16.00 pm. They are 876.0 W/m^2 and 263 W/m^2. The intensity affect of the current of the PV. The PV produce an electric current of 4.7 A at intensity of 876.0 W/m^2 while 1.4 A at intensity of 263 W/m^2. The single panel is only able to charge 75% on battery 100 AH, 12 V. This was shown in TABLE II that the SOC (state of charge) until 16.00 pm the battery capacity was charged by 75% of a full capacity. Fig. 2. shows the SOC for the battery 65 AH, 12 V and 100 AH, 12 V using the single panel.

The parallel PV panel of 100 Wp can improve the capacity charging for battery of 100 AH, 12 V. The 100 %

full capacity of SOC battery of 100 AH, 12 V can be achieved by 5 hours of exposure in sunshine.

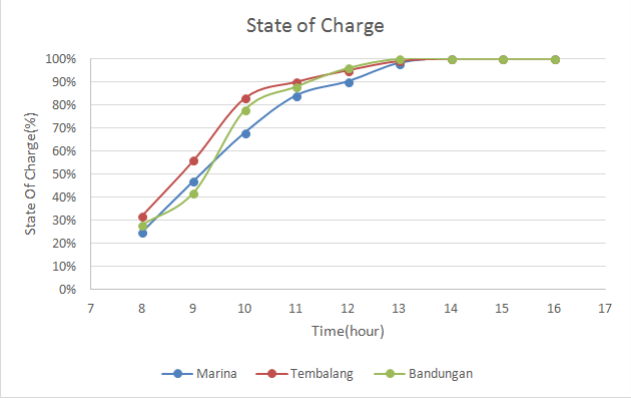

Fig. 3. The graph of SOFC Battery of 100 AH, 12 V at Different Altitudes Marina Beach, Tembalang and Bandungan

The selection of parallel installation of PV is caused to keep the output of the voltage from PV appropriate the battery voltage. It keeps the safety of the battery. It was hoped it still can be operated as long as possible [12]. The lower capacity of charging is at Marina Beach, but the full capacity charging is still around 5 hours. The quality of charging has affected the intensity of sunshine. The sunshine also is affected by weather such as cloud, rainy [9].

IV. CONCLUSION

Several conclusion can be taken as following

1. The single panel monocrystalline PV of 100 Wp can't be achieved to charge the full battery of 100 AH, 12 V.
2. The capacity of 100 % SOC battery 100 AH, 12 V can be charged as long as 5 hours using two panels monocrystalline PV of 100 Wp which were installed by parallel.
3. The altitude area has to affect on the quality of intensity of sunshine that affects producing the electric current of PV which can charge the battery.

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