

RENEWABLE ENERGY OFF-GRID SYSTEM FOR ELECTRIC VEHICLE CHARGING

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ABSTRACT

The increasing use of electric vehicles (EV) in society requires a power system electric network that is sufficient for charging electric vehicles at home. The duration of charging at home can be a challenge because it increases the load on electric network at home. Utilizing renewable energy can be a solution to reduce the load on the electricity network at home. Therefore, this paper aims to design an off-grid solar panel and wind turbine charging system for an integrated home charging system. The renewable energy storage system is switched on and off when the demand for grid charging increases. A demand response model program was used to monitor the off-grid system model. Results show significant cost reduction and power savings based on the flexibility of home electric vehicle charging. The demand response control system is a useful control model to accurately manage the power demanded by electric vehicle charging to reduce the cost of electrical energy consumption and grid load at home by utilizing renewable energy.

Keywords: off grid system, renewable energy, solar cell, wind turbine, electric vehicle charger

INTRODUCTION

The development of the electric vehicle transportation sector has increased in recent years. Efforts to reduce environmental damage caused by air pollution of fossil fuel vehicles can be reduced. Therefore, the use of electric vehicles (EVs) has advantages in terms of energy conservation and environmental protection [1-2]. It is estimated that the number of EVs will reach nearly 14 billion by 2030 [3]. However, with the increase in the high growth of electric vehicles, the scale of the original charging station is likely to be unable to meet the charging demand, leading to electric vehicle charging problems experienced by electric vehicle users, such as; charging queues that increase drivers' time costs, distribution network power quality and cause traffic system congestion and other problems [3].

A feasible attempt to reduce charging at charging stations is to design an electric vehicle charging system at home to maximize electric vehicle charging. How to formulate an effective electric vehicle charging system strategy to reduce the total cost of charging electric vehicles and the impact

on the distribution network and transportation system is the basis and guarantee for the large-scale popularization of electric vehicles in the future [4-6]. Electric vehicle charging systems can be connected to the power grid and recharged using clean renewable energy sources. This model as an alternative to the use of electric vehicles presents a more sustainable energy system. Electric vehicle systems use electric power storage systems with lithium-ion (Li-ion) batteries being the most widely used due to their high energy. Recharging batteries can optimize the performance of electric vehicles [7]. Currently, the average cost of Li-ion battery cells is about \$73-100/kWh, with an energy density of 200-300 Wh/kg, this can illustrate the high efficiency level of electric vehicle systems can offer competitive mileage [8].

The challenges that need to be addressed for home charging of electric vehicles are the charging power source, as well as fast charging that recharges the vehicle battery which can make electric vehicles more practical for long trips. Electric vehicle charging systems need to be developed more comprehensively, to overcome the problem of charging electric vehicles at home. The integration of home electricity grid systems with renewable energy sources, such as; solar cells, and wind turbines makes a very promising option due to its productivity and favorable investment costs [9-10]. Off grid systems for electric vehicle charging are highly advantageous in terms of system operation and home grid electrical energy consumption costs. In this study, we propose an innovative off grid model approach to reduce the power grid capacity required for electric vehicle charging through the design and framework of DC bus, optimized model to determine the ideal capacity for charging and energy storage [11-12].

DC Microgrid system models have been the focus of many researchers. However, it still requires efforts to overcome the problems in the DC Microgrid model, such as; stability, protection, grounding, control, energy storage for the realization of DC Microgrid. In addition, the main challenges of DC Microgrid systems are related to voltage regulation, load current sharing, and parallel operation can improve the performance of electric vehicle charging systems, where are increase of DC currents is which requires a high degree of accuracy when short-circuiting varying DC sources [13-15].

This study describes a DC Microgrid system with renewable energy sources of solar cells and wind turbines that have different types of electric currents and are integrated with the Alternating current (AC) home power grid. An investigation was conducted to determine the performance of the DC Microgrid system for electric vehicle charging with load demand response control.

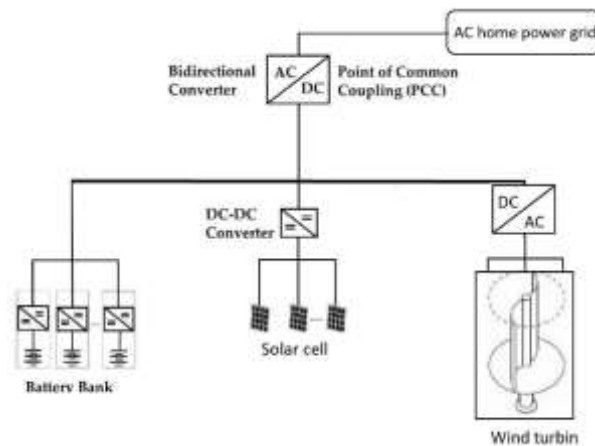


Figure 1. Schema DC micro grid

METHOD

The materials and equipment used solar PV Monocrystalline type 250 Wp with specifications; maximum power (P_{max}) = 250 Wp, the voltage at maximum power (V_{mp}) = 30.3 V, current at maximum power I_{mp} = 8,25 A, open circuit voltage V_{OC} = 36.3 V, short circuit current I_{SC} = 8.75 A, *Temperature Range* = 45 °C – 80 °C, dimension = 1640 x 992 x 35 mm, max. series fuse rating = 15 A. Inverter prime 2000 W 48 V MPPT, twelve solar cells array power (P_{max}) 3000 watt, Max. voltage 400 V, and wind turbine max power 1000 watts.

Technical Analysis

The installation of solar cells and wind turbines at the research site in Malang City Indonesia as a case study, the measurement of electricity generated by solar cells and wind turbines is calculated using a Kwh meter. In addition, the consumption of electrical energy for electric vehicle charging systems is also analyzed based on the demand for electrical power needed. Schema of the solar cell/wind turbine hybrid system is presented in Figure 2.

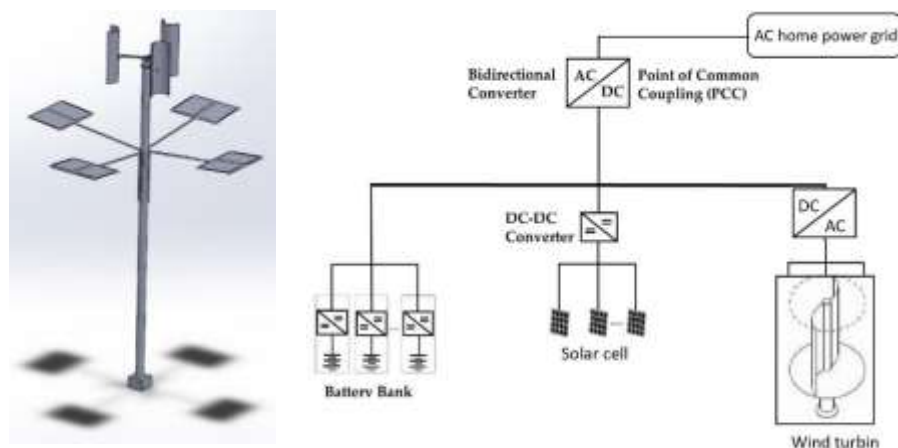


Figure 2. Schema of the solar cell/wind turbine hybrid system

Meanwhile, the model of DC microgrid for electric vehicle charger system control is presented in Figure 3.

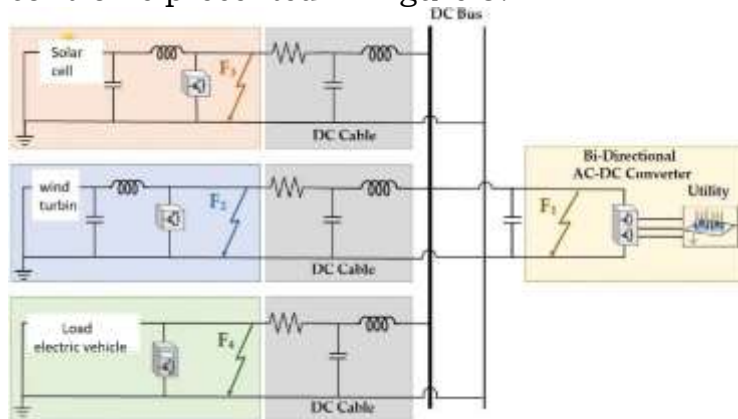


Figure 3. DC microgrid for electric vehicle charger system

RESULTS AND DISCUSSION

Meanwhile, the residential electrical energy consumption such as; LED lamps, iron, water pump, rice cooker, television, laptops, and refrigerators used are presented in Table 1.

Tables 1. Household scale electricity needs

Electricity needs	Electricity consumption (kWh)
4 LED Lamp 12 watt	0,384
6 LED Lamp 20 watt	0,72
Iron 250 watt	0,25
Water pump 125 watt	0,25
Rice cooker 250 watt	0,25
Television 20 inchi 100 watt	0,5
Laptops 15 watt	0,2
Refrigerator 100	2,4
Total electricity needs/day	4,95
Total electricity needs/month	148,62
Total electricity needs/year	1782

The decrease in irradiation on the surface of the solar cell caused by changes in the angle of incidence of sunlight can have an impact on the decrease in electricity production of the solar cell. In addition, the hybrid wind turbine system can increase the supply of electricity during the day and night with electricity production of 0,315 Kwh/day. The production of hybrid solar cell and wind turbine electricity is presented in Table 2.

Tables 2. Electric energy production from 3 Kwp solar cell

Time	Electricity energy Production (kwh)
Solar cell	
07.00-08.00	1,365
08.00-09.00	1,674
09.00-10.00	1,632
10.00-11.00	1,431
11.00-12.00	1,655
12.00-13.00	1,646
13.00-14.00	1,412
14.00-15.00	1,036
15.00-16.00	0,803
Wind turbin	0,315
Electrical energy/day	1,721

Measurement of 3 kWp solar cell electricity production was carried out during clear sky conditions (dry season), the average electrical energy produced was 1.406 kWh/day (table 2). The solar cell was effectively illuminated for 8 hours/day, the total electrical energy produced by the solar cell/day can be calculated from the multiplication of the solar cell output power by the duration of exposure at Peak Sun Hour. Meanwhile, the electrical energy of the wind turbine is 0.315 Kwh/day. while the need for household-scale electrical energy per day is 4.95 kWh [16].

Tables 3. The estimation electrical energy consumption

Number Day		Electricity energy consumption (kWh)		Total
		Daytime	Night time	
		(06.00 AM- 05.00 PM)	(05.00 PM- 06.00 AM)	
1	Monday	2.2	2.89	5.09
2	Tuesday	2.22	2.12	4.34
3	Wednesday	2.48	2.85	5.33
4	Thursday	2.85	2.55	5.4
5	Friday	2.89	2.23	5.12
6	Saturday	2.15	2.12	4.27
7	Sunday	2.8	2.35	5.15
Consumption of electrical energy/day				4.95

Analysis of the demand for electrical energy for various household activities, charging electric motorbikes, and electric cars shows that the energy demand is too large for all of them to be met by a renewable energy hybrid system and still requires a supply from the home electricity network.

Tables 4. Energy consumption

Unit	Energy consumption (kwh)
Household activities	4,95
Electric bike charging	1
Electric car charging	10
Consumption of electrical energy/day	15,95
Electric energy production	1,721

CONCLUSION

Application of renewable energy hybrid system with home electricity network with off grid model for electric vehicle charger system with DC microgrid can help provide additional electricity energy of 1,721 Kwh. However, electricity production cannot meet all electric vehicle charging power consumption of 11 Kwh based on demand. The applied DC bus model can automatically optimize the electric vehicle charging system by connecting to the home electricity network.

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