LOGIC
Journal of Engineering Design and Technology
Vol.20 No.3 November 2020; p. 200 - 204

p-ISSN : 1412-114X
e-ISSN : 2580-5649
http://ojs.pnb.ac.id/index.php/LOGIC

ANALYSIS FEASIBILITY OF PHOTOVOLTAIC ARRAY DRIVE A MEDIUM TEMPERATURE REFRIGERATOR

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Abstract. Solar power (photovoltaic) is one of the clean energies that is very well developed in a tropical country like Indonesia. This is due to the high intensity of the sun and shining throughout the year so that the annual energy obtained is relatively high. The solar energy system in this research was developed with a photovoltaic array system that can be optimized for angles and facing according to where the experiment was carried out. The solar system using Solar Control Charge (SCC) and an inverter in order to get both alternating and direct current output. This energy output from solar power is used to drive the medium temperature refrigerator system for storing fresh vegetables and fruit. The results obtained from this preliminary study are the best angle and direction is an angle of 15 degrees to the north. And this condition will be determined in the form of a fixed tilt on the solar power system located at the Bali State Polytechnic and its surroundings.

Keywords : photovoltaic array, medium temperature refrigerator, optimum angle and facing.

1. INTRODUCTION

The feasibility of using solar power as an energy source in the refrigerator system has been studied in various countries that are similar to Indonesia's condition. Modi at al. [1] conducted a study on the use of solar power for conventional refrigerator systems. The system was re-designed with the addition of batteries, inverters and transformers with solar panel photovoltaic (SPV) energy sources. The results showed that the performance (COP) of the refrigerator decreased from morning to evening, with a maximum COP of 2.1 at 7 am and economically it still requires a rather high investment cost because the battery price is still relatively expensive. Bilgili [2] investigated by making a solar electric-vapor compression refrigeration (SEVCR) system, this system is very suitable for cooling during the day. Gupta et al [3] conducted research with the development of stand-alone solar panels as an energy source for the refrigerator system, and analyzed the suitable solar panel design for a certain refrigerator capacity and found that solar power was very suitable for the refrigerator system. Daffallah [4] investigation an energy-efficient approach to providing cooling needs is one of the challenges facing most developing countries. This research was conducted to assess the performance of DC 12 V and 24 V photovoltaic refrigerators with / without loading which were operated at 25 ° C and 35 ° C. Experiments were carried out at different thermostat settings in the refrigerator. Daily compressor running time and refrigerator energy consumption are calculated under various operating conditions. Monthly and yearly refrigerator consumption is also carried out. Minimum and maximum increase in compressor running time per day for each degree increased (on average from 25 to 35 ° C) in ambient temperature.

The reduction in energy consumption allows a reduction in the capacity of the PV generator and solar battery. This optimization reduces the cost of autonomous PV installation and helps generalize renewable energy in the domestic refrigeration sector [5]. It has also been observed that AC refrigerators are associated with relatively high power consumption and power spikes compared to DC refrigerators. The economic assessment carried out between an AC refrigerator (with an inverter) and a developed DC refrigerator (without an inverter) are both supported by a solar / photovoltaic electric system showing that DC refrigerators have the potential to reduce the overall system installation costs by 18% because they are compared to AC refrigerators. recommended that for stand-alone cooling using a solar PV system as an energy source, it is more economical to use a DC refrigerator than an AC refrigerator [6].

Simulation of a solar vapor compression refrigeration system with a variable speed compressor in real weather conditions using data sheets (PV panel and compressor) available from the manufacturer. Compressor operating speed is determined to model the variation in the performance of the refrigeration system per hour. The analysis and simulation results show that the COP of the refrigeration cycle for the selected day is around 2.25 when the compressor is running at low speed, and the COP drops to the lowest value of 1.85 when the compressor operates at the highest speed. Furthermore, the simulation results show that an estimated radiation intensity of 315 W / m2 must be received at the tilt panel to run the compressor with a minimum rotating speed of 1800 rpm. To drive the compressor at its maximum rotating speed (4200 rpm), an estimated radiation intensity of 700 W / m2 is required to fall on the PV panel. Finally, the proposed method can be used to estimate the performance of a solar PV cooling system in direct combination with a variable speed compressor under certain weather conditions [7].

Based on that previous review , study on solar power aimed at driving the refrigeration system has not been widely discussed for the Indonesian region, where solar power is abundant throughout the year and with high intensity. So this research is very urgent to get a solar power system that is in accordance with environmental conditions and loading conditions, namely the refrigerator system.

2. METHODS

In this research, the design of the photovoltaic system was designed to meet the experimental test achievements of the development of a refrigerator prototype with an alternating current (AC) compressor and a refrigerator system with a DC (direct current) compressor which was simultaneously built in this whole research. The photovoltaic design is a full system using a solar energy system (photovoltaic) or a stand alone off-grid system without grid from National Grid (PLN) as shown in Figure 1.

Solar-Photovoltaic power system which consists of a photovoltaic circuit, Solar Charge Control (SCC), DC / AC Inverters and Batteries / Accu. In this system the output of solar energy is AC and DC currents and can directly drive the AC refrigerator system and the DC refrigerator system. The design of a solar power system begins with a simulation of the calculation of the capacity of the components to be used, namely: solar panels (photvolatic array), solar charge controller (SCC), batteries and DC / AC inverters. The balance of the capacity of each component is simulated with a spread sheet (exel) and the simulation is also assisted by the @PVSys software program. In the simulation also consider the configuration of the solar panel array, for example series, parallel or series-parallel combination and alternative battery voltage systems (for example: 12V or 24V) to be implemented including the type and size of cables required.

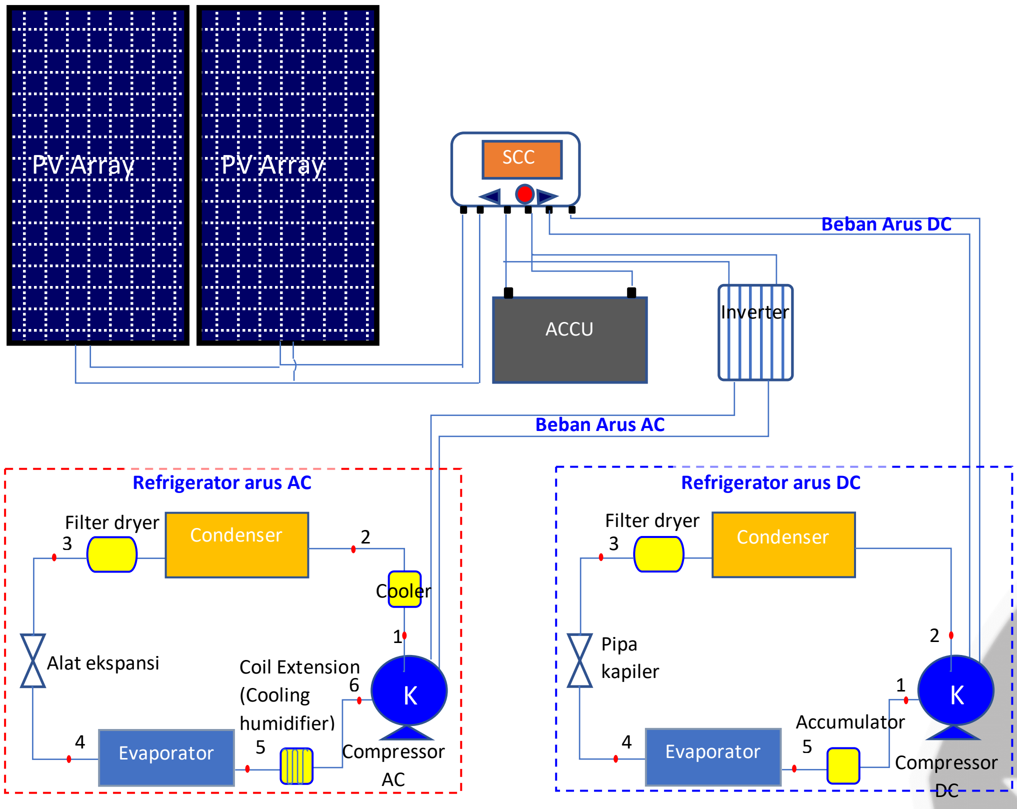

Figure 1. Schematic diagram of PV array drive refrigerators system

Photovoltaic arrays can be simulated according to the needs and the desired optimization. A combination of parallel circuits, series, or a combination of parallel and series of photovoltaics to get the desired current or voltage. Photovoltaic designed to meet the electrical energy load of the prototype refrigerator. Meanwhile, the PVSyst software can be used to simulate an off-grid PV system with a database of components such as solar panels, batteries and SCC.

2.1 Experimental Procedures

In this research period, the solar power system was tested from June to September and the testing will continue until February so that complete data can be obtained throughout the year. The test is carried out from 8.30 to 16.30 local time. To get the photovoltaic tilt angle optimization tested at an angle of 0 degrees (angle of 0 degrees in a horizontal position), 15 degrees, 30 degrees and 45 degrees. Tests are carried out at these angles using the fix tilt method. Measurement of electric current (I) and voltage (V) is measured at each part, namely the Photovoltaic exit, Solar Charge control (SCC) exit, and the inverter entry and exit. Data were taken every 30 minutes on each part with a digital ampere meter and digital voltmeter. The surrounding environment is also measured including temperature, humidity, and dew point because it greatly affects the operational efficiency of the photovoltaic and refrigerator load.

2.2 Data Acquisition and Data Analysis

Login data every 10 seconds and save it on the laptop. All experimental data is imported into a spreadsheet for easier calculation and analysis using simple statistical methods. Data is tabulated in tables as well as in graphs. The calculation of the performance coefficient (COP) of the system uses a computer program @ Cool pack and is analysed under load and no load conditions.

3. RESULTS AND DISCUSSION

3.1 Experimental Data

Environmental data (ambient) is very important to analyze because it is a medium to be conditioned to increase humidity in the cold room. Fresh air is introduced into the chamber periodically by means of a blower mechanism which is controlled by a timer. Meanwhile, for solar panels (photovoltaic), humidity and temperature data on the surrounding air greatly affect the performance of the photovoltaic system itself. One of the environmental data when taking performance data is shown in the following figure.

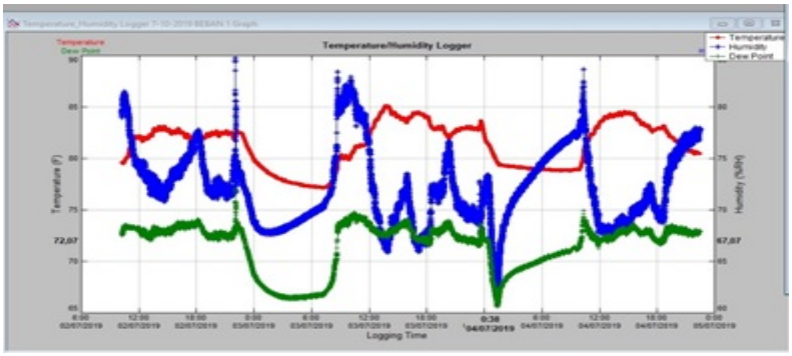

Figure 2. The results of measuring environmental conditions with a data logger

Environmental data is shown by temperature data (red line) 81.4 ^{o}F or about 27.4 °C and maximum humidity (blue line) 84.8% and a minimum of 75.34% and dew point data (green line) of 72 ^{o}F or around 22 ^{o}C. Due to the unsatisfactory environmental conditions of natural humidifiers, a mechanical humidifier that can be controlled according to the desired humidity is added. For product analysis needs, a mechanical humidifier is activated as an additional humidifier to ensure humidity above 85% - 95%.

The solar power in this experiment takes photovoltaic data out to get the optimum voltage and current according to the direction and tilt angle of the solar panel. The data is summarized in all cardinal directions (East, North, West and South) and all angles 0^{o}, 15^{o}, 30^{o}, and 45^{o}. the current according to the direction and angle is shown in the following Figures.

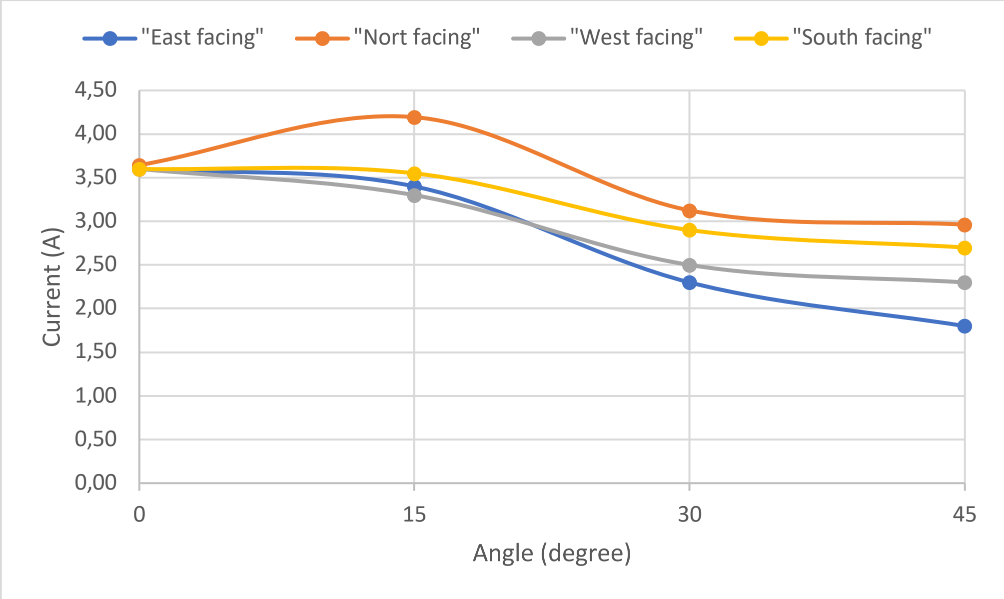

Figure 3. Variation of angle and facing on current output

Figure 3 shows the results of the data in terms of facing and angle that can produce maximal current is north with an angle of 15 degree, so that further data trends show the current output from the photovoltaic along the shining sun from 8.30 WITA to 16.30 WITA (local time) as shown in Figure 4

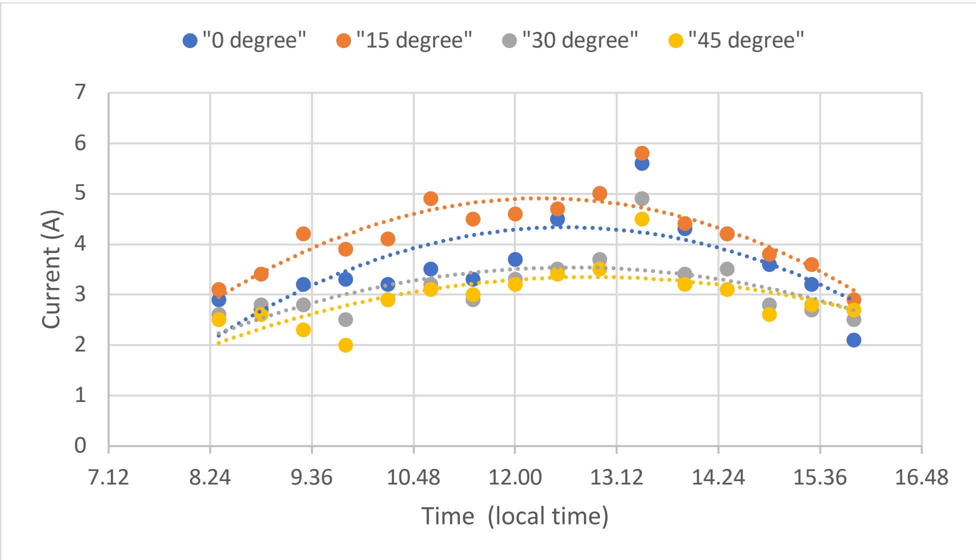

Figure 4. Current (I) output on hourly data

3.2 Refrigeration Operating Condition and Product Quality

Two main condition which are with and without load. Data show operational conditions and COP which has been calculating using @Cool Pack based on data from the state of the refrigeration system after modification. Analysis results found that the COP of 3.5 and 3.3 for without and with load, respectively. This COP is a good performance for the general refrigerator system, in a further study will be examined in the improvement of the COP in detail with the optimization of the humidifier system.

Visually, Figure 5 show the product that was kept refrigerated for 7 days. The vegetables seems still fresh enough, as good as put for early time. The vegetable condition put in the refrigerator is not the best the condition, because it is taken from traditional market that has undergone a lack of quality of cooling previously. In the advanced study will be tested in the humidity 90% so that the condition optimization is obtained the humidity that best suits the product storage conditions and combined with optimum temperature. Finally, the solar system can drive the refrigerator system properly.

Figure 5. Product visually after 7 days keep refrigerated (temperature set at 5ºC)

4. CONCLUSION

Depend on the analysis has been done , it can be concluded that the configuration of the angle and direction of the solar panel is observed carefully and it is found that the angle of 15 degrees and the north direction gets the greatest output from the solar power system, the trend of solar power output has produced currents from 8.30 to 16.30. at local time. From this configuration, it can also move the refrigerator system, especially at high sun intensity. This is preliminary data from a series of studies carried out and this research will continue to build a DC (direct current) refrigeration system and its performance will be observed according to the energy source from the solar panels. Data on the performance of the refrigeration system and optimization of the use of solar energy will be further analyzed so that it can become a cheap and reliable alternative energy for refrigerator systems in the context of storing fresh fruit and vegetables to increase storage time and quality of healthy and export quality products to improve food security and community health.

5. ACKNOWLEDGEMENT

This research was supported by the Direktorat Riset dan Pengabdian kepada Masyarakat (DRPM) - Ministry of Research and Technology-BRIN, Indonesian Government, No. SPKK : 133/SP2H/AMD/LT/DRPM/2020 and (SP DIPA- 042.06.1.401516/2020) for the in cash contribution. The authors wish to acknowledge the contributions of Mechanical Engineering Department -Bali State Polytechnic for the in-kind contributions. Also Centre for Research and Community Service (P3M) for all administrative support.

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