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# Comparative Efficiency of Solar Panel by Utilize DC Water Pump and DC Hybrid Cooling System

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**Keywords-** Solar photovoltaic (PV); DC water pump; DC hybrid; solar irradiance; temperature

**Abstract.** The purpose of this paper is discussed about comparative efficiency of solar panel by utilize DC water pump and DC hybrid cooling system. Ambient temperature and solar irradiance are played main role of the efficiency of PV module. When temperature of PV module increase, the efficiency of PV module will decreased and vice versa. When solar irradiance increase, output current and output power will increase with linear and output voltage will increase with marginal and vice versa. A solution is provided to solve problem of low efficiency of PV module which is DC cooling system. DC brushless fan and water pump with inlet/outlet manifold were designed for actively cool the PV module to improve efficiency of PV cells. The PV module with DC water pump cooling system increase 3.52 %, 36.27 %, 38.98 % in term of output voltage, output current, and output power respectively. It decrease 6.36 ˚C compare than to PV module without DC water pump cooling system. While PV module with DC hybrid cooling system increase 4.99 %, 39.90 %, 42.65 % in term of output voltage, output current, and output power respectively. It decrease 6.79 ˚C compare to PV module without DC water pump cooling system. The higher efficiency of PV module, the payback period of the system can be shorted and the lifespan of PV module can be longer.

## Introduction

In all over the world, energy is thus one of the essential issues for continuous progress and economic growth. Two forms of energy sources that are non-renewable energy sources and renewable energy sources nowadays. Many countries publicize renewable energy which is solar energy, wind energy, biomass energy, and hydropower nowadays. As the renewable energies become popular in the energy market, the requirement of non-renewable energy will be reduced. In the process of photovoltaic (PV), PV cell is converted from sunlight into electrical energy. PV system is a renewable energy and an important part in our lives. PV power is cheaper form of electricity. It can lower utility bill, reduce non-renewable consumption and global warming. PV system operates in situation silent and environmentally friendly as it will not emit carbon dioxide into atmosphere.

The particular ambient temperatures along with solar irradiance participate in significant aspect specifically for efficiency of the PV module. When ambient temperature of PV module is typically raised, the efficiency of PV module is decrease and the other way around. This regular principle is definitely the decrease as a result of the open cell voltage drop is determined. For that reason, an efficient PV performance condition needed cooling. Even though PV module operating outside; PV modules have a high irradiance condition upon getting high temperatures. Consequently, the cooling system of PV modules is an important key to enhancing the efficiency of the PV system.

H.G Teo et al. [1] presented the efficiency of different configurations of PV module. Without active cooling, the temperature of the module was high and solar cells can only achieve an efficiency of 8-9 %. However, when the module was operated under active cooling condition, the

temperature dropped significantly leading to an increase in efficiency of solar cells to between 12 % and 14 % [1].

J.K. Tonui, [2] carried out the improvement of the low cost air typed PV/T collector with the problem of less material consumption and low running costs. Using the ways of add thin flat metal plate in the centre or just add fins in the flow channel, It will achieve high heat energy output, and decrease the temperature of PV, in order to improve the efficiency of electric. J. K. Tonui [2] mentioned air cooling is preferred than the other cooling arrangements due to minimal use of material and low operating cost despite its poor thermo physical properties.

Rustemli and Dincer [3] discussed that increasing of panel temperature is affected electricity generation capacity of PV panels and as the panel temperature is increasing, current is very little increased but voltage is decreased. Tiwari and Sodha [4] presented that one of the main reasons for reduction of electrical efficiency of the PV module is the increase in the temperature of the PV module due to solar radiation.

W.G Anderson et al. [5] described a cooling design that uses a copper/water heat pipe with aluminum fins to cool a Concentrating PV Cells (CPV) by natural convection. Heat pipe can be used to passively remove the heat, accepting a high heat flux at the CPV cell, and rejecting the heat to fins by natural convection, at a much lower heat flux [5]. This work successfully demonstrated the feasibility of a heat pipe cooling solution for CPV [5].

Sharp Solar Module ND-130T1J has been chosen to analysis PV modules performance in this investigation. The primary concentration is compared with parameter performances of the PV module with and without cooling system. A report consists of the key parameters and the provisional result through the component to the user.

**Methodology**

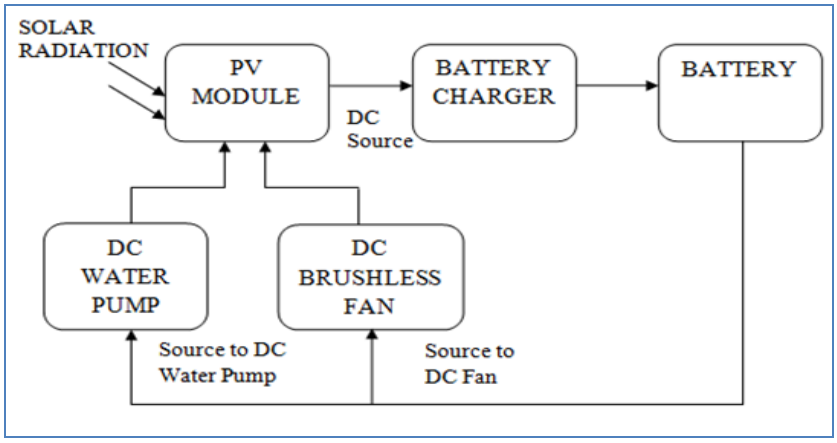


Fig.1 Block diagram overview of the investigation.

Figure 1 shows the block diagram summary of the investigation. The PV module generates electrical energy and supplies DC source to battery charger. The output power of PV module is used to charge the 12 $V_{DC}$ batteries by using battery chargers. It continuously charge the battery until it shows at the sign of full status on and will cut-off charging process. Battery is used to keep electrical energy that produce by PV module. Battery supply DC source to DC brushless fan and DC water pump that is placed at back side and front side of PV module respectively. DC brushless fan and DC water pump as PV cooling system to decrease temperature for improving efficiency output power of PV module. Besides, the output of the PV module power DC lamp (12 $V_{DC}$, 75 W) as a load.

Midi Logger GL220 was used to measure and collect the output voltage of both PV modules. In each ten minutes, the output current of both PV modules were measured and recorded by using Digital Multimeter same as method to measure and collect the output voltage of both PV modules. A Davis Vantage PRO2 Weather was utilized to determine the daily ambient temperature and solar irradiance.

**Experimental results and discussion**

This investigation was conducted at Centre of Excellence Renewable Energy (CERE) on 2 April 2014 from 9:00 a.m until 5:00 p.m. The DC water pump cooling system and DC hybrid cooling system were experimented at the outdoor CERE.

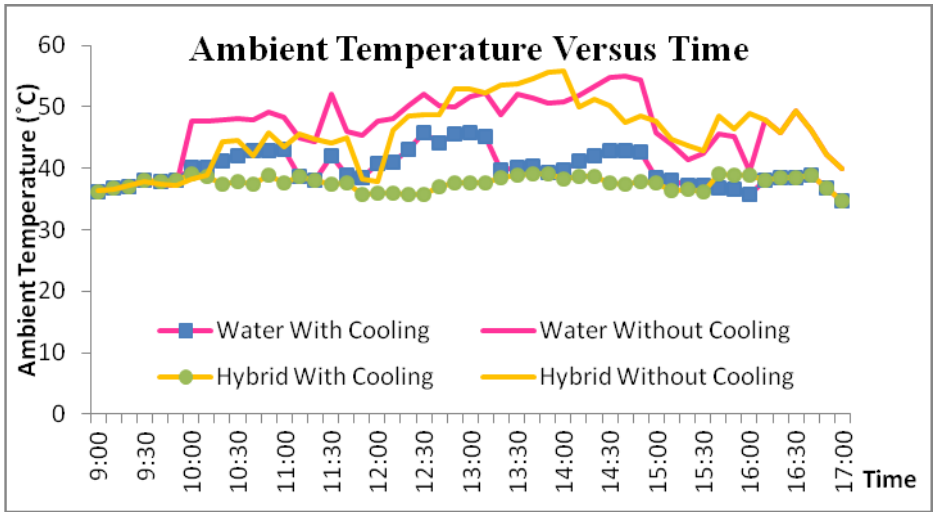


Fig. 2 Comparison of ambient temperature versus time between DC water pump and DC hybrid.

The average temperature of PV module with DC water pump cooling system seemed to be reached at 40 ˚C while the average temperature of PV without cooling system seems to be 46.79 ˚C. The temperature variant of PV module without DC water pump cooling system seemed to be increasing 6.79 ˚C reviews to be able PV module along with DC water pump cooling system. However, the average temperature of PV module with DC hybrid cooling system was reached at 37.65 ˚C while the average temperature of PV without DC hybrid cooling system was 45.74 ˚C. The temperature variation of PV module without DC hybrid cooling system was increased 6.1 ˚C compare to PV module with DC hybrid cooling system as shown in Figure 2.

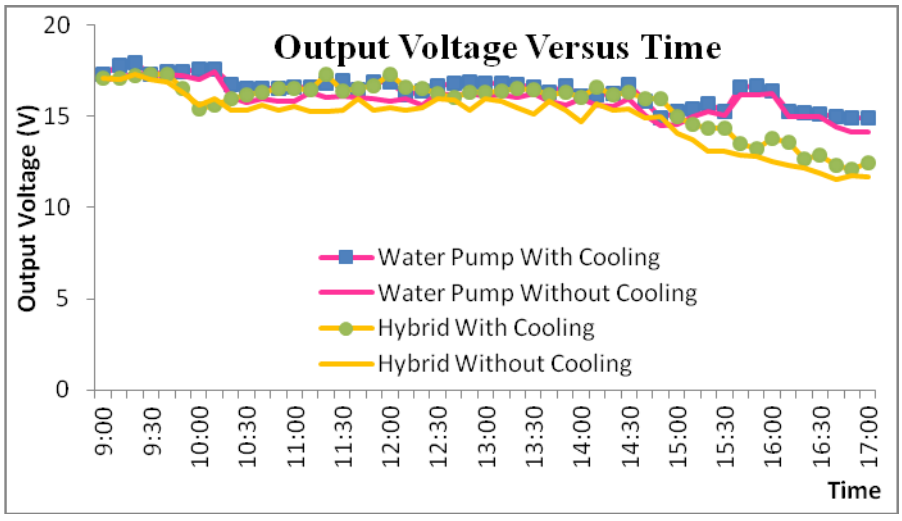


Fig.3 Comparison of output voltage versus time between DC water pump and DC hybrid.

Figure 3 illustrates comparison between DC water pump and DC hybrid in term of output voltage versus time. The figure displays maximum output voltage of PV module with DC water pump cooling system was 17.78 V and average output voltage was 16.45 V. The output voltage of PV module with DC water pump cooling system increased 3.52 % compared to PV module without DC water pump cooling system. Besides that, the maximum output voltage of PV module with DC hybrid cooling system was 17.33 V and the average output voltage was 15.674 V. In the comparison between both DC hybrid cooling systems, the output voltage of PV module with DC hybrid cooling systems increased 4.99 % compared to PV module without DC hybrid cooling system. PV module with DC hybrid cooling system will generate more 1.47 % output voltage compared to PV module with DC water pump cooling system.

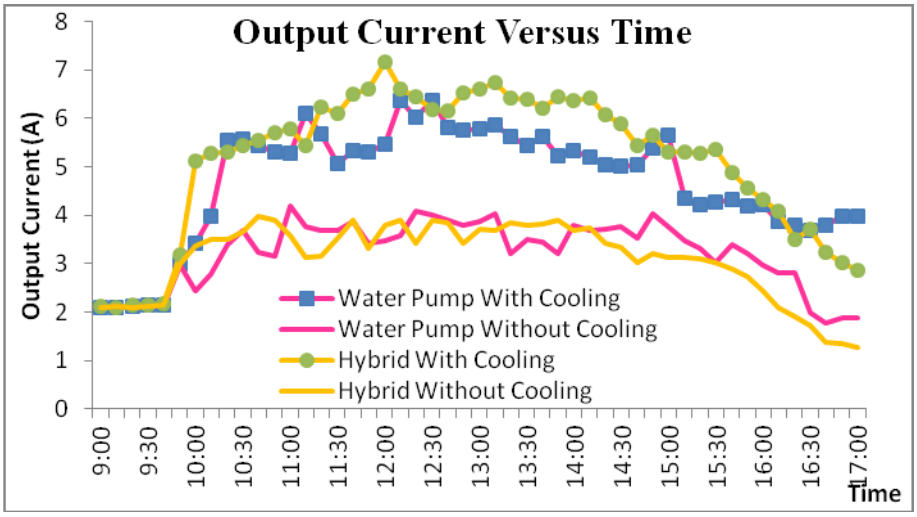


Fig. 4 Comparison of output current versus time between DC water pump and DC hybrid.

Figure 4 displays comparison between DC water pump and DC hybrid in term of output current versus time. It could be discovered maximum output current that is generated by PV module with DC water pump cooling system was 6.87 A and average output current seemed to be 3.27 A. In the comparing result among both of each system, the output current of PV module with DC water pump cooling system was increased 36.27 compared to PV module without DC water pump cooling system . Furthermore, maximum output current that produced by PV module with DC hybrid cooling system was 7.16 A and average output current was 5.146 A. The comparison between both DC hybrid cooling systems, the output current increased 39.90 % when using cooling system. PV module with DC hybrid cooling system will generate more 3.63 % output current compared to PV module with DC water pump cooling system.

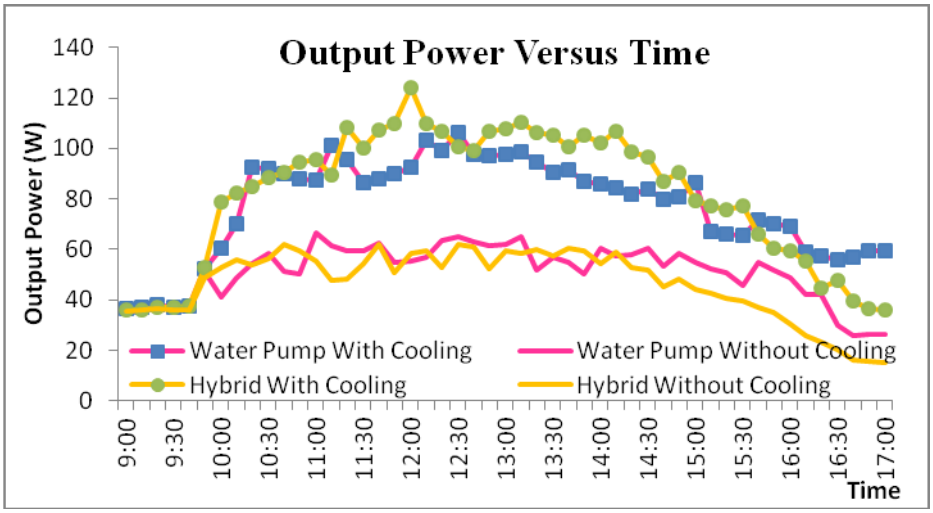


Fig. 5 Comparison of output power versus time between DC water pump and DC hybrid.

Figure 5 shows comparison between DC water pump and DC hybrid in term of output power versus time. The maximum output power of PV with DC water pump cooling system was measured and calculated at 115.55 W and average output power of was 83.79 W. Through in comparison concerning these kinds of each system, the output power improved 38.98 % when using DC water pump cooling system. Besides, the maximum output power of PV module with DC hybrid cooling system was measured and calculated at 124.08 W and average output power was 81.33 W. The increase percentage in the output power in unit of electricity is calculated to be 42.65 %. PV module with DC hybrid cooling system will generate more 3.67 % output current compared to PV module with DC water pump cooling system.

## Conclusion

This paper has discussed comparison between DC water pump and DC hybrid solar panel cooling system. The efficiency of PV module is depending on solar irradiance and ambient temperature. When the ambient temperature of PV module is increase, the efficiency of PV module is decrease and also the other way around. When the solar irradiance increase, output current and power will increase with linear and output voltage will increase with marginal and vice versa. The comparison between both systems of various types DC cooling system, the PV module with DC hybrid cooling system is most efficient compare to DC water pump cooling system. The PV module with DC hybrid cooling system increase 4.99 %, 39.90 %, and 42.65 % in term of output voltage, output current and output power. The DC water pump cooling system increase 3.52 %, 36.27 %, and 38.98 % in term of output voltage, output current and output power. The efficiency of PV module with cooling system was increasing compared to PV module without cooling system; this is because the ambient temperature dropped significantly. An increase in efficiency of PV module, investment payback period of the system can reduce and the lifespan of PV module will be prolonged.

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