An Analysis Efficiency of the Roof Photovoltaic Array for Tilth in Nongpling Sub-district Mueang District Nakhon Sawan Province

Thirayu Pinthong

Energy Engineering Branch, Department of Industrial Technology,
Faculty of Agricultural Technology and Industrial Technology,
Nakhon Sawan Rajabhat University, Nakhon Sawan, 60000, Thailand
*Corresponding author. E-mail: volt-energy@hotmail.com

ABSTRACT

This research was designed to test the efficiency of the Roof Photovoltaic Array for Tilth, as well as analyzed the energy consumption and economic viability of the Roof Photovoltaic Array. The 10 Modules of 280 watt solar cell installed capacity of 2.8 kWh. The roof photovoltaic Array has 1 meter of width and 10 meters in length. The power of pumping water is 3 horse power (HP) that installed a submersible pump 55 meters in depth and pump to a 6,336 litre storage tank 28 meters in high. The solar cell also provides power to sprinkle plant for 5 rais by installing 1.5 HP pump. The sprinkler system containing 210 sprinkler head is 6 rows are 35 head per rows. The result of the experiment, the average solar irradiance is 844.27 W/m^2 on 27^{th}-29^{th} January 2017. The average efficiency of producing electricity via the roof photovoltaic array is 0.23 on 27^{th}-29^{th} January 2017. The average energy consumption reduced per day of the Roof Photovoltaic Array was 16.416 kWh on 27^{th} January 2017, 16.731 kWh on 28^{th} January 2017 and 17.145 kWh on 29^{th} January 2017. The electricity saves cost is 51.21 baht per day. The payback period of the Roof Photovoltaic Array for Tilth is 5.35 years.

Keywords: Photovoltaic, Roof, Pump, Tilth

INTRODUCTION

Roof photovoltaic Array is often used for agricultural operations, especially in remote areas or where the use of a renewable energy Source is desired. In particular, they have been demonstrated time and time again to reliably produce sufficient electricity directly from solar radiation (sunlight) to power tilth and irrigation watering systems. A benefit of using solar energy to power agricultural water pump systems is that increased water requirements for tilth tend to coincide with the seasonal increase of incoming solar energy. When properly designed, these PV systems can also result in significant long-term cost savings and a smaller environmental footprint compared to conventional power systems(Teresa D. Morales, 2010). The volume of water pumped by a solar-powered system in a given interval depends on the total amount of solar energy available in that time period. Specifically, the flow rate of the water pumped is determined by both the intensity of the solar energy available and the size of the PV array used to convert that solar energy into direct current (DC) electricity. The principle components of a solar-

powered water pump system include the roof PV array and its support structure, an electrical controller, an inverter hybrid, a Sprinkler Head system and an electric-powered pump. It is important that the components be designed as part of an integrated system to ensure that all the equipment is compatible and that the system operates as intended. It is therefore recommended that all components be obtained from a hybrid supplier to ensure their compatibility. The following information is required to design a Roof photovoltaic Array-powered pump: the site-specific solar energy available (referred to as "solar insolation), the volume of water required in a given period of time for tilth purposes, as well as for storage. A storage volume equal to a two-day water requirement is normally recommended for tilth as a backup for the system's safety features and cloudy days. The total dynamic sprinkler power for the pump is supplied from the Roof Photovoltaic Array to the tilth.

Thus, the aim of this research was installed the roof photovoltaic array on the roof of the house in the Nongpling Sub-district Mueang District Nakhon Sawan Province in the year 2017(Libra et al., 2016). An application of the solar energy technologies that is converted into electrical energy use with the roof photovoltaic array for the tilth using solar energy to power water pump systems. Moreover, the economic aspect is analyzed in this research.

MATERIALS AND METHODS

The Figure1 shows the detail how the system works in a Roof Photovoltaic Array for tilth. Figure1 show the Roof Photovoltaic Array get the solar energy and convert to electrical energy (George E. Pataki,2015). The electricity goes through the breaker and inverter to supply power to the submersible pump and surface pump. The Rooftop Photovoltaic Array and transforming solar energy to electrical for the tilth are shown in Figure 2 and Figure 3. Basically, The Roof Photovoltaic Array produces electrical energy by using 10 modules of 280 watts solar cells are shown in Figures 4 and Figure 5, which of each module, connected in both series and parallel to increase both current and voltage simultaneously.

The working system operates when sunlight hits the solar panels on the Roof Photovoltaic Array for tilth and then photons are absorbed. Electrons move from the n-side to the p-side of the p-n junction creating holes. Other bonded electrons move into these holes creating yet another hole behind. This dynamic process generates a direct voltage from the two electrodes. Electricity flows through the passed inverter system to the load and charging batteries (Herbert W., 2003). The second part, which produces electrical for solar pumping systems, consists of two pumps (Submersible pump and Surface pump) are shown in Figure 6 and Figure 7 (Nader H. Shehadeh, 2015). The water is pumped by submersible pump then flows into a 6,336 litre storage tank is shown in Figure 7. The surface pump is pumped water from a 6,336 litre storage tank into sprinkler head system for tilth.

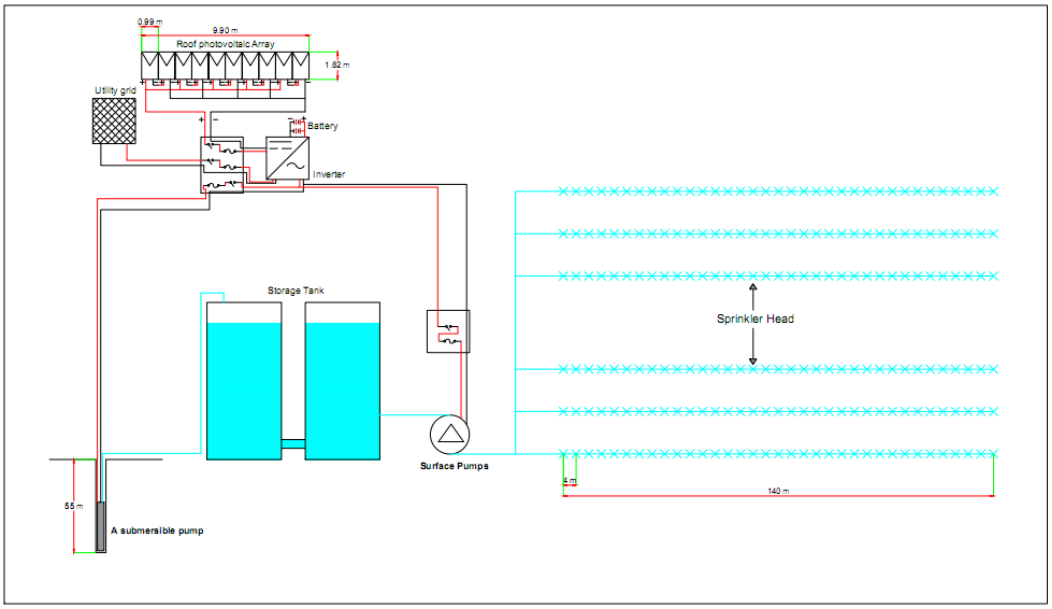

Figure 1 Model of the Roof Photovoltaic Array for Tilth

Figure 2 The Roof Photovoltaic Array

Figure 3 System of Roof Photovoltaic Array

Figure 4 Storage Tank

Figure 5 Sprinkler heads system for tilth

Figure 6 Submersible Pump

Figure 7 Surface Pump

Figure 8 Inverter control system

The Roof Photovoltaic Array for tilth is divided into inverter hybrid control systems, Photovoltaic power generation system, and produce electricity by solar energy is shown in Figure 8.

ANALYSIS OF THE TEST RESULTS

This study analyzed data from the recording parameters shown in the equation (1) and describe: To analyze the efficiency of the Roof Photovoltaic Array for tilth to generate electricity are evaluated as follow:

$$\eta = \frac{P_{out}}{P_{in}} = \frac{IV}{I_T A} \quad (1)$$

η : Efficiency of the Roof Photovoltaic Array for tilth, P_{out} : Electric power produced by Roof Photovoltaic Array for tilth (W), P_{in} : Power from solar energy (W), I : Electricity from solar panels (A), V : The voltage of the solar panels (V), I_T : Solar intensity (W/m^2), A : Solar roof space (m^2)

RESULTS AND DISCUSSION

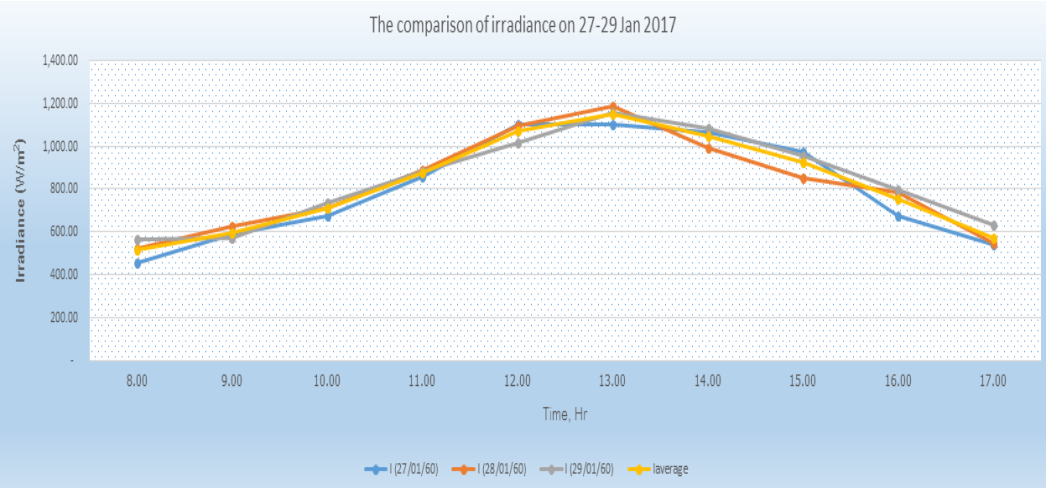

Figure 9 The comparison of irradiance on 27th-29th January 2017

From Figure 9, it was found that the maximum value on 27th-29th January 2017 of the solar irradiance is 1,189 W/m^2 on 28th January 2017. The average of solar irradiance for each day is 828.61 W/m^2 on 27th January 2017, 843.18 W/m^2 on 28th January 2017 and 861.04 W/m^2. The average irradiance is 844.27 W/m^2 on 27th-29th January 2017.

The Average generated output power testing of the Roof Photovoltaic Array

Table 1 shows in detail how the input power and generated output power of the Roof Photovoltaic Array on 27th-29th January 2017. The result of the experiment, the Areas of the Roof Photovoltaic Array is 10 m^2. The average input power of the Roof Photovoltaic Array each day is 8,035 W on 27th January 2017, 8,211 W on 28th January 2017 and 8,387 W on 29th January 2017. The average generated an output power of the Roof Photovoltaic Array each day is 1,824 W on 27th January 2017, 1,859 W on 28th January 2017 and 1,905 W on 29th January 2017.

Table 1 Production of electricity from Roof Photovoltaic Array for Tilth on 27th-29th January 2017

Time (h)	8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00	17.00
$I_{27\ Jan\ 2017}$ (W/m^2)	455	589	676	859	1,099	1,102	1,067	972	674	542
$I_{28\ Jan\ 2017}$ (W/m^2)	523	626	714	889	1,095	1,189	989	852	786	548
$I_{29\ Jan\ 2017}$ (W/m^2)	563	569	735	879	1,015	1,158	1,084	954	798	632
$A_{Roof\ PV\ Array}$ (m^2)	10	10	10	10	10	10	10	10	10	10
$P_{in\ 27\ Jan\ 2017}$(W)	4,550	5,890	6,760	8,590	10,990	11,020	10,670	9,720	6,740	5,420
$P_{in\ 28\ Jan\ 2017}$(W)	5,230	6,260	7,140	8,890	10,950	11,890	9,890	8,520	7,860	5,480
$P_{in\ 29\ Jan\ 2017}$(W)	5,630	5,690	7,350	8,790	10,150	11,580	10,840	9,540	7,980	6,320
$P_{out\ of\ Roof\ PV\ Array\ 27\ Jan\ 2017}$ (W)	1,190	1,390	1,650	1,990	2,350	2,450	2,450	2,000	1,670	1,100
$P_{out\ of\ Roof\ PV\ Array\ 28\ Jan\ 2017}$ (W)	1,210	1,400	1,840	2,010	2,300	2,490	2,440	2,120	1,780	1,000
$P_{out\ of\ Roof\ PV\ Array\ 29\ Jan\ 2017}$ (W)	1,290	1,370	1,990	2,000	2,310	2,480	2,420	2,150	1,840	1,200

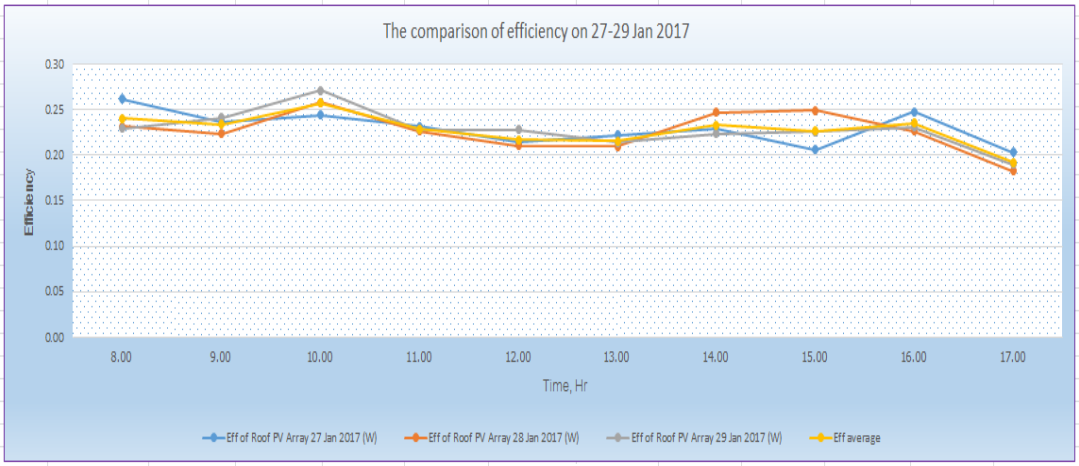

Figure 10 The comparison of efficiency of the Roof Photovoltaic Array on 27th-29th January 2017

Also, it was found that there was a slight difference in efficiency between each a days but it was insignificant in the number of energy perspective. Figure 10 presents the maximum efficiency each day is 0.25 on 27th January 2017, 0.26 on 28th January 2017 and 0.27 on 29th January 2017. The average efficiency of the Roof Photovoltaic Array is 0.23 on 27th-29th January 2017.

Table 2 The energy consumption reduce used for water pumping by submersible pump and surface pump for Tilth

Time (h)	8	9	10	11	12	13	14	15	16	17	Average
$P_{out\ of\ Roof\ PV\ Array\ 27\ Jan\ 2017}$ (W)	1,190	1,390	1,650	1,990	2,350	2,450	2,450	2,000	1,670	1,100	1,824
$P_{out\ of\ Roof\ PV\ Array\ 28\ Jan\ 2017}$ (W)	1,210	1,400	1,840	2,010	2,300	2,490	2,440	2,120	1,780	1,000	1,859
$P_{out\ of\ Roof\ PV\ Array\ 29\ Jan\ 2017}$ (W)	1,290	1,370	1,990	2,000	2,310	2,480	2,420	2,150	1,840	1,200	1,905
$P_{load\ water\ pump\ 27\ Jan\ 2017}$ (W)	1,300	2,100	1,400	1,920	0	1,340	1,990	1,240	1,910	0	1,320
$P_{load\ water\ pump\ 28\ Jan\ 2017}$ (W)	1,350	2,000	1,340	2,000	0	1,340	1,990	1,400	2,000	0	1,342
$P_{load\ water\ pump\ 29\ Jan\ 2017}$ (W)	1,410	1,990	1,370	1,930	0	1,420	2,000	1,350	1,950	0	1,342

Table 2 shows the detail how the energy consumption and load for water pumping system for tilth of the Roof Photovoltaic Array on 27th-29th January 2017. The result of the experiment, the areas of the Roof Photovoltaic Array is 10 m^2. The average energy consumption reduced per day of the Roof Photovoltaic Array each day is 16.416 kWh on 27th January 2017, 16.731 kWh on 28th January 2017 and 17.145 kWh on 29th January 2017. The maximum value the load power for pumping system is 2,100 W on 27th January 2017, 2,000 W on 28th January 2017 and 2,000 W on 29th January 2017. The results average load for water pumping per day is 11.880 kWh on 27th January 2017, 12.078 kWh on 28th January 2017 and 12.078 kWh on 29th January 2017.

ANALYSIS OF ECONOMIC VALUE

1) The Investment cost building of the Roof Photovoltaic Array is 100,000 baht.

2) The Roof Photovoltaic Array to produce electricity 9 hours per day. A day of the solar roof can produce maximum value of electrical energy is equal to 17.145 × 2.987 = 51.21 baht/day (1 kWh of 2.987 baht tariff: PEA, 2014).

3) The payback period of Roof Photovoltaic Array for tilth is 5.35 years. The Investment cost to build a Roof Photovoltaic Array for tilth is 100,000 baht. The Roof Photovoltaic Array for tilth to produce electricity amount of 17.145 kWh / day, compared to the use of electric power to be equivalent to 51.12 baht/day. The Roof Photovoltaic Array for tilth can reduce the total amount of electricity 51.21 × 365 = 18,691.65 baht/year.

CONCLUSION

The major conclusions that can produce electricity and reduce energy consumption from the present study are summarized as follows:

1) The average solar irradiance is 844.27 W/m^2 on 27th-29th January 2017. The Areas of the Roof Photovoltaic Array is 10 m^2.

2) The average generated an output power of the Roof Photovoltaic Array each day is 1,824 W on 27th January 2017, 1,859 W on 28th January 2017 and 1,905 W on 29th January 2017.

3) The average efficiency of the Roof Photovoltaic Array is 0.23 on 27th-29th January 2017.

4) The average load for water pumping per day is 11.88 kWh on 27th January 2017, 12.078 kWh on 28th January 2017 and 12.078 kWh on 29th January 2017.

5) The Roof Photovoltaic Array for tilth can reduce the total amount of electricity cost as 51.21 × 365 = 18,691.65 baht/year. The Roof Photovoltaic Array payback period of is 5.35 years.

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