Solar Cell Water Pump Mobile for Agriculture in Thailand

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Abstract. The water pump has been supported by agriculturalist to control the quantity of water with agriculture. However, the water pump used oil or electrical energy which increased cost of agriculturalist and some area no have electricity or far from the marsh. We proposed the innovative mobile solar cell water pump which clean energy for solving the problem of no electricity, agricultures far from water and pumping water ground and underground. It was found that the mobile solar cell water pump can tacking Z-axis 0-70° and X-axis 0-360°, changing battery storage: 24 V; 50 Ah and moving anywhere by agriculturalist control. The stroke pump can pump water 3000 L/h and transfer water 200 m to agricultural area which easily and low cost maintenance by agriculturalist. The microcontroller system like artificial intelligence (AI) is shown on the monitor of electrical power, electromotive force, electrical current, water flow rate, and quantity water.

1. Introduction

The world these days is suffering from a shortage of freshwater resources. Water demand all over the world is increasing because of population growth, industry, agriculture, and tourism development. To solve the critical water problem, countries must start searching for ways to optimize available conventional water resources and get the maximum benefit from the unconventional water resources [1].

Across the agricultural sector in developing countries, access to irrigation is an important step in improving agriculturist livelihoods and productivity as it increases production yields. The value of irrigation is dependent on rainfall patterns. For example, in a climate like Thai’s where a four-month-long monsoon season is followed by eight months of little or no rain, irrigation makes the agriculturist’s land available for cultivation for three seasons instead of two, significantly improving their productivity and income. Many other countries may experience a season that is drier than others and while their...
rainfall patterns allow them to cultivate year-round, irrigation can significantly improve yields, and provide a wider variety of crop options.

Pumping water from either surface sources such as ponds, lakes, and canals, or from underground through open wells or deeper borewells, is the primary driver for irrigation. These pumps come in a variety of power sources, including hand pumps, diesel pumps, grid-tied electric pumps, and solar pumps [2 - 4].

In Thailand, access to irrigation is seen as a policy priority for meeting important development objectives. Yet, significant roadblocks exist, for example, weak water markets and fragmented institutional coordination and implementation. Further, the environmental impacts of expanding irrigation have raised concerns about over-extraction of groundwater, which has become the dominant irrigation source, especially in the presence of a lack of political and social incentives to institute efficient irrigation practices namely, pricing water to reflect its true value [5 - 9]. Nadia M. Eshra et al. were used solar energy in drainage pumping stations to saving water and reducing CO₂ emission [10]. The better efficiency of solar energy was developed by a tracking system with two sensors; the first sensor for finds the location of the sun and second the sensor for sensing whether it is day or night (Pavushetti Abhilash). The different pumping heads (50 m, 60 m, and 70 m) and for 8S × 3P PV array configuration is various to considering a submersible type variable speed DC water pump system and found a lower pump head results in higher flow rate regardless of the variation in solar irradiation level. The obtained result also indicated that an increase in solar radiation intensity resulted in an increase in the pump flow rate, pump efficiency, and system performance [11].

In this context, solar pumping has been identified as a desirable technological solution. For instance, one research group found that out of four renewable energy technologies for irrigation, solar-powered pumps seemed to have the highest utilization potential across Thailand.

We proposed the solar cell water pump mobile has the following objectives:

(1) To study the Thai-agriculturist community context, (2) To design and fabrication solar cell water pump mobile, and (3) To propagate and transfer solar cell water pump mobile to Thai-agriculturist community are shown in Fig.1. This invention aims to solve the critical water problem of the Thai-agriculturist community which the general solar system insulation cannot move, and the solar panel angle cannot be adjusted. Some areas no electricity consumption system and no energy storage system and no water content system.

![Fig. 1 The research concept using solar cell energy for pumping surface and groundwater.](image)
2. Materials and Methodology

We study the Thai-agriculturist community context of agricultural products using surface water and groundwater problems. Figure 2 shows the sketch of the solar cell water pump mobile design composed of two systems: (1) cart, photovoltaic module (JY330P72; Guangdong Jinyuan Lighting Technology. Co., Ltd.), brushless DC motor (BLDC-500W-24V; POERSINO), and stroke pump (5100L; Kobota) can easily move by wheels go to a water source and agricultural area. The top side is composed of two solar panels of 660 W and the bottom side of the solar panels can adjusted the angle for tacking solar by rotated the cart. The advantaged stoke pump is a long horizontal and vertical transfer of surface water and good pumping groundwater. (2) solar cell charger, battery, monitor, and microcontroller to charge deep cycle battery storage, shows working electricity system of electrical power, electromotive force, electrical current. Moreover, the water flow rate was evaluated by a microcontroller and sensing to monitor. Propagate and transfer solar cell water pump mobile to Thai-agriculturist community total 70 devices. The solar cell water pump mobile was laboratory testing in center of excellence on alternative energy (CEAE) at Sakon Nakhon Rajabhat University (SNRU), filed testing at learning center to increase the efficiency of agricultural products in Thailand measured panel voltage and current of solar cell and water pump and sensor flow rate and quantity of water used for agriculture as shown in Fig. 3.

Fig. 2 Sketch of the solar cell water pump mobile design (a) side fold solar cell panels and (b) front fill out solar cell panels.

Fig. 3 The solar cell water pump mobile circuits.
3. Results and Discussion

3.1. Thai-agriculturist community context

We study the context of the Thai-agriculturist community to investigate water pumps supporting agricultural products and make data analysis are shown in Fig. 2.

![Target group diagram](image)

Fig. 4 The target and impact of the project promote of using renewable energy in pumping to agriculture using solar cells.

3.2. Design and fabrication of solar cell water pump mobile

The solar water pump mobile was fabricated by following the sketch and circuit design: there composed of brushless DC motor (24 V) 500 W, polycrystalline solar cell (330 W) two panels total 660 W, stroke pump 1 inch tagged pulley to high speed and highest torque, deep cycle battery (45 Ah) two batteries to good discharge and storage total 24 V, and flow rate sensor for monitoring water quantity are shown Fig. 5 However, the water quantity was depended on a pipe of stroke pump for example 1, 1.5, and 2 inches.

![Solar cell water pump mobile components diagram](image)

Fig. 5 The solar cell water pump mobile components.
The CEAE team attempted to gather data on as many pumps as possible in the field, resulting in a sample size of 3 pumps, owned by 200 agriculturists. The measured data included the number of turns in one minute (rpm), adjusting solar cell panels angle (°), maximum safe pumping rate (l/min), total amount water required per day (l), total water quantity, pump efficiency (%), minimum pump size (hp), and maximum pump size (hp), as shown in Table 1.

| Parameters                                           | Performance       |
|------------------------------------------------------|-------------------|
| Outlet pipe of stroke pump                           | 1 in              |
| Maximum horizontal water transfer                    | 250 m             |
| Maximum vertical water transfer                      | 10 m              |
| Maximum pumping ground water                         | 15 m              |
| Maximum pumping for full battery                     | 2 h 40 mins       |
| Brushless DC motor                                   | 24 V 500 W        |
| The number of turns in one minute                    | 486 rpm           |
| Adjusting solar cell panels angle                    | 0 – 70°           |
| Maximum safe pumping rate                            | 52 l/min          |
| Total amount water required per day (8 h)            | 24960 l           |
| Total water quantity                                 | 3.12 m3/h         |
| Pump efficiency                                      | 60%               |
| Total efficiency system                              | 33.39%            |
| Total hydraulic head                                 | 8                 |
| Minimum pump size                                    | 0.47 hp           |
| Maximum pump size                                    | 0.67 hp           |

Figure 6 shows the recorded instantaneous flow rate and time (3 h) for pumping water. We selected this system because it was also tested in the lab. As with the laboratory data, the total head and flow rate 40 - 50 l/min, respectively. As expected, the performance of the solar cell water pumps in the field is significantly reduced when compared to the laboratory data, this is assumed to be due to general usage. The average efficiency was 60 % again this low efficiency is attributed to the harsh nature of the environment. On average, the Thai agriculturist reported growth the Legumes, chili, and grass expected solar cell water pump lifetime to be 2 - 3 years before needing replacement due to rust. Note that the lifetime of structural components in a harsh environment is extremely difficult to measure in a laboratory and speaks to the importance of field research. Therefore, with an extremely limited sample size and no available performance data on the same solar cell water pumps used in different environments, these results must be taken with a suitable for agriculture that does not use a lot of water.

The pump efficiency ($\eta_p$) is given by the following equation [11]:

$$\eta_p = \frac{P_h}{P_e} \quad (1)$$

where $P_h$ is hydraulic power output of stoke pump and $P_e$ is electrical power input to the stroke pump.

The total efficiency ($\eta_{sys}$) is given by the following equation [11].:

$$\eta_{sys} = \frac{P_h}{G \times A_{array}} \quad (2)$$

The total hydraulic head ($H$) is given by the following equation [11]:

$$H = \eta_{sys} \times G \times A_{array}$$
\[ H = \frac{p_h}{\rho Q g} \]  

(3)

where \( \rho \) is fluid density, \( Q \) is flow rate and \( g \) is gravitational constant.

Fig. 6 The relationship between time and water flow rate of pumping water.

We design a diagram of microcontroller components of solar cell water pump mobile by using the sensor to send data of speed motor, voltage solar cell, current solar cell, flow rate water, volume as shown in Fig. 7 and Fig. 8.

Fig. 7 The relationship between time and water flow rate of pumping water.
3.3. Propagate and transfer the solar cell water pump mobile

We selected the learning center to increase the efficiency of agricultural products groups in Thailand for propagate and transfer the solar cell water pump mobile. They can propagate and apply knowledge and solar cell technology to another agricultural device are shown in Fig. 9.
4. Conclusion

The solar cell water pump mobile was developed with solar cell panels and a stroke pump to solve critical water problems and manage surface water and groundwater of Thai-agriculturists. The solar cell water pump mobile can long horizontally transfer water about 350 m, highest vertical transfer about 10 m, maximum safe pumping rate around 3000 l/h, and total amount of water required per day about 24960 l, which is therefore suitable for agriculture that does not use a lot of water enough such as Legumes, chili, and grass. The learning center to increase the efficiency of agricultural products in Thailand can propagate and apply knowledge and solar cell technology to another agricultural device. In future work, the solar cell water pump mobile will be controlled by a smartphone and possibly with artificial intelligence for setup demand of quantity of water of agriculturalists.

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