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Feasibility assessment of renewable energies for cassava irrigation in China

Chenyao Xiang[a], Jiahong Liu[a*], Yingdong Yu[a], Weiwei Shao[a], Chao Mei[a], Lin Xia[a]

[a]State Key Laboratory of Simulation and Regulation of Water Cycle in River Basin, China Institute of Water Resources and Hydropower Research, Beijing 100038, China

Abstract

In recent years, clean energies are more and more valued. Applying wind power and solar power to farm irrigation can contribute to energy saving and carbon emission reduction. Based on the irrigational water demand of cassava in an area in Guangxi Province, China, this study compared the supply capacity of hybrid wind/solar power water pumping and that of photovoltaic (PV) water pumping through experiments and calculation. Results show that, the hybrid pumping system supported by a 22kW solar panel and wind turbines of 44kW can fully satisfy cassava's water demand for irrigation in a 26.66 ha field with surplus energy, so shutdown of wind turbines in the initial stages of cassava growth is suggested. The 22kW photovoltaic water pump alone is not sufficient for a 26.66 ha field, but a 1.5-time larger solar panel (33kW) with an enhanced pump should be able to meet the demand. Considering local uneven distribution of wind power and relative high cost of a hybrid power system, the enhanced photovoltaic water pumping is recommended for popularization.

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Keywords: hybrid wind/solar power water pumping; photovoltaic water pump; cassava irrigation; feasibility analysis

1. Introduction

The applications of solar and wind power technologies are increasingly welcomed into agriculture recently. In remote regions beyond the reach of the power grid, it is difficult and expensive to irrigate farmland and grassland with electrical pumps, while another option, diesel or propane water pump, not only requires fuel constantly, but also

* Jiahong Liu. Tel.: +86 10 6878 1936; fax: +86 10 6848 3367 (O).
E-mail address: liujh@iwhr.com .

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produces noise and air pollution, raising concern about environmental damages. In this background, the irrigation systems powered by clean, renewable energies are widely desired. The cost of a diesel pump is usually 2-4 times of that of a solar photovoltaic pump, when operation and maintenance cost are considered [1]. Meanwhile, the steady downward trend of the price of good-quality photovoltaic pumps enables its popularization in rural areas for small scale irrigational purposes [2].

Photovoltaic (PV) water pumping transforms solar energy to electricity via photovoltaic technologies, and eventually supports a pump to lift water. Early versions of photovoltaic pumps used direct-current generators and alternate-current motors with variable frequency. Their water head efficiency was at around 15%~25%. Since then the techniques of pumps and motors have significantly advanced, together with tracking devices. Currently, solar-energy pumps in the market can reach water head from 5 m to 200 m, and provide a maximum flow of 250 m^3/d [1].

Mechanical windmills have been used to pump water. Small wind turbines are not as popular as solar PV arrays or mechanical windmills [3]. One concern raised is its high maintenance cost. However, in some regions solar power is deficient. Therefore, hybrid wind-turbine/photovoltaic array systems have been studied. These systems when equipped with battery backup have shown to be more reliable [3].

In recent years, several pilot sites have successfully combined photovoltaic water pumping and water-saving irrigation techniques, including Qinghai, Inner Mongolia and Xinjiang Province [4]. Those practices proved it feasible to irrigate without the help of the power grid. Guangxi province has also succeeded in applying solar-power water pumping in rural hydraulic engineering, including two drinking water infrastructures and four irrigation infrastructures.

Wind/solar hybrid water pumping and photovoltaic water pumping are both common alternatives for farm irrigation without the grid. However, because the relatively high expense of the hybrid system and the possible deficiency of solar power alone, sometimes it can be difficult to determine between the two options. To the best of our knowledge, there has been no study on the feasibility of using hybrid power and solar power in irrigational water pumping in the southwest China. The present study therefore aims to assessed the feasibility of using clean energies (namely wind energy and solar energy) to irrigate farmland for cassava in Guangxi Province, where cassava occupies more than 2600 km^2 farmland, and attempt to determine the better choice. Results of this study could provide information for popularizing clean energy for cassava's irrigation in Guangxi Province and other similar regions worldwide.

2. Materials and methods

2.1. Study site and equipment

The study site is located in Mingyang Farm in Nanning, Guangxi province. It has a subtropical climate, with long summers and short winters. Sunlight and precipitation there is abundant. Local landform is mostly low hills and plains. According to long term observation data, the mean annual temperature there is 21℃. The mean annual sunshine duration is 1850 h, and peak period of sunshine in a year is from July to September. The mean annual precipitation is 1292 mm, but it is distributed unevenly during the year, concentrating between May to September. The mean annual wind speed is 2.3 m/s at 2 m height.

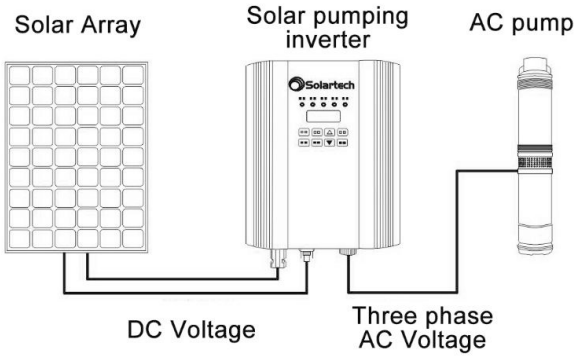

Figure1. Sketch of the photovoltaic pump