Sustainable Farming: Application of Solar Power for Irrigation on Small Farms

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Abstract

The movement and distribution of water is among the most important aspects of farming, and as the global population continues to increase there is a need to improve the sustainability and efficiency in this area. Smaller farms comprise a significant part of the farmland in the United States and are even more prevalent in developing nations. These farms often do not have elaborate irrigation systems and rely on gasoline-powered pumps. Unfortunately, these pumps cause a significant risk of fuel spills and create a dependence on fossil fuels. On the other hand, solar-powered appliances utilize the energy already present at farms. Sunlight is essential for growing crops, and now we have the technology to extend the energy from the sun to also power the mechanical needs of farming. This provides farmers with independence and the convenience of a more self-sustaining farm and would be a natural progression of sustainable and water-smart agriculture. To facilitate this development, a mobile system for a solar-powered electric pump was designed. The unit has a solar panel that charges a lead-acid battery which in turn powers a DC pump. Thanks to the battery, the system can store electricity, and be used on demand similarly to fossil fuel-powered alternatives. The unit was designed for and tested on a sprinkler irrigation system. However, because smaller farms may have unique water systems, the solar-powered pump can also be used to transfer water between different reservoirs or enable gravitational irrigation by pumping water to an elevated storage.

Introduction

Because small-scale farms generally have not invested heavily in elaborate irrigation systems, they have smaller barriers to adopting changes or a new system. The goal of this project is directed towards smaller scale farming where it will be easier to introduce solar and promote a transition towards renewably powered agriculture. With low maintenance and no long-term fuel costs, a solar-powered pump is a financially profitable investment. It is thus a viable option for established farms here in the United States or in developing nations.

Objectives

- Design a solar-powered alternative to fuel-powered pumps and facilitate a transition to renewable energy within small scale farming.
- Have a simple and effective design for a solar irrigation system that allows users to understand and use the unit similarly to a fuel-powered system.

Figure 1. Solar Irrigation Pump attached to rainwater supply.

Methods

- Literature review of agriculture-related research to determine applicability and desired design features (1).
- Evaluation and calculations of the ideal configuration of the solar panel and the capacity of the other components of the system.

Design

Smaller farms often have unique methods for irrigation and water use. Flexibility was therefore an integral part of the design. The pump has two rubber hoses which can connect a water supply and an irrigation system or transfer water between two water storage tanks. The system also includes a particle filter that allows the pump to handle dirty water and be used for drainage work or even storm cleanups.

Because electrical pump systems typically have multiple components, solar-powered alternatives may be favored because they are easier to handle and transport. Mobility is therefore another important aspect of the design. The unit has a compact design with the components being attached to a steel plate underneath the solar panel. This way, the entire system is kept together and fits on a cart that can easily be pulled or towed to where the pump is needed.

Figure 2. Solar-Powered, Mobile Irrigation Pump.

Finally, integration of new technology often meets resistance due to users not knowing how to use the appliances. Having a design that is intuitive and easy to understand is thus a key component for promoting adoption. Thanks to the charge control unit, the electrical circuit is greatly simplified, and the system can be operated with a simple on and off switch.

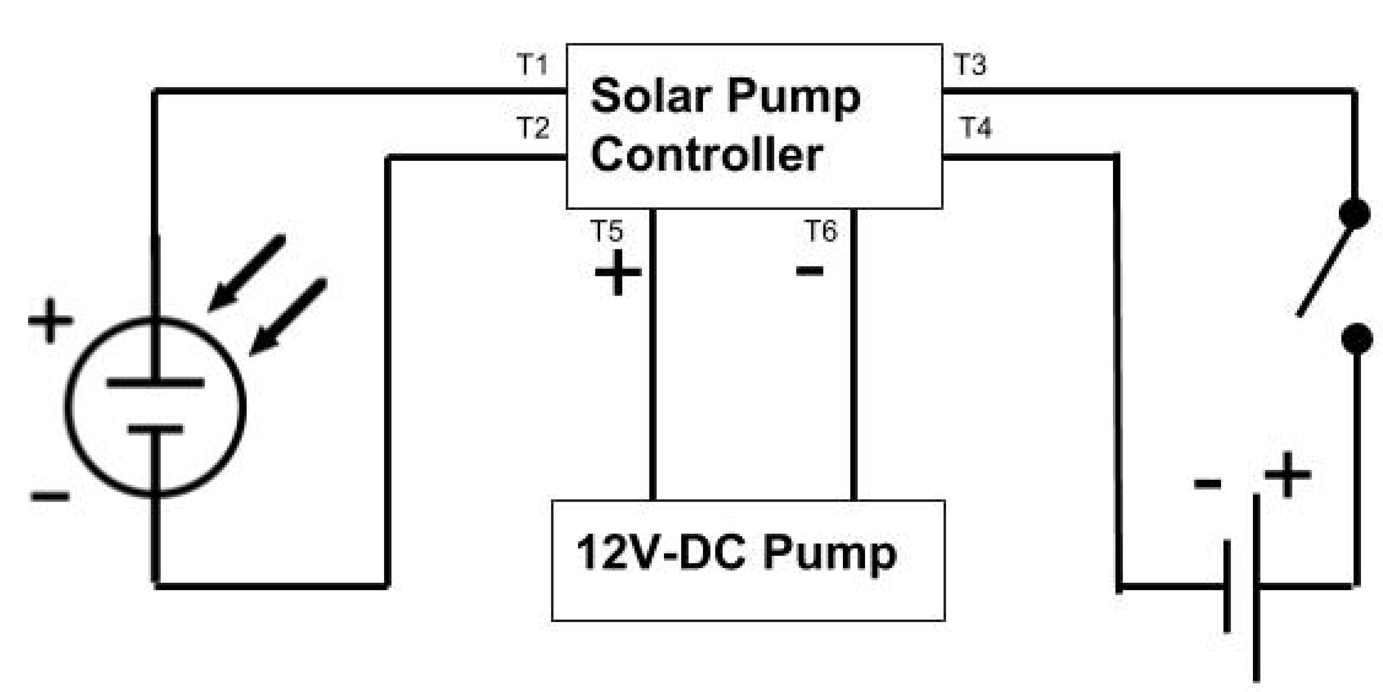

Figure 3. Pump Unit Circuit (Solar panel on left, Battery on right).

Table 1: System Components

Solar panel Rural Power Systems SMG-100W-18	Monocrystalline 100 Watt Dimensions(mm):670x945x30
12V Battery Deep Cycle Marine 24DC-1	Voltage: 12V Amp-hours: 58.33 Watt-hours: 700
12V-DC Pump RONDA DP-35	Max current: 7A Max pressure: 130psi Flow rate: 0.26-2.51 GPM
Solar Pump Controller Rural Power Systems	T1 & T2: + and – for solar panel T3 & T4: + and – for battery T5 & T6: + and – for pump

Application

The system is composed of a solar panel, a 12V battery, a 12V DC pump, and a charge controller that links the components together. In sunny conditions, the 100-watt solar panel can produce a current of about 7 amps through the circuit. Assuming about 6 hours of usable sunshine daily, this gives enough energy to power the pump for about 6 hours. The pump has a flow rate of 2.51 GPM at 7 amps. Thus, the system can supply about 900 gallons daily, or with a fully charged battery a total of 1,200 gallons. While water demand varies with different crops and soil conditions, sprinkler and drip-irrigation systems require about 4,000 and 1,000 gallons per acre per day, respectively (2). This solar-powered system is thus well suited for smaller scale irrigation demands.

Future Work

- An analog or digital timer could be integrated in the electrical circuit. This would allow the unit to perform irrigation at ideal times without supervision.
- For larger farms, the system could be scaled up with larger solar panels, batteries, and a more powerful pump.
- Pumps at this scale have a tradeoff between the flow rate and pressure they can supply. A more specialized unit could therefore have a higher pressure for sprinkler systems or greater flow rate for drip irrigation.

References

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