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Solar Water Pumping Guide

GSES® global sustainable energy solutions

First Edition Australia

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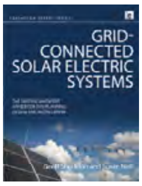
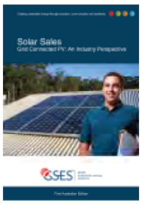
GSES Publications

		Quantity	Price (inc. GST & freight)
	*Grid-Connected PV Systems: Design and Installation 7th Edition* A comprehensive handbook that contains detailed information on designing grid-connected photovoltaic (PV) systems, including descriptions of the different components, sizing a system, matching components, conducting site surveys, system installation, troubleshooting, maintenance and the economics of grid-connected PV systems.	____	$143.00
	*Grid-Connected Solar Electric Systems* The solar PV industry has grown immensely in recent years, resulting in a demand for entrants into the Renewable Energy Sector to be knowledgeable of solar power and products. This book is intended to provide readers with a non-electrical background information on solar technology and the issues faced when designing, installing and maintaining grid-connected solar PV systems.	____	$60.00
	*Solar Sales – Grid-Connected PV: an industry perspective* What does it look like to sell solar power effectively? In this book, GSES provides theoretical and technical information regarding selling solar power so that businesses and the end customer receive the best outcome from solar technology.	____	$25.00
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Introduction

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Introduction

Increasingly it is being made obvious that communities need to be able to access and distribute water reliably, efficiently and cheaply. There are many different technologies that have been implemented for water pumping: some which drive the pump directly, such as windmills and diesel pumps, and others which generate electricity to power an electric pump, such as petrol/diesel generators and pumps powered by the electricity grid. The use of solar photovoltaic technology to power an electric water pump has increased consistently as the interested parties, e.g. farmers, mining, remote villages better understand the potential and benefits of solar power used in this way.

Solar PV as a power source for rural and remote water pumping has many advantages. The electricity generated is clean (producing no emissions), cheap (having no fuel costs) and reliable (generating whenever the sun shines). Solar water pumps can be installed wherever there is sunlight. Solar pumps are also particularly useful for remote applications as they have low maintenance requirements.

This Guide and how to use it

This guide on solar pumping includes information on:

- How the technology works,
- Where it is best suited as an improvement to an existing operation,
- The economic case for adopting a solar pumping system, and
- Which parameters to consider when deciding on the feasibility of the technology for a particular application.

This guide is not designed as a fully comprehensive decision making tool. While there is valuable information that will provide better understanding of the available technologies, it is important to understand that there is a complex and unique decision making process inherent in selecting the correct system for each application. While this guide will provide advice and understanding, we recommend that you consult with a qualified professional before deciding on the type and size of a solar PV pumping system.

Key sections

This report is organised into the following sections:

- Section one is titled 'Solar PV pumping systems'. This section offers an introduction to solar PV pumps and describes the purposes best suited for their application. It also details the key questions that should be asked in order to determine if solar PV is right for a particular purpose.
- Section two is called 'Technology background'. It covers the types of configurations that can be used and provides information and technical details about the characteristics and considerations that are involved with all the main system components that can make part of a solar PV pump.
- Section three, titled 'Design process', outlines the process of designing a PV system that will meet a given set of requirements: the example used for this section is based on farming.
- Sections four address the various requirements and standards involved in the installation and commissioning of solar PV pumping systems.
- Section five sets out maintenance considerations for both pumps and the solar equipment.
- Section six, 'System economics', outlines the methods and process of reviewing the financial case of a solar PV system compared to alternative solutions (such as using grid power or diesel powered motors).

1 Solar PV Pumping Systems

Solar PV pumping systems

A solar water pumping system utilises energy from the sun to pump water. A typical solar water pumping system contains the following equipment: a solar array, which converts sunlight into electricity; system controllers, which control the array and the pump; an electric motor, which drives the pump; and a water pump, which moves the water from a source to its delivery point (Figure 1.1).

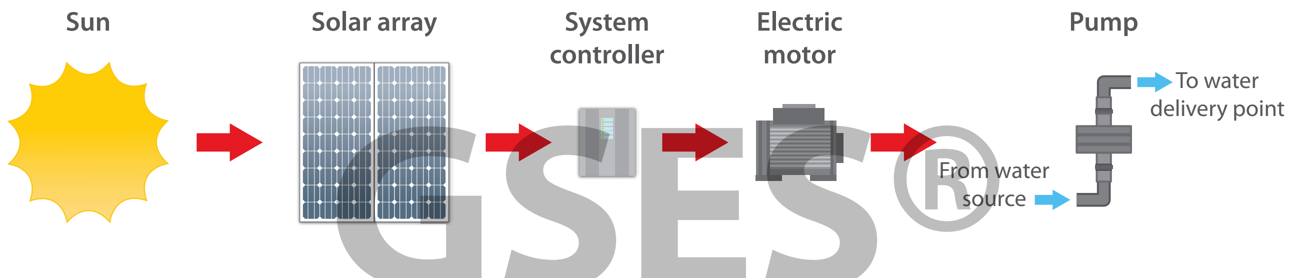

Figure 1.1 - The basic components of a solar water pumping system. (Source: GSES)

The solar array provides the energy required for the system. The energy produced by the solar array fluctuates due to changing solar radiation during the day. The solar array also produces no energy during the night. Therefore the solar pumping system needs to be designed to pump the daily water requirements within these energy limitations. The size of the solar pumping system is determined by the amount of water that needs to be moved and how far and high it needs to be moved.

The energy, power and water flows in a simple solar water pumping system are shown in Figure 1.2. If desired, optional energy or water storage can be included in the system. These store excess energy generated on days where solar energy is higher than average, either by pumping extra water and storing it, or by storing the extra electricity generated in battery storage. Water can then be provided on very cloudy days or overnight.

Most solar power pumping systems in Australia do not include battery storage. Instead they rely on accurately sizing the system to pump sufficient water each day and, in some cases, using water storage.

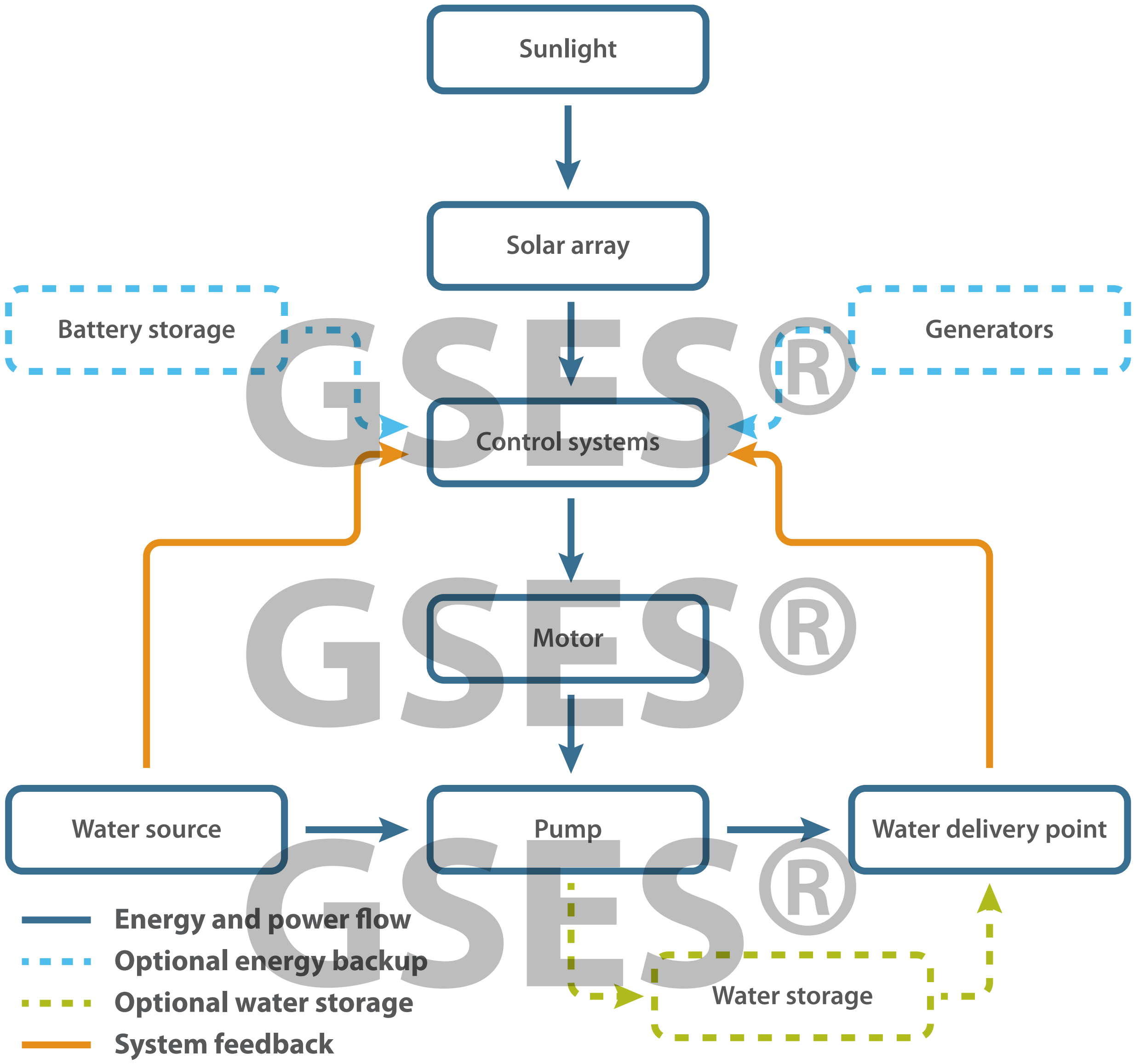

Figure 1.2: The energy flows in a solar pumping system. (Source: GSES)

A brief explanation of the key components follows:

- **Solar radiation (sunlight):** The amount of energy received from the sun at a given location. This determines how much power each solar module will generate in a day, and thus how large a solar array must be to pump a required volume of water. A site with low solar radiation levels will need a larger array than a site with high solar radiation levels.
- **Solar array:** A generator that converts solar radiation into electricity. An array consists of solar modules (the generation components), a mounting structure, and electrical safety equipment (known as electrical protection).
- **Control systems:** The units that control the array and the pump. The array control system is for optimising the production of electricity from the sun and matching the electricity to the pump motor requirements. The pumping control system will manage when, and for how long, the pump operates.
- **Pump and motor:** The pump moves the water from a source to its delivery point. It needs to be powerful enough to move the necessary volume of water over the required distance.
- **Battery storage and other generators:** Backup electricity can be provided by batteries storing excess solar energy or by additional generators, such as a wind turbine or diesel generator.

1.1 What can solar PV pumps be used for?

Solar systems provide power whenever the sun is shining. This means that they provide power during the daytime and all throughout the year. When designed properly, they can give a steady and reliable water supply, as seen in rural applications. These rural or remote applications are generally used as bore, dam or stream pumps, or potentially as pumps for pressurisation. They can also be used for other purposes.

While solar water pumps have no fuel costs and low maintenance costs, they generally have a higher upfront cost than other pump technologies. Generally solar is well suited to pumping requirements that are regular and consistent. Solar may not be financially worthwhile for pumps that only run for a portion of the year, such as some irrigation pumps. An example of a financial analysis for a rural, broad acre irrigation system is found in the economics section of this report (Section 6.3).

1.1.1 Stock drinking water

The drinking water requirements for stock are generally consistent throughout the year, making this application well suited to solar water pumping. Water can be pumped during the daytime from the bore/dam/stream to a stock dam or water troughs each day.

1.1.2 Domestic water and cleaning

Domestic and cleaning water requirements are generally consistent throughout the year (although often needed at night). They often require pressurisation. Depending on the volume of water required, solar PV can be used in these applications together with some form of energy storage, such as batteries. The storage will usually be required to provide power on demand. This would increase the upfront cost of using a solar pumping system.

1.1.3 Irrigation systems

Irrigation water requirements vary drastically depending on the crop. Fruit tree plantations generally require irrigation throughout the year, with increased irrigation during fruit production. These irrigation systems may be naturally suited to solar pumping, especially if more water is required during the summer months (e.g. blueberries). This is shown in Figure 1.3.

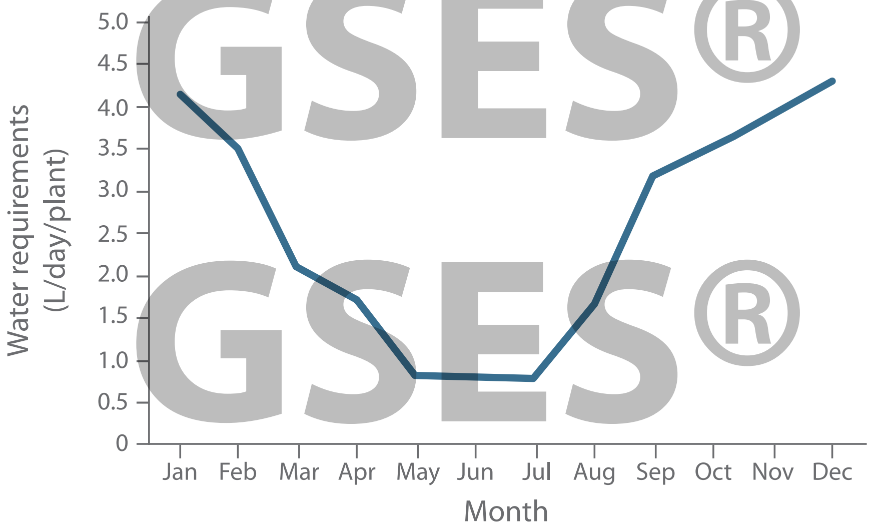

Figure 1.3: The water requirements of a blueberry tree. (Source: PrimeFacts, NSW DPI)

Irrigation for broadacre crops usually occurs during certain periods of the year. For example, some broadacre crops are irrigated over 6-8 months, such as rice and lucerne, whereas others are irrigated at certain times of the year, such as wheat and mung beans. Using solar power to pump large amounts of irrigation water only a couple of times a year may be less cost effective than using other power sources, such as diesel. However, it may be still worth considering solar power, especially if there are other applications that the solar pumping or solar power can be used for during the times of the year when irrigation is not required. An example of the water requirement for a cotton crop can be seen in Figure 1.4.

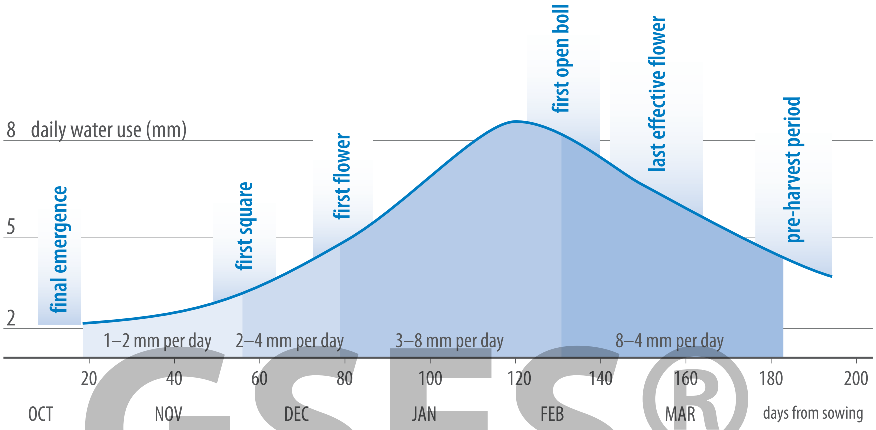

Figure 1.4: The water requirements of a cotton crop. The irrigation scheme runs for approximately 6 months of the year. (Source: WATERpak, Cotton Research and Development Corporation)

The irrigation requirements of broad acre crops can be very large. This might mean that there is not a solar pump package large enough to supply the full water requirements. However, there may be the option to install a custom solar system and pump, or options for integrating solar with other fuel sources to reduce the overall operating costs of the pump.

EXAMPLE

Rice is a summer crop, which uses approximately 2-3ML of water/hectare per month over a six month period. Even though there would be unused solar generation during the winter months when there are no irrigation water requirements, solar pumping could still be more cost effective than a diesel pump. The system could be optimised to produce the most power during the summer months.

Mung beans are a spring or summer crop requiring two irrigations approximately one month apart. They require a total of about 4ML/hectare. The infrequency of these irrigations means that a solar pump may not be the most cost effective option. A large solar system would be required to pump the large volumes of water. If there are no other loads for the solar array, this power would be wasted at other times of the year.

Is solar pumping right for me? Which configuration would be most suitable?

There are several questions that can be asked to decide whether solar pumping is feasible, both technically and economically, for a particular application and, if so, which configuration would be suitable:

- ***Is there an existing water pump?*** An existing pump that is not driven by electricity (e.g. a diesel motor) cannot be integrated with solar and would need to be replaced, incurring financial costs. It may be possible to integrate solar with an existing electrical supply (e.g. diesel generator or grid) to reduce the operating costs of an electrically driven pump.
- ***What is the cost of operating the existing water pump?*** A solar pump has high upfront costs, but low operating costs. Replacing an existing pump with a solar pumping system may result in significant savings over the life of the system. Integrating solar with an existing power supply could reduce operating costs.
- ***How far away is the proposed pump site to the electricity grid?*** A solar pump can be used to power a pump that is far away from the grid and for which a solar/grid configuration would not be feasible. The solar pump could potentially pump water to a location near the electricity grid for grid-powered pumping or pressurisation.
- ***How often is the pump used?*** Pumping applications requiring regular operation are well suited to solar pumps. It may be more economical to use a mobile fuel generator for pumps that are only used a couple of times a year.
- ***What time of day does the water need to be pumped?*** A solar pump will pump water during the daytime. Applications that need water at night or only on-demand should consider combining solar with water storage or battery storage. It may also be more economical to use a different pump technology.
- ***How much water needs to be pumped?*** Solar pumps can be designed to pump large volumes of water. However, it may be more economical in such applications to install solar for the purposes of reducing the size of a main generation unit rather than using solar as the only power source.
- ***Is there existing water storage?*** Solar pumps are well suited to pumping water to some form of water storage where it can be used when needed (e.g. stock dam), gravity fed or fed on-demand by an alternate power supply.
- ***How critical is the pumped water?*** An application that has very specific water needs may be more suited to solar combined with batteries, generator or grid.
- ***Will the water be pressurised?*** Pressurised systems require a consistent energy source. Combining solar with batteries could provide this consistency. Otherwise it may also be more economical to use a different pump technology.
- ***How much will a solar pump cost compared to other pump technologies?*** Solar water pumps are often an economical choice for a rural water pump as they have minimal operating costs and low maintenance requirements. However, for some applications the upfront and operating costs of the solar water pump and any additional equipment may not turn out to be less than the upfront and operating costs of another pumping technology. See Section 6 for more on system economics.

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