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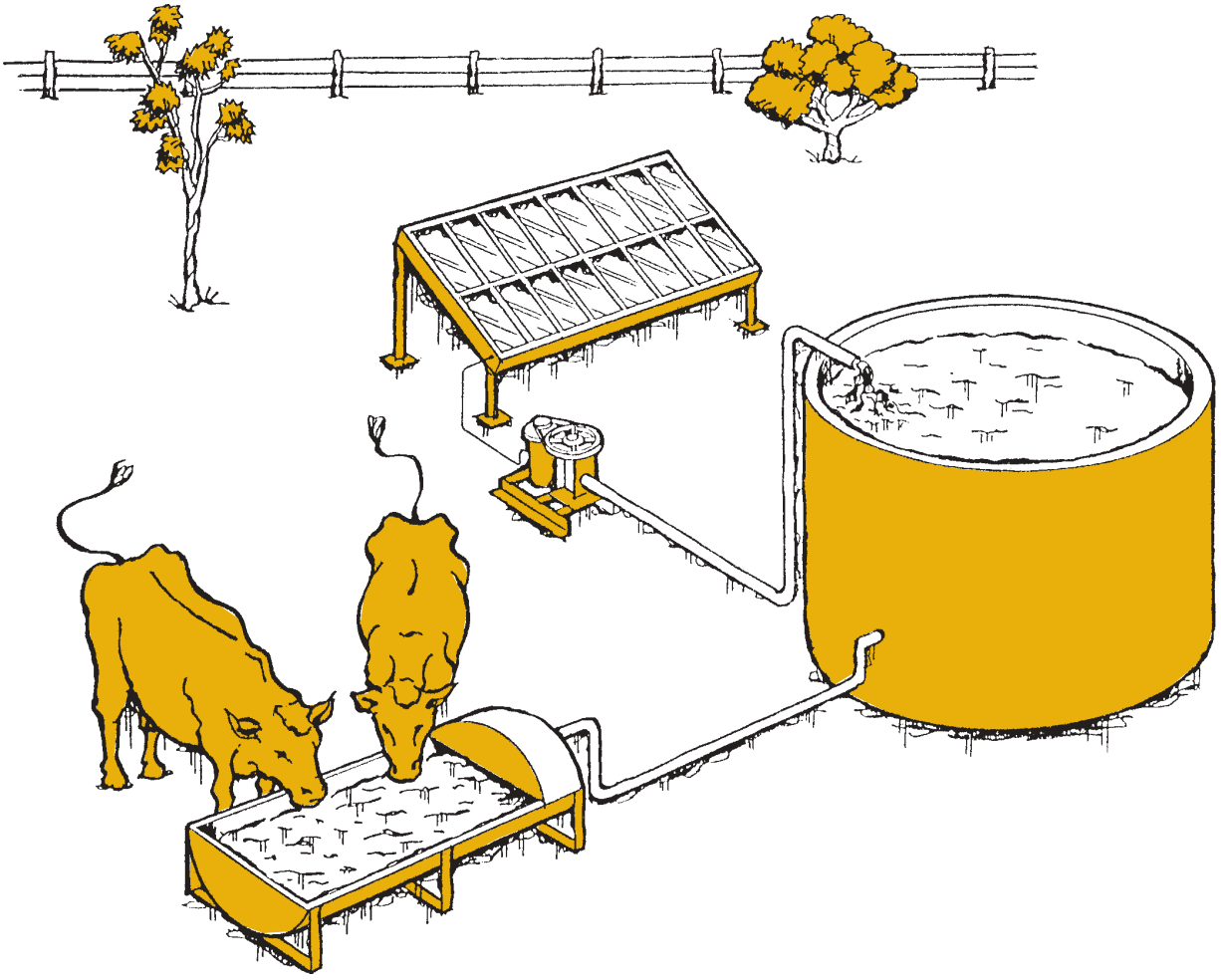
Renewable Energy

Solar Water Pumping



- **Solar pumping uses a free, easily accessible and renewable source of energy. Power bills are eliminated.**
- **With solar pumping maintenance costs are minimised. Solar modules are strong, robust and encapsulated into toughened glass in a sturdy, aluminium frame that will last even in harsh environmental conditions.**
- **Using solar allows opportunities for livestock, vegetables, trees and other crop production to be developed in areas where other forms of pumping are impractical.**
- **Solar water pumping systems are reliable. Solar systems won't fail on those hot, still days when the windmill stands motionless.**
- **Solar water pumps perform at their best and provide water throughout summer months when demand is greatest.**
- **Solar water pumping systems need little supervision requiring only periodical checking. Solar pumps automatically start soon after sunrise and continue to work unattended until sunset.**
- **Solar water pumping systems operate all year round, even on cloudy dull days with little or no direct sunlight.**
- **Solar water pumping systems can be designed to be transported for use at a number of sites. This can eliminate the need for multiple pumping units.**
- **Solar modules have no moving parts and an expected working life of at least 20 years.**

What is a solar water pumping system?

Pumping water is a sensible and effective use of solar electric power. During the hot months, when water requirements are highest, a solar pump will provide a reliable water source for the farm. Wind power, by comparison, can be inconsistent, and may not be available during the hottest months in many inland areas. Wind may be too unreliable for water pumping when a relatively constant supply is required, as for stock watering.

A solar water pumping system is essentially an electrically driven pumping system. Electricity, in this instance, is produced by the sunlight energising photovoltaic (solar) modules.

The typical solar cell is a thin wafer of silicon that transforms light energy into electrical energy. The cells are encapsulated in flat modules to protect them from the weather. Any number of modules can be connected together to form an array. The array is sized to meet a pumping systems' power requirements.

A solar pumping system is available for almost all applications where an electric pump can be used.

Because solar energy varies from one location to another, and over the course of a day, system design is important. Adequate water storage ensures that water is available whenever needed, and balances daily variations in water supply and demand. Thus a small pump only running when the sun shines, plus water storage, can provide the average requirement for water supply.

For the best electrical and mechanical performance, all components of the solar pumping system must be carefully matched. Correct sizing of the pump, motor and controlling devices, will allow the system to operate at the highest efficiency to ensure economical water pumping.

Types of solar pumping systems

Although solar water pumps have been developed from some fairly sophisticated "hi-tech" components, they are relatively simple, uncomplicated packages of equipment.

Solar water pumping systems consist of three basic components:

- Power source (photovoltaic solar modules)
- Motor/pump (or motor/compressor) assembly
- Power controllers for matching the changing electrical output of the array to suit the motor/pump

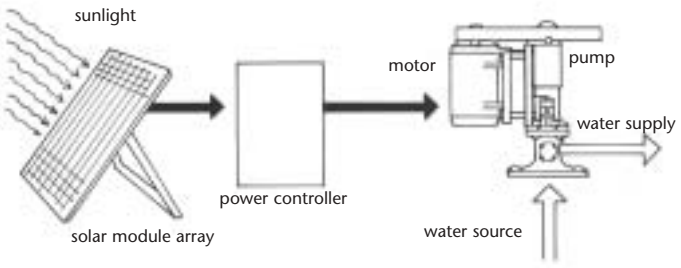


Figure 1. A typical solar water pumping system

A. Power source

Each solar cell produces about 0.5 volts in bright sunlight. Solar cells are linked together in a series to form a module and to produce the required voltage. Solar modules are linked together in a series and in parallel to provide the power levels needed for the required application. Typical system voltages are 12 volt and 24 volt, 48 volt, 110 volt and 180 volt DC.

The linked modules, called an array are usually fixed to a light aluminium structure and can be mounted on the ground, on a roof or on a trailer.

In Australia, an array should face 'true' North. The tilt angle is set to suit the season and the latitude of the pumps location. As the sun varies with the season, the angle of the solar array may be further adjusted to achieve maximum output (see Figure 2), although the gains produced by this method are small.

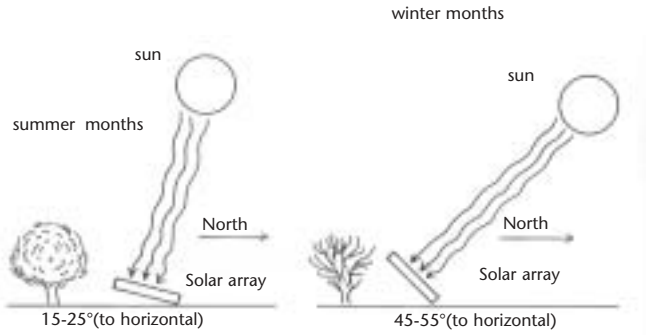


Figure 2. Seasonal changes in array tilt angle to maximise pump output

Sunlight levels vary with latitude and a larger solar array would generally be required the further south the location.

Extra performance, possibly up to 30% can be achieved by turning the solar array to track the movement of the sun throughout the day. These 'sun trackers' are automatic mechanisms that add complexity and extra cost to the system. However on larger systems tracking the sun can significantly reduce the cost of delivered water.

Photovoltaic cells convert sunlight into direct current (DC) electricity. Some solar water pumping systems use DC motors, whilst others use AC motors (alternating current) and incorporate an inverter.

B. Motor/pump assembly

Off–the–shelf, mass produced motors and pumps can be used for solar water pumping. Special pumps and motor have also been developed for solar systems.

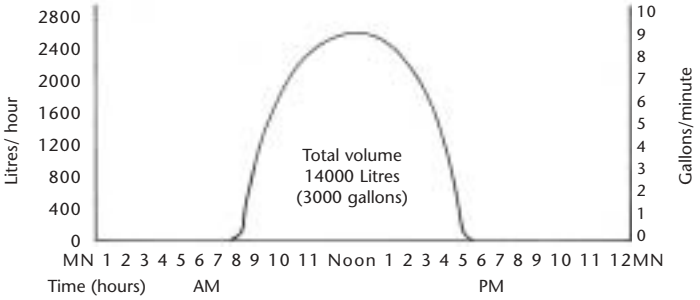


Figure 3. Typical variation of pump flow rate with time of day (average day based on four years solar data)

The power from a solar system and the volume of water pumped varies with the amount of solar radiation. This means that the system must be designed to work efficiently over a range of voltage and current levels (see Figure 3).

(i) Electric motors

Solar water pumps that are currently available, use the following types of motors.

- AC synchronous motors
- AC asynchronous induction motors
- DC series motors
- DC permanent magnet motors
- DC permanent magnet brushless motors

The permanent magnet DC motor achieves higher efficiencies, whilst the use of an AC motor in a solar pump requires an inverter.

(ii) Pumps

Centrifugal pumps

Centrifugal pumps are designed for a fixed head and their water output increases with rotational speed. Centrifugal pumps are not self–priming and are

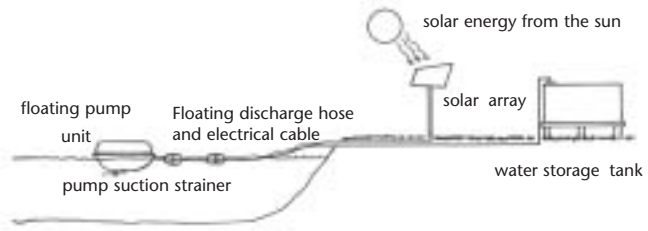


Figure 4. Typical installation of floating pump unit drawing water from river or shallow well

seldom used for suction lifts greater than 4–5m. Solar powered floating pumps are often of this type (see Figure 4). At low heads, centrifugal pumps are usually more efficient than positive displacement pumps.

Positive displacement pumps

Positive displacements pumps have a water output which is directly proportional to speed. Helical shaped rotor pumps have very few moving parts, operate at

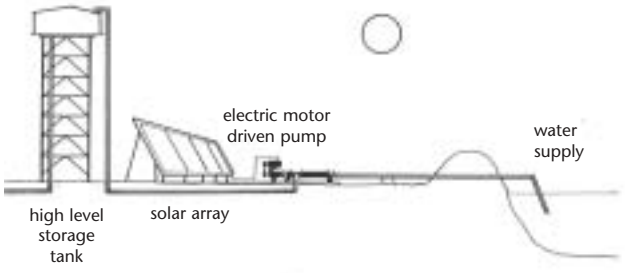


Figure 5. Typical solar powered pump unit for surface water supplies

low speeds and are able to handle dirty water. The flow is non pulsating and ideal for long distance pumping. The efficiency of the pump increases with head and consequently at higher heads, positive displacement pumps can be more efficient than centrifugal pumps (see Figure 5 and 6).

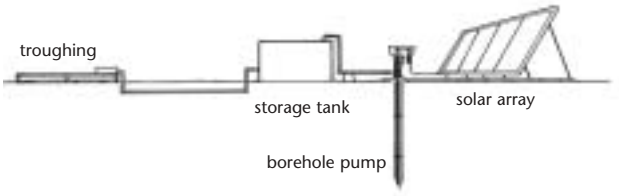


Figure 6. Typical solar powered borehole pump layout for stock watering.

Air lift pumps

These use an air compressor driven by an electric motor. The compressed air is piped to the bottom of the bore, the rising bubbles then 'pump' the water to the surface. This is very useful with dirty or sediment–rich water which may damage other types of pumps. This is usually the least efficient type of pump.

A specialised application of this principle is used to keep the water in reservoirs in good condition. Compressed air bubbling from the bottom of the reservoir eliminates the thermal stratification that can contribute to the contamination of the water supply.

C. Power controllers

There are several types of power controllers available:

- Impedance matching devices (such as power maximisers)
- DC to AC inverters (used with AC pumps only)
- Switches and protective controllers.

Impedance matching devices such as power maximisers, sometimes called maximum power point trackers (MPPT's), control the output of the array so it will operate close to its maximum efficiency (power) over a range of sunlight levels.

Note: MPPT's are electronic maximisers and should not be confused with mechanical array trackers.

Applications for solar pumping

Solar pumps can be used almost anywhere electrically operated pumps are used. However, the most cost effective applications of solar water pumps occur when either:

(a) there is a low power requirement;
(b) the area or application is remote and it is costly and time consuming to operate and maintain diesel or petrol engines; or

(c) where there is no reliable electricity supply readily available.

There are numerous applications where solar pumps can be used. The most common are:

- Livestock water supply
- Domestic and home water supply
- Irrigation—drip and spray jet
- Water transfer—eg. dam to tank
- Pumping to assist control of water salinity

Solar pumping–sizing checklist

When choosing a solar pump the following factors need to be considered:

- The amount of solar energy available in the location proposed
- The total dynamic head of the system
- The amount of water required
- The quality of water to be pumped

The sizing of the solar pumping system that suits your needs requires expert advice. Reputable manufacturers and suppliers of solar water pumping systems can accurately predict performances from various systems.

The amount of solar energy available will give an indication of the number of solar modules needed to provide the power to pump the required quantity of water at the calculated head.

The available energy and the amount of water pumped varies during any season. In order to avoid oversizing ask the supplier of solar water pumping systems to predict performance, so you can choose the system sized for your needs.

Water supply

Solar can pump water from bores, wells, creeks, rivers, dams or tanks. The available water supply must exceed your proposed pumping requirements. There are normally few problems with a river or large creek, but when pumping from a dam or bore its capacity should be known.

Water storage

Solar water pumping systems are generally not designed to operate as on–demand pressure systems. Water is pumped during daylight hours and stored for use as required.

Storage can be either in a dam or a tank. It is usual to position the tank at a height which allows sufficient pressure to reticulate the water to where it is needed. Storage capacity should be great enough to provide four times the maximum demand (which may last for several days) or for days of heavy cloud cover, when pumping rates are lower.

Water requirements

This is usually estimated in litres per day of the water needs of both stock, domestic use, and garden requirements. The following table will assist you in making an estimate. It would be useful to the solar pump supplier if you could also provide likely minimum/maximum demands.

Use	Litres of water per day*
Beef cattle	25–50/head
Dairy cows (in milk)	50–70/head
Horses	35–55/head
Sheep	3.5–7/head
Lambs	1.2–2.5/head
Domestic (kitchen, bathroom, toilet, laundry)	140–270/person
Garden sprinkler (10 litres/square metre to give good soaking)	About once per week as required

* The quantity of water drunk by animals depends largely on pasture conditions and the weather.

Note: Domestic consumption can increase by more than 50% when a house is connected to a septic system.

How much power is required for water pumping?

The amount of power that is required for a solar water pumping system, depends on the quantity of water to be pumped, the rate at which it is to be pumped and the total head at which the system must operate.

Total head consists of two parts:

(i) the static head (the height through which the water must be lifted), and

(ii) the dynamic head (the pressure increase caused by friction through the pipework and expressed as an equivalent height in metres).

The static head can be easily determined by measurement. The dynamic head depends on a flow rate (which must be based on the maximum pump performance in peak sunlight intensity), pipe sizes and pipe material. The smaller the pipes and the greater the flow rate, the higher the pressure required to force water through the pipe (see Figure 7).

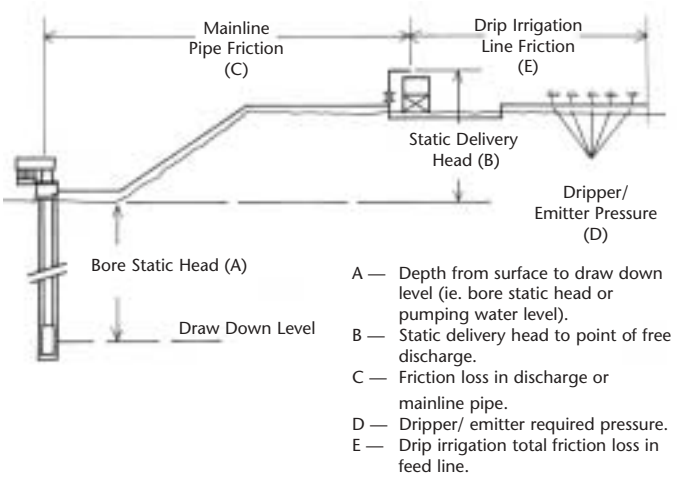


Figure 7. Illustrates some factors that influence the total head of the system

Because the major cost in a solar water pumping system still remains in the solar modules, it is more cost efficient to consider a large diameter pipeline to significantly reduce the dynamic head and so lower the power requirements of the solar pumping system.

Sizing the solar array (power required) to suit your specific needs and location, should be done in consultation with a solar pumping supplier.

What can you expect from your solar water pump?

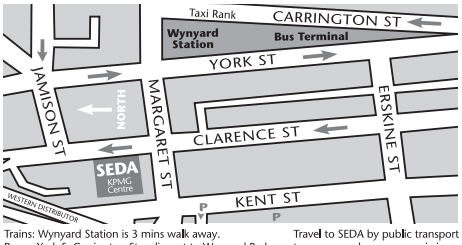
The cost comparison between wind, solar, diesel engines and electricity, show that water pumping can be very cost competitive in certain circumstances. Every application is different and should be evaluated on its merit, giving consideration to the following:

- initial cost of the system
- expected system life (15–20 years)
- running costs (eg., fuel and oil for diesel engines)
- maintenance costs
- time and labour to supervise the system's operation
- time value of money (discount rate of return).

Other factors such as fuel cost escalation, depreciation allowances and tax implications, should also be considered.

The true cost of solar water pumping systems when these factors are considered, may well be cheaper than you think. Check with your local supplier and get an accurate quotation for your application.

The Energy Smart Information Centre is a free advisory service provided by the NSW Government. Energy experts can provide information on a wide range of topics including Energy Smart design for new homes and renovations, appliance selection, solar and wind power systems, choosing heating and cooling systems, insulation, lighting and water saving devices.



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