Solar Water Pumping

Example engineering report

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Introduction

Water pumping is an important part of many communities and businesses. Without water agriculture and humans would not exist. In cities we have town water supplied and are ignorant of the length to which some rural communities must go to in order to have access to high quality water. In Sydney, water availability has become an issue with the drought and dam levels reaching record low levels. Many rural areas in Australia are very dry and require careful use of water to ensure that there is enough for every one. Traditionally, solar water pumping has been used in rural areas where mains electricity is not available to power pumps because it is cheap and reliable under these circumstances (South West Technology Institute, 1995). Solar water pumping also has a number of other applications as well as numerous system layouts that suit specific applications. With water being one our most precious resource, solar water pumping is an attractive alternative to mains electricity, petrol and diesel powered systems.

Photovoltaics and Water Pumping

Solar water pumping is particularly cheap and useful where no electricity grid exists and water must be used. All pumps need energy to operate, usually in the form of electricity. This can come from the grid, diesel generators, animal labor or photovoltaic panels (South West Technology Institute, 1995). The best way to understand solar water pumping is with an example:

> I am a farmer in central NSW and farm sheep and cattle that need regular water to remain in peak condition and prevent monetary loss to myself by dieing from dehydration. The water troughs that I wish to fill regularly with water are near a bore but 10km from the homestead where the grid finishes on my property. To extend the grid 10km costs about $100,000 and the upkeep on a diesel generator is high as fuel prices increase, higher maintenance costs, they are unreliable and frequent trips to the generator is time consuming. Having done some research I feel the best and most economic solution is direct pump photovoltaic powered system, which, if correctly designed will run reliably and with low maintenance costs for up to 30 years and costs below a small fraction of the grid extension price depending on the desired water flow rate and the size of the photovoltaic system. Not only is it relatively cheap and low maintenance but it operates during the day which is when the animal need most of their water. I can also put a timer (troughs can be automatically filled by timing) or float valve (automatic trough refill when they reach a certain low level) connected to the pump (EERE, 2005).

The example above has been used to highlight how solar pumping can be used in an agricultural situation. There are many other applications of solar water pumping which provide similar benefits in low maintenance, high reliability and low cost and are listed in the next section.

Applications of Solar Water Pumping

Solar water pumping is particularly well suited to rural areas where no grid is available. This is mainly due to the expanse but also the low maintenance involved with a solar system. Some of the common applications include (S Wenham et.al, 1994):

- Filling agricultural troughs for watering livestock
- Filling water tanks for homes, irrigation and stock
- Providing drinking water to remote communities in developing countries
- Supplying small town with water from remote water reserves where grid powered pumping is not possible
- Fountains and water features in backyards and large areas (not a common application)

How Solar Water Pumping Affects Society

The use of water pumping has many effects on society. They vary from affecting the owners of the system to the general public and even the entire world. These effects include:

- Prevents expense of extending the grid – this has a double impact in reducing costs. It means that the grid extension that may cost tens of thousands of dollars is not required. All utility grid lines require maintenance and upsizing periodically. The cost for this are considerable and are paid for by all users of the electricity grid through the access charge and can be avoided if solar systems are used to prevent grid line extension (EERE, 2005).
- Allows farming and agriculture to exist in areas where no grid electricity is available – farming in many areas of Australia is in isolated areas and requires large energy requirements for water pumping in these often dry areas. Solar pumping is ideal in this situation because it can pump large amounts of water at a cheap price and with little maintenance (EERE, 2005).
- Reduces expense for the people who install it – The use of a solar water pumping system is often in remote areas with difficult road access. As a result of low running costs and little maintenance requirements solar pumping systems can be attractive. This is particularly the case when compared to extending the grid network, trucking water or installing notoriously unreliable diesel generators. Trucking and generators have a high fuel cost and due to the pumping often being in remote areas can be time consuming to refuel etc (S Wenham et.al, 1994).
- Reduces maintenance required on the pumping system – The solar component of the system has very low maintenance requirements, but does depend on the type of system being used (M Thomas et.al, 1994). The different system layouts are discussed below but a direct pump system has the lowest maintenance requirements with the only moving parts being the pump itself. Slightly more maintenance is required for battery systems but I still much less than a diesel powered system where engine overhauls are required regularly, which are time consuming and costly South (West Technology Institute, 1995).

- No increase in GHG production by not needing any more coal fired power – If the pump was to be operated using mains electricity, (ie extend the grid lines in the above example) more electricity would need to be produced to provide the extra power to the new load. In doing this, extra greenhouse gases would be produced which contribute to climate change. By using a photovoltaics system, greenhouse gas production can be minimized and reduce the onset of climate change.

Will this Application be useful in the Future

Yes, this application of solar energy will be useful in the future. This is simply because it is the cheapest way to pump water in remote areas where grid electricity is not available. Compared to extending the grid, solar power is cheap, low maintenance, reliable and long lasting which makes it very attractive to farmers, owners of other remote properties and remote communities (South West Technology Institute, 1995). Another area where solar water pumping will continue to be used is in remote area of developing counties to provide clean drinking water, as they are a relatively cheap way to reduce the risk of water borne diseases and increase the quality of life markedly for those who have access to these systems.

Possible System Layouts

There are a number of different types of solar water pumping systems depending upon the application. Direct pump systems are where the panels are connected straight to the pump and whenever the sun shines the pump operates. These systems are becoming less common but have been the most popular system type used to fill irrigation reservoirs in the past. A block circuit is shown in Figure 1 (M Thomas, 1996).

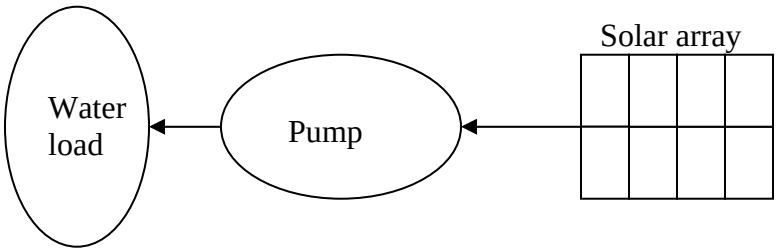


Figure 1: Direct pump solar system

A second type of system is one with a timer placed on the pump. Pumping is not required continuously in most applications and the pump operates either on a timer or based on a system of level switches. This system can still only pump during the sunshine because there is no storage. These systems are common for filling household water tanks, livestock troughs and irrigation reservoirs. There are many possible layouts but below there is Figure 2 with a timer and Figure 3 with a float switch that activates the pump when the leveling a tank gets to a pre-designated level (M Thomas, 1996). Figure 4 shows the combination of a timer and float switch (M Thomas, 1996).

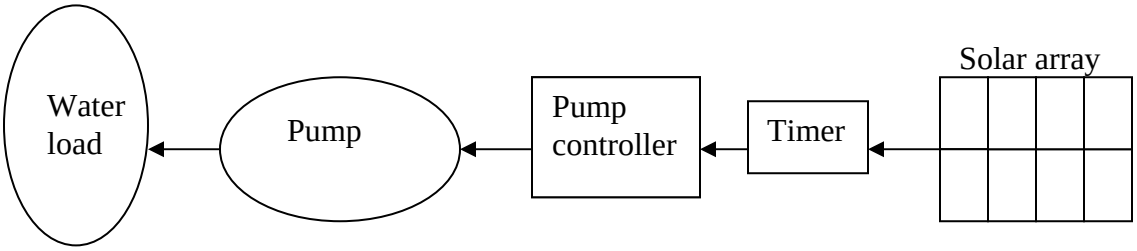


Figure 2: Solar pumping system using timer pump activation

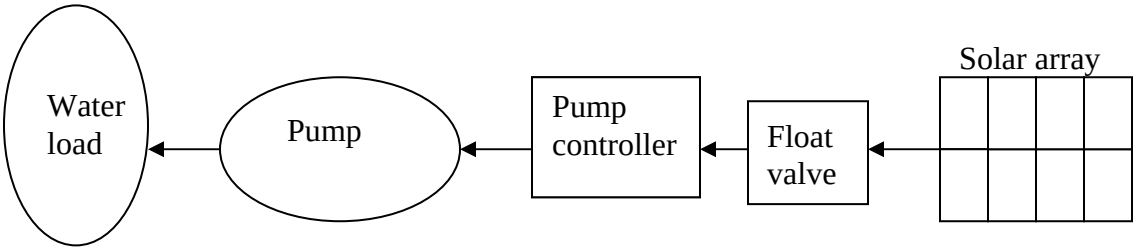


Figure 3: Solar pumping system using float valve pump activation

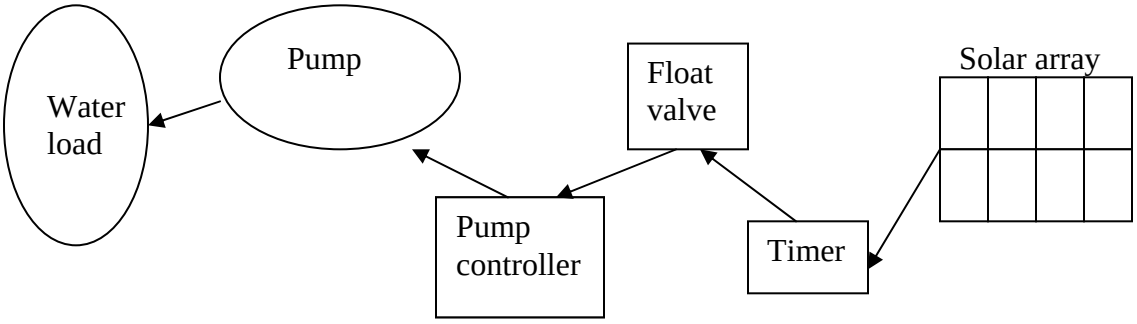


Figure 4: Solar pumping system that uses timer and float valve pump activation

Described above are a few of the commonly used system types for solar water pumping. More complex systems can also integrate battery charging so that the array can operate at any time of the day or night. The main disadvantage of such a system is that it is more expensive than the layouts in Figure 1, 2, 3 and 4. In this case the electricity used to power the pump comes for the batteries. Generally timed or float valve systems are used in this situation because direct pump systems would require a large solar array to pump the pump 24 hours a day from the batteries. A possible topography is shown in Figure 5 using float valve activation (S Wenham et.al, 1994).

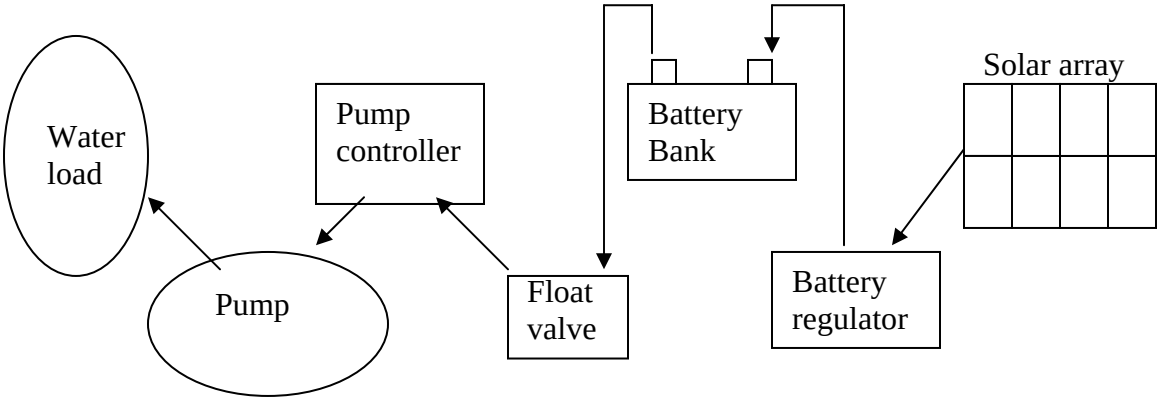


Figure 5: Energy storage in batteries with a float valve activation

Importance of Correct System Design

Like any solar system it is very important that the system is designed to suit the application and is correctly sized to supply the required amount of water. The topologies discussed in the previous section each suit particular applications and each should be considered before a system is designed. The pumping system will not provide the required water, and therefore be dysfunctional, if the type of system does not suit the application (M Thomas, 1996). After an appropriate system layout has been identified, components such as pumps and controllers must be chosen to meet the water supply needs. Once components have been chosen the solar system can be sized to provide electricity. The choice of components and power supply is critical to supplying the water needs of the application. This means that a pump capable of pumping the required amounts of water and over the required head is chosen. Sizing of the solar system should take into account the possibility of inclement weather as well as degradation that occurs to solar modules due to a number of circumstances (J Stevens et.al, 2000). Without making these allowances the system will not function correctly during extended periods of cloudy weather or dusty conditions etc (M Thomas, 1996).

Without taking the measures discussed above into consideration the solar pumping system will not provide the required performance. This means that the customer will be unhappy and the use of solar technology by that customer in the future is unlikely. Customers always remember the bad experiences and tell all their friend about it! It may also have more severe ramifications such as causing stock or crop deaths or causing a household to have drinking water trucked to their property at great expense South West Technology Institute, 1995). Correct design of solar water pumping systems is what gives them a good reputation and makes them work to customer satisfaction, allowing the technology to be used in the future (J Stevens et.al, 2000).

Conclusion

Solar water pumping is a technology that has great potential for use well into the future in Australia, largely due to the large areas of remote farm and agricultural land. It suits use in isolated areas because it is self powering, low maintenance and relatively low cost in these circumstances. Applications include pumping to water stock, humans, crops, towns, settlements and fountains. By using solar water pumping in remote areas it can remove the need of expensive electricity grid extensions, allow farming in previously unavailable areas due to remoteness and minimize installation expense, maintenance required and the potential for greenhouse gas emissions for use of grid electricity. There are a number of possible system designs including the direct pump, timer regulated, float valve regulated and battery storage or any combination of these. Perhaps the most important aspect of any solar system is the importance of correct design so that the system delivers the required performance. The system must be able to deliver the amount of water in the required time as designated by the user. As a technology solar water pumping is exciting because it provides a viable alternative to conventional pumping methods of using mains electricity, petrol or diesel to power the systems and can be sized to deliver any water load.

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