Off-grid water systems
Building a solar reticulation system

Martin Chape explains how he replaced a power-hungry bore pump with a low-cost solar unit and automated his watering system at the same time.

FOR some time I'd wanted to get rid of my power-hungry three-phase mains-operated bore pump, used to water my garden from the aquifer beneath my house. This forms part of a bigger plan to move all my 240 volt appliances off-grid. The large power drain of the three-phase bore pump would almost double the size of the inverter I'd need to go off-grid, even though it only gets used in summer, and then for just 15 minutes, three times a week.

So, I decided to replace it with a 24 volt DC bore pump run from solar PV. This pump fills a rainwater tank from the bore, using a float switch to turn the pump off when the tank is full. The resulting system can be completely automated and independent of utility-supplied water and electricity.

The pumps and tank

I ordered a 24 volt DC multistage submersible bore pump (a Kerry M243T-20) from a dealer on AliExpress, for US $178. This pump is class IP68 (fully dust and water tight; see en.wikipedia.org/wiki/IP_Code), has a 25mm outlet pipe, can pump to a head of 20 metres at 3000 litres per hour and draws 384 watts (at 24 volts that's about 16 amps).

While waiting for the solar pump to arrive I removed the existing bore pump and sold it for $500. Using that as my starting capital, I hunted down a 2500 litre poly rainwater tank through Gumtree and, with the help of my neighbour, installed it on a brick and concrete foundation. I had first considered building an elevated tank stand, to provide water pressure from the height, but decided against this after reading a story of a home-built stand collapsing on someone. I also would have needed local government approval.

So the tank ended up on the ground and I purchased a second pump to move the water out of the tank to the garden. It's a 24 volt DC submersible pump (US$35 from another AliExpress seller) with a single impeller (the spinning rotor that pushes the water), a 25mm outlet pipe, 12 metre head capacity and it draws 120 watts. Oddly, it claims a flow rate of 8000 litres per hour compared to the 3000 litres of the bore pump.

[*Ed note*: Cheap devices bought directly from China can vary in quality; checking the seller's feedback score and comments can assist, but as Martin's experiences show, there can still be issues.]

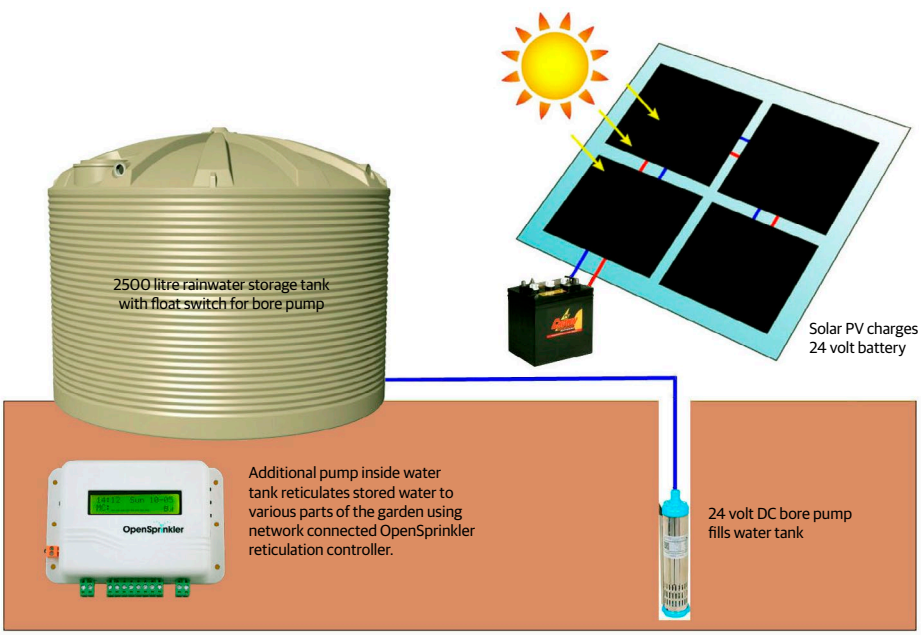
Anyway, when this pump arrived from China it had been damaged in transit so I ordered a second one and then contacted the supplier. The supplier was very good and supplied parts which I used to repair the first pump, which is now in my shed as a spare.

The solar bore pump then arrived and with the help of a friend I soon had it installed in the bore. It seemed to work initially, but then stopped after just 10 minutes.

I contacted the supplier in China but they claimed their pumps don't fail. After many tests and emails, I removed the pump from the bore and made a video of it running in a container of water. The video clearly showed that it didn't pump water but rather blew out smoke. Only then did the manufacturer agree to replace the pump—if I paid the shipping from China for the new one.

When the replacement bore pump arrived, I installed it in the bore and wired it through the float switch (a boat bilge switch) mounted upside down in the top of the rainwater tank. This switch turns the pump off when the tank is full.

[*Ed note:* in February 2015, Martin let us know that the replacement bore pump has also failed. It has since been replaced with a diaphragm pump.]



↑ Martin's watering system uses two pumps powered by a DC solar/battery system, one to pump water from the bore to his rainwater tank and one to pump water from the tank to the garden. The watering controller is an open-source system called OpenSprinkler.

Water reticulation system

The next stage of the project was to install the output pump into the bottom of the tank and build a water manifold to distribute water to various parts of the garden. The pump pumps water to the manifold and each manifold outlet has a solenoid to turn the flow to that outlet on and off (see photo at right). I looked at some commercial manifolds, but decided instead to build my own from PVC pipe fittings.

It is possible to use regular 24 volt AC solenoid valves (which control the flow of water) on 24 volts DC. However, this causes them to draw over 600 milliamps of current (over 14 watts). This is far too much for the semiconductor switching devices in most water reticulation controllers and would burn the controller out. If you run them on 12 volts DC, the current drops to around 300 milliamps, similar to the current when they are run on 24 volts AC.

Far better, when only solar DC is available, is to use DC solenoids. These are more like the type used in washing machines and don't rely on high water pressure to open the valve as with the regular 24 volt AC solenoids. They can be purchased via AliExpress for around US$11 each. Because they have metal parts that may corrode, I mounted mine indoors.

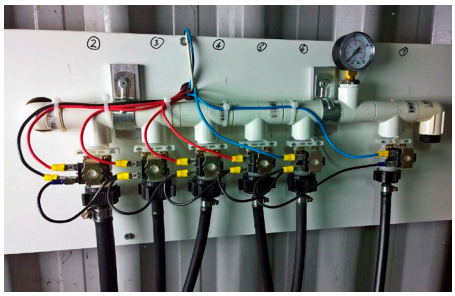
Reticulation controller

I had originally planned to build my own reticulation controller using an Arduino or Raspberry Pi microcomputer but after a bit of searching online I came across the OpenSprinkler system.

OpenSprinkler can be supplied in kit form with one of three microcontrollers, including Raspberry Pi. The software is open source, so if you've got programming skills you can modify it for your needs. OpenSprinkler can also be purchased fully assembled and is easily wired up like any regular reticulation controller.

The OpenSprinkler controller connects to your home network via RJ45 ethernet cable or wi-fi. Free apps are available to control it from iOS, Android and Windows mobile phones.

It comes with eight solenoid outputs (called stations; note you can add more as needed), any of which can be programmed as a master control for the pump. There is provision for connection of rain sensors, and it can also use internet weather sites to vary its sprinkler programs if rain is predicted or has occurred.



↑ The distribution manifold was made from standard PVC pipe fittings. The solenoid valves control each outlet individually.

← The control panel for the system includes isolator switches for both the solar PV and the battery bank, while an ammeter (top centre) displays the PV charge current. The solar controller has a dedicated blower fan as it can overheat in extremely hot weather. The black box, top left, has two 30 amp slave relays to operate the two pumps. One protects the OpenSprinkler system by indirectly operating the distribution pump and the other prevents the float switch contact (rated at only 10 amps) from burning out. The blade fuse panels and the commoning block allow all components to be individually protected with fuses.

The fully assembled OpenSprinkler sells for US$150 (less for the DIY kits) and expansion boards are US$58. For me, the best part was that OpenSprinkler offered to modify it to work on my DC solenoids for a mere extra US$20. Most reticulation controllers use triacs to switch power to the station outputs, and triacs are a type of semiconductor that can only switch AC. By replacing the triacs with transistors the controller can then switch DC solenoids.

Powered by solar

The solar power system uses a pair of 255 watt, 24 volt solar panels from YHI Power. Wired in parallel, they can deliver 18 amps to charge the 33 Ah, 24 volt Shoto GFM battery bank, more than enough to run the 384 watt submersible pump. A 30 amp MPPT solar controller, of the same type used in my solar cooler system (see *ReNew 126*), manages the charging of the battery bank and the loads.

Operating the system

The complete system is currently operating successfully filling the water tank during the day and watering the garden at night. This has been achieved with the addition of a daylight switch from Jaycar Electronics which only allows power to the bore pump during the day.

The final refinements to my project are the addition of an ultrasonic wireless tank water-level device and a water meter on the bore pump line. The water-level meter allows the tank level to be monitored remotely in the house. It has a built-in low water level alarm to help prevent running the pump dry. These devices are easily installed and cost only $49 from Bunnings. They come in two parts, with an ultrasonic sensor/wireless transmitter that you fit on the water tank and a display that you place inside your house.

I've also installed a simple in-line water meter (US$12) which will keep track of the total groundwater I have drawn from the aquifer beneath my home.

This project has been very successful in my move towards energy and water independence. I estimate that I spent less than AU$1700 (minus the $500 for my old pump) on the whole project, and learnt one or two more things about buying from China!

I believe this project could be taken on by most people with a little knowledge of wiring things up; being extra-low voltage, you don't need an electrical licence. However, caution should still be used around extra-low voltage things such as batteries as they can deliver very large currents which may start fires.

Although I live in a major city, this project might ideally suit someone living in a remote area without mains power, and I'd be happy to offer advice! ✱

Martin is a retired engineer whose projects are on Facebook under Sustainability Solutions. You can contact him at martyc@perthpcug.org.au.