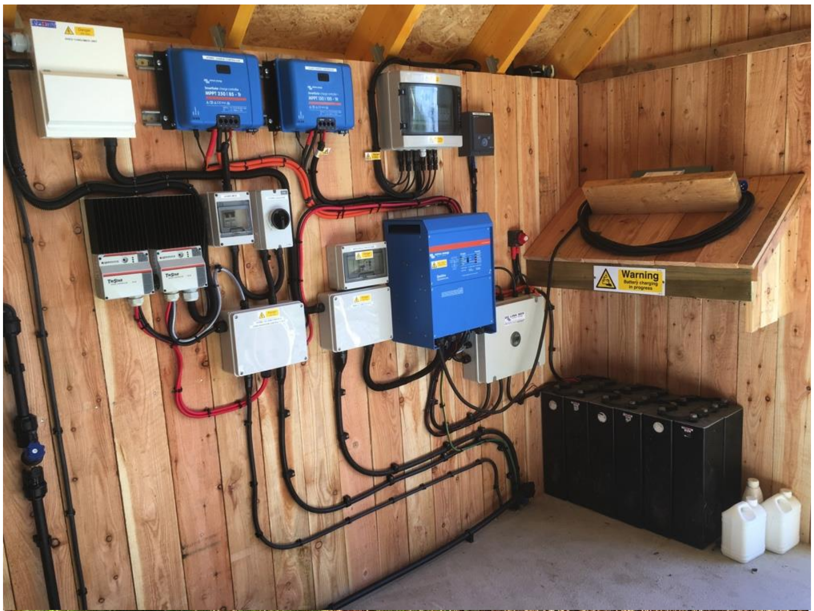
Case Study 7 - Off-grid PLT installation with Victron MPPT 250 controller



With Jamie Robinson www.alternativeengineering.co.uk

1. BACKGROUND

The property is located in a remote glen in Lochaber, Scotland. It is a holiday property and has been enjoyed by the same family for holidays for many years. The owners have used a Stream Engine (hydro turbine from Energy Systems and Design) as the main source of battery charging since 2002 and are well aware of how useful small hydro plants can be. There is no diesel generator at all, and hydro was the only source of meaningful power to the property.

This particular location has no real run of water to speak of except for quite a large area of seepage from under an area of forestry. The owner was an enterprising DIY type of person and created a large pond by mounding up an earth retaining wall and thus holding back the water.

The Stream Engine was installed and the system ran just fine for many years, in spite of the rather grotesquely inefficient manifold opposite. (MDPE elbows and Tees have rather small inner diameter.) The family found that because there was no real flow to speak of, after they had been in the property for about a week in dry periods the level of the loch began to run low and they had to shut the turbine down. The batteries are not particularly large so when the turbine was not running, they quickly had no electricity because there was no diesel back up.

The problems started because they got a bit greedy. It was decided that the answer to this problem was to store more water and thus be able to run the turbine for longer periods even in dry conditions. A large concrete wall was then constructed to significantly increase the water level and the system continued to run as before.

A couple of years later in a very wet period, the sluice became partially clogged by a fallen branch and the water level increased sufficiently for the water to overflow the earth dyke at the side rather than the concrete sluice. This very quickly scoured out the entire height of the dyke and totally emptied the loch, dumping approximately 7000 cubic metres of water down the local forestry track.


This caused significant damage and incurred considerable expense to rectify. There was also a fairly large legal "slap on the wrist" by the local environmental protection body. All budding amateur civil engineers beware!!

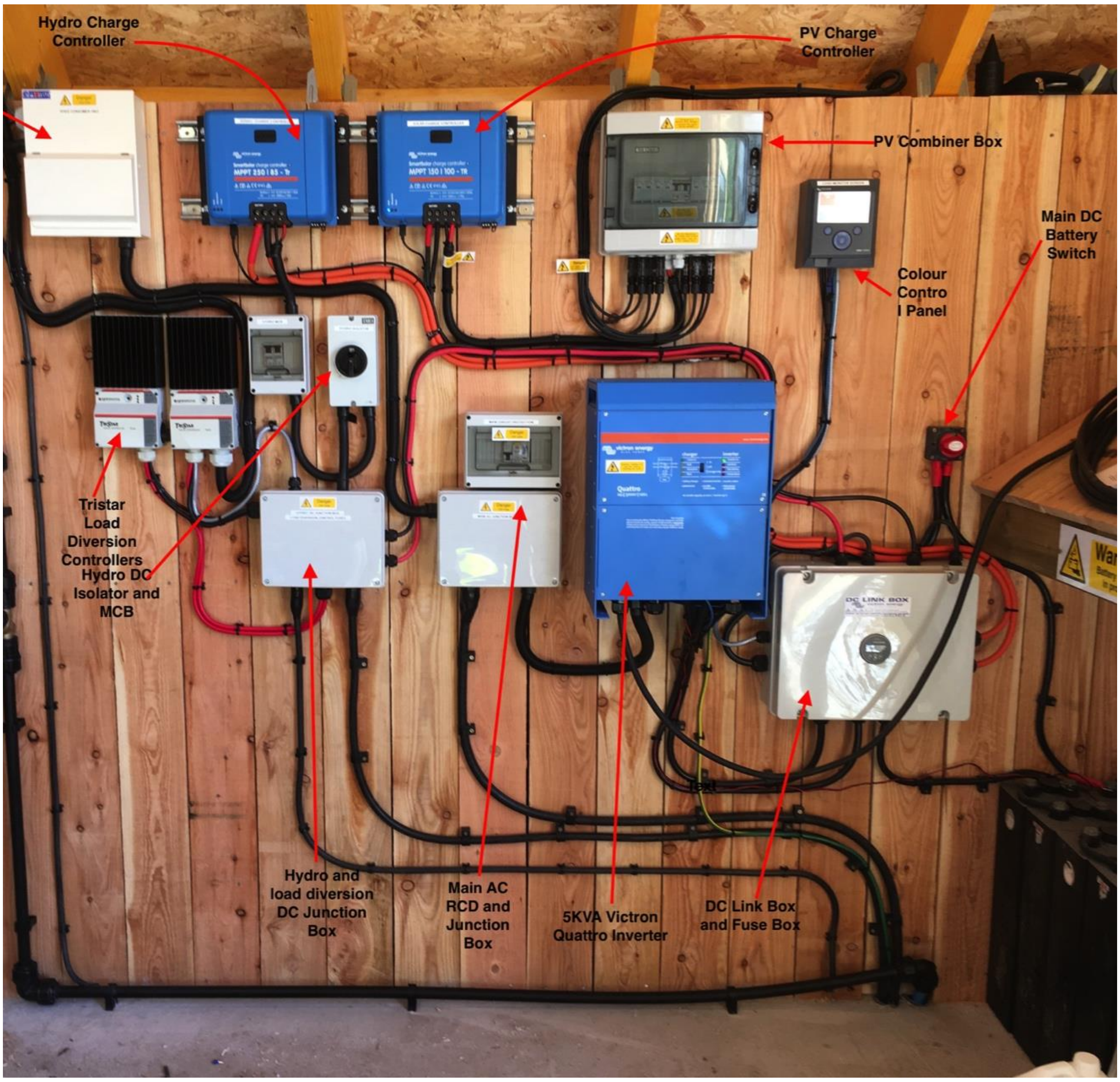
It was decided, following this unfortunate series of events to employ a bona fide groundworks specialist and repair the dam, but at a much-reduced level. This would still enable hydropower to be utilised, but the dry periods would be covered by installing a good sized PV array on the new shed roof. One or both valves on the turbine can be closed in sunny weather to eke out the water reserve.

The forestry track needed a huge amount of work to repair and, as much of the buried penstock was exposed by the scouring effect of the escaping water, this needed re-burying. Thankfully, it was not too badly damaged.

2. THE SOLUTION.

When the installer Jamie Robinson came to visit the site, the poor Stream Engine was buried under a significant amount of rubble and debris from the damaged dam. When it was finally exposed it was decided to go with a new PowerSpout turbine rather than trying to repair the old machine. A brand new shed was also constructed to house the equipment, amongst other things, and this was built with orientation and roof pitch to maximise potential solar yield.

The flooded lead acid batteries were, surprisingly, still OK (550Ah 24V). Jamie installed a new, larger inverter, along with the other components needed for the job. He decided upon Victron products for various reasons, but a significant attraction was the "Colour Control" panel. If Victron products are used throughout, this panel will provide a full user interface with battery condition, domestic load, solar yield and hydro yield all at the same time. If internet is available, this can all be logged online through the Victron VRM portal.



Victron has just introduced the 250VDC MPPT charge controller, which was installed here with a PowerSpout PLT85 without the need for any over-voltage protection. This is probably the first time the Vctron 250V controller has been used with hydro. Jamie can confirm that it works well.

The PV array comprised of 12x 300Wp Solar World mono-crystalline panels. These were connected in four parallel strings (three panels per string, keeping the Voc below 150V) to another Victron MPPT charge controller, rated at 150V/100A. The maximum PV output for the 24V battery bank, close to its absorption voltage, is 2900W. An array of this size can produce on average around 10kWh of energy per day in this area in the summer.

Load diversion was also a significant item here. The large PV array means that there is significantly more power than before. The "Tristar Follower" designed by Hugh Piggott at Scoraig Wind Electric was a perfect solution. The charging process is controlled by a Tristar PWM load controller in diversion mode. (The MPPT controllers are set to operate in Bulk all of the time by raising their charge setpoints slightly above the Tristar's setpoints.) The Tristar dumps surplus current to DC resistors in the normal way, but the Tristar Follower uses this activity to "phase in" a suitable amount of AC power from the inverter to other loads. The AC power diversion pre-empts the wasteful DC diversion process.

This allows you to directly wire a normal AC appliance, such as an immersion heater, without the need for any new heating elements or calculations converting the wattage of a 230V element to that of a DC supply. When the water is hot, the thermostat opens and the DC diversion takes over the job of disposing of surplus power.

Previously the surplus energy had been diverted by a C40 PWM controller to a DC space heater, helping to keep the house dry when unoccupied.

Because of the PWM current, the heater made a loud buzzing noise, which was not acceptable in a living space, so the heat was manually switched to the battery shed.

2.1. THE JOB

There was a delay in starting because of the large amount of groundwork needed. Once the dam was repaired, the penstock re-buried and the scour pipe closed, they only then had to wait till the loch flooded. This took place in one of Scotland's very rare dry spells and it took the best part of a week for the loch to fill to above the intake.

Jamie built the intake filter from two concentric 2m lengths of PVC pipe, in a vertical orientation.

- The inner one is 110mm OD and has a series of 60mm holes cut into it along its length and around its circumference.
- The larger one is 160mm OD, and has a series of 60mm slots cut into it.
- Nylon mesh is wrapped around this, and secured with cable ties.

There are 2 bushes made from "plastic wood" that keep the outer pipe centred on, and supported by, the inner one. To clean the filter, you can scrub it in situ, or remove the outer pipe and mesh so as to clean it more thoroughly. As there is a large body of still water, any debris tends to float or sink, so there is not much fouling of the mesh.

The penstock was 680m of 75mm MDPE pipe. Once the pipe was flooded, the static pressure was measured at 4 Bar. Jamie waited until he had this pressure reading before ordering the turbine. It's important to have an accurate head measurement, and a turbine delivery is generally quite prompt. The calculation is here at the end of this document.

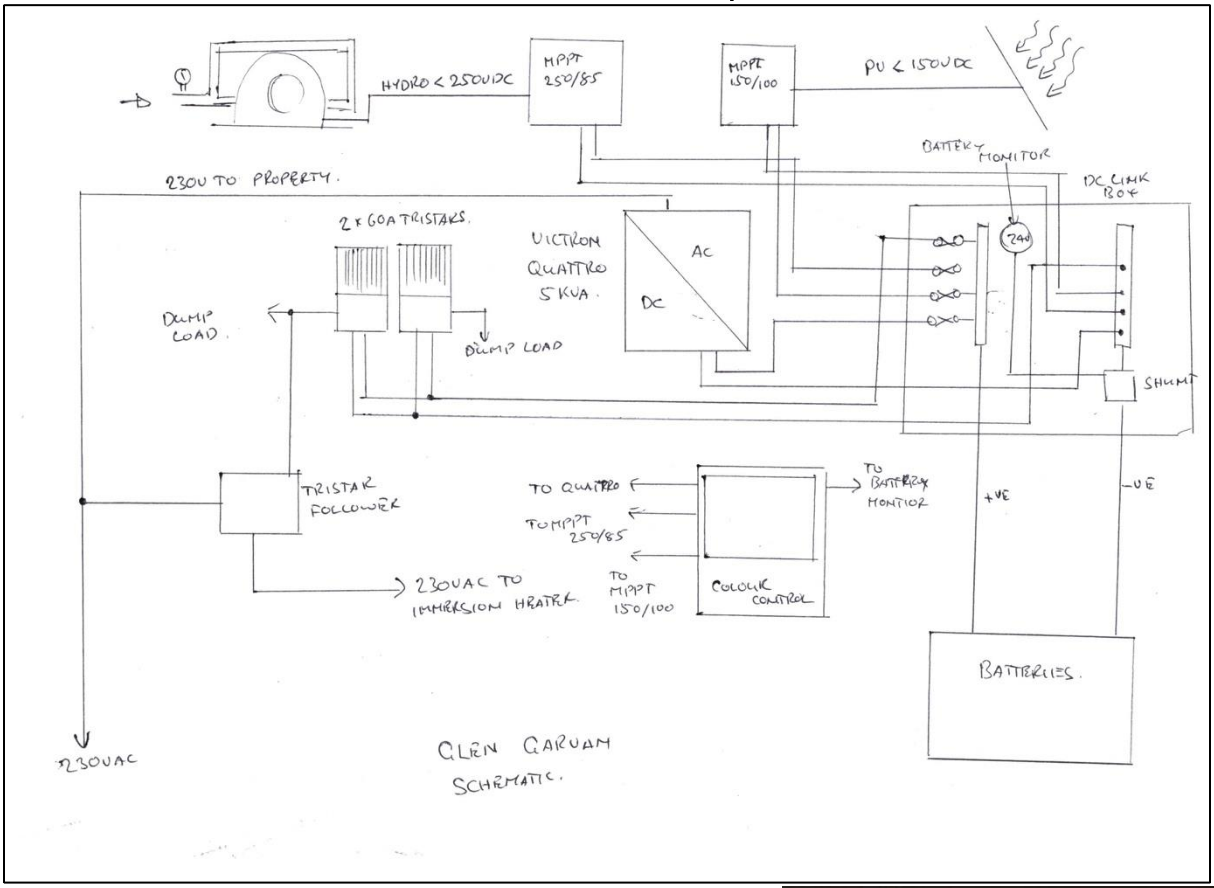
Jamie ordered from his nearest dealer, Hugh Piggott at Scoraig Wind Electric, who had supplied him with a number of PowerSpouts in the past. It also came to light upon ordering the new Powerspout, that Hugh supplied and installed the original Stream Engine, which had performed without a hitch for many years and only failed when it was buried in rubble. It's a small world when it comes to off grid installations!

Meantime the rest of the electrics had been installed. The PV panels were mounted directly onto the steel corrugated roof with TEK screws. Renusol supply a mounting system, which allows attachment directly to round corrugated material.

The 4 strings are wired to the MPPT via a PV combiner box, which joins all the strings together and also provides fuse protection for them. This output is then isolated with a suitable DC circuit breaker.

The batteries were moved to the shed and suitable ventilation was added. The battery has it's own isolation switch and a shunt for the Victron BMV battery monitor.

The 5KVA Victron Quattro inverter, the two Victron MPPT charge controllers and the Tristar diversion load controllers, are all connected to the battery via suitable fuses.



All Victron components are connected to the Colour Control Panel. This gives real time data and also data logging capability. The data can be logged online if the unit is connected to the internet. If no internet is available (as in this case) there is an option to log data to a micro SD card. Note that the output hydro output is 602W. This is 18% higher than predicted by the calculator. This outcome is normal for well installed PLT turbines.

Two 60A Tristar units were needed to manage the rather high load diversion current for this 24V battery system. These were connected to appropriately sized DC resistors and one of the units was connected to the Tristar follower and wired to a new 3kW immersion heater. It was really sunny weather during commissioning of the system. Once the batteries reached absorption voltage, the water started getting hot in no time at all. Jamie reports, "This is a huge improvement for load diversion. It uses existing domestic wiring and appliances and is really simple to put together."

The turbine arrived eleven days after the order date. It was fitted with a PVC pipe manifold and mounted to the original concrete slab. A quick Voc test confirmed that the no-load voltage was safely below the 250V maximum limit of the MPPT charge controller (Voc=225V). It was a very quick job to wire it all up. (This was a good thing because the Scottish Midges had just made their first significant appearance for 2017!) The Victron controller does not allow any adjustment to the MPPT settings like the Midnite Classic does. You can hear a very slight cyclic alteration to the turbine RPM as the controller works through the input voltage range. The power output is steady.

3. The PowerSpout Advanced Calculator

Below please find the requested results from the PowerSpout Advanced Calculator:
Your Reference is: **PS6009-19386C5A**
Your Job Reference is: **Garvan 3lps**
Click here to view them in the calculator.

Preferences

These are the preferences you indicated and any applicable safety notes.
Units: Metric
Type: PLT

Hydro

Units: Metric
Flow: 3.0 lps
Used Flow: 3.0 lps
Pipe Head: 40.0 m
Pipe Length: 800 m
Pipe Efficiency: 90 %
Pipe Diameter: 75 mm (This value was locked and may not have been the diameter recommended by the calculator)
Number of Powerspouts: 1
Nozzles: 2
JetDiameter: 9.4 mm
ActualPipeEfficiency: 85 %
Speed: 970 rpm
Output: 516 W
TotalOutput: 516 W

Electrical

OuputVoltage: 81 V
CableEfficiency: 95 %
CableLength: 50 m
LoadVoltage: 80 V
ActualLoadVoltage: 80 V
CableMaterial: Copper
CableSize: 10.0 mm^2 (This value was locked and may not have been the size recommended by the calculator)
CableAWG: 7 AWG
CableCurrent: 6.4 A
ActualCableEfficiency: 99 %
ActualTotalOutput: 509 W
Thank you for using the PowerSpout Advanced Calculator.