Making my home free from the grid
Trials and tribulations of DIY solar

Martin Chape has made an independent power supply for his lights and home office. Next it will be the whole home as he tries to escape his electricity retailer.

AS A semi-retired engineer I have always dabbled in technical projects and probably always will. This latest project came about when my electricity retailer Synergy cut the rate paid per kilowatt-hour of electricity sent to the grid to 7c per kWh, to coincide with the introduction of the West Australian government's feed-in tariff in 2010.

The thought that, after my solar feed-in tariff ended in ten years, my system would become merely a cheap generator supplying all the local air conditioners at a profit to my power company annoyed me. Especially as I would have to fund any maintenance to the solar PV system from my pension.

So I decided not to invest further in additional grid-connect panels but rather, to put my dollars into making my home office totally independent of the grid. I built an off-grid solar power system with 12 volt battery storage, supplying a 240 volt inverter at the lowest cost possible.

↑ Running out of roof space! Martin has both 12 and 24 volt power systems, solar hot water and a wind turbine.

Online shopping for parts

I sourced a pair of new 6 volt deep cycle lead-acid batteries from a local retailer. The brand was Interstate Batteries model GC2-HD-UTL, with a capacity of 216 amp-hours each. I purchased a 200 watt, 12 volt monocrystalline solar panel for $500 from eBay store LHP Power, which came with a 25-year warranty, and found a low cost 10 amp solar controller from a Chinese eBay supplier.

The solar controller has three sets of connectors, one for the PV panel, one for the load, and the third for the battery bank. The solar controller prevents overcharging the batteries, unwanted discharge of the batteries through the PV system at night, and disconnects the load to prevent battery damage if it becomes run down.

After purchasing a couple of low cost 800 watt 12-240 volt inverters from another Chinese eBay store I was ready to roll with my first system.

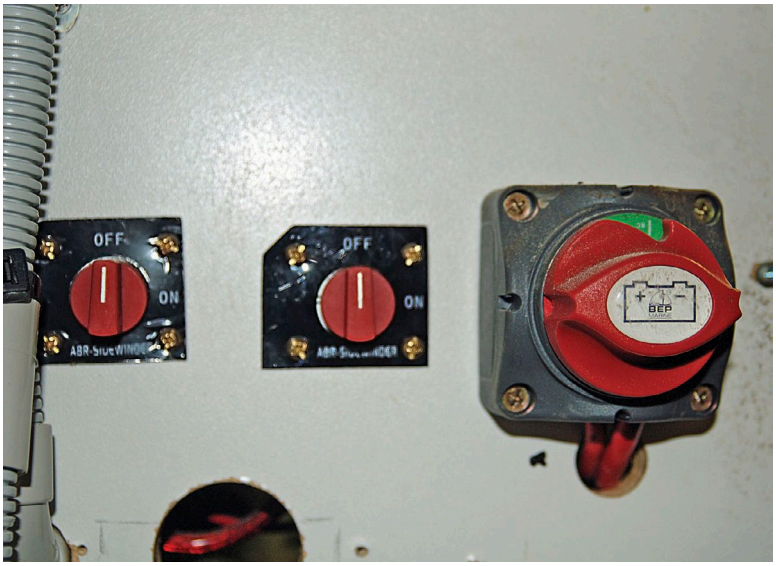
How it was done

With some sturdy shelves already in place in the garage, I mounted the two 6 volt deep cycle batteries in maritime battery boxes from Boating Fishing Camping. With lugs and a crimping tool I fabricated connecting cables from 6mm^2 building wire to connect the two 6 volt batteries in series to provide my 12 volt battery bank.

The solar controller was mounted on a wooden panel with ammeter measuring PV current and a voltmeter to show battery voltage.

The battery bank can be isolated from the whole system with a maritime battery isolation switch costing around $35. In-line fuses with LED indicators, sourced from Jaycar Electronics, are used throughout to provide adequate protection from the risk of fire.

After mounting the PV panel on the upper north-facing roof, the 12 volt battery system was soon charged. The two 800 watt inverters were connected up to the load



↑ The main battery switches for battery bank isolation.

↑ Isolation switches on the solar panels are important safety devices.

terminals on the solar controller and my home office was off and running independent from my grid-connect solar power supply.

Quick failure: the inverters

My joy was short lived when one of the Chinese inverters failed, then the other! The reason is unclear but in my opinion it is likely the stated rating of the inverters was less than conservative, and in the hot Western Australian summer heat they were not up to the job.

With the inverters purchased from a foreign eBay supplier I had little success in getting help or recompense. I decided to write the 12 volt system off, at least in terms of using it to provide 240 volt power for my home office.

Quick fix: a low voltage lighting system

Sitting back and considering my dilemma, I began to question the point of converting 12 volts DC to 240 volts AC for lighting when there were plenty of 12 volt LED globes available. I had been slowly replacing my 240 volt CFL globes around the house with 240 volt LED globes that fit into a normal bayonet socket.

I had even gone to the trouble of purchasing a two-way, centre-off switch for my mains power board so that I could run all my 240 volt lighting from a future 240 volt inverter with the Synergy supply as a backup. My efforts included obtaining permission from the State Electrical Authority to be able to do this.

I decided to turn my small failure into success by using my working 12 volt solar-charged battery system to light my home using 12 volt LED lighting. This wouldn't require me to hire an electrician either, as I could do it all myself.

I sourced a number of suitable 12 volt MR16 light globes from China along with several types of motion sensors, with the globes ranging from $2 to $8 depending on the power rating. The motion sensors, also from China, were all less than $10 and not only detect movement but are light sensitive as well. This means they do not switch on during the day and battery power is saved, and if you turn on the normal 240 volt mains light in the room the 12 volt DC light goes out.

I installed one or two downlight fittings in each room alongside the existing mains 240 volt light fitting. All connections were soldered to the supplied MR16 socket wiring and heat shrinked. The recessed light fittings were wired from a central point blade fuse box using a 100 metre roll of 0.75mm^2 twin flex costing $45.00. Working to a central point means the 0.75mm^2 wire is only carrying the current for its own light, reducing the chance of heating. Several lights were wired to each 10 amp blade fuse.

In some rooms, such as bedrooms, I used a remote 12 volt dimmer-switch from eBay for less than $10 to switch the lights. In other areas of the house, such as the passages, toilets and laundry, the lights are activated by the motion/light sensor.

This 12 volt system means that I can mostly walk around my house without touching a light switch, and if there is a blackout my house is still lit, and all driven by the sun for free.

My electricity use over the last 12 months has dropped from 15kWh a day to 9kWh and is continuing to drop. My 12 volt system has turned from a failure into a success.

LED benefits

As well as the low power drain of LED globes for good light output, LED globes do not get hot like other types of globes thus presenting a much lower fire risk. For example, a 7 watt LED globe is equivalent to a 65 watt incandescent globe.

The expected life span of an LED globe is also considerably longer than other types and SMD globes give higher output than even normal LEDs. The table below shows some typical specifications.

	Incandescent	Halogen	CFL	LED
Power	65 watts	35 watts	15 watts	7 watts
Lamp life	1000 hours	3000 hours	6000 hours	30,000 hours

↑ The vertical axis wind turbine. They are much quieter than most horizontal axis machines.

Power for my home office

Since the original failure I've built a separate 24 volt system which will drive a 5kW inverter to power my home office with wind as well as solar. After all, my motivation not to become a cheap generator for Synergy after my feed-in tariff ended was still strong.

And I was still determined to put my dollars into making my home office totally independent of the grid rather than invest further in grid connect PV panels.

The new 250 watt, 24 volt panel was sourced from the same Sydney eBay supplier that I purchased my first 12 volt panel from. Having found a new wholesale source for batteries I purchased four 6 volt Supreme CR-225 deep cycle lead-acid batteries, slightly larger than those in the previous 12 volt system. These 225 amp-hour batteries are quite common, being used in electric golf carts, fork lifts and the like, and cost less than $200 each.

How it was done

The four 6 volt batteries were placed below the original 12 volt battery bank. Putting all the batteries in one spot meant maintenance would be easier.

I wired the four batteries in series to give a 24 volt battery bank with the same type of emergency isolation switch and set of fuses that I used in the 12 volt system. The isolation switch is very necessary as the current delivering capacity of this battery bank is very large and there is a consequent high risk of damage or fire.

A separate control and monitoring panel to mount the solar controller and metering was constructed and placed alongside the 24 volt battery bank. At this stage the same model solar controller was initially able to be used as I had purchased a spare and it auto detects if the battery bank is 12 volts or 24 volts.

The new 250 watt, 24 volt panel was mounted on the north roof close to the original 12 volt panel and wired using UV stabilised conductors through a terminal box with isolation points mounted on the roof.

Down in the garage, where the battery banks are, both panels can be isolated from the system by the 500 volt rated switches; 500 volts is fine for a single panel.

After testing the new system and finding the 24 volt battery bank charging successfully I turned my mind to procuring a 24 to 240 volt inverter. After looking at a number of Australian suppliers I decided to purchase one on eBay.

Probably due to my engineering background I wanted to completely over-rate for my planned load. So the 24 volt inverter was rated at 5 kilowatts continuous with a surge rating of 10 kilowatts. This unit is adequate to not only easily run my home office, including high startup currents from laser printers, but is able to also run the entertainment equipment (LCD TV, blue ray and more) in the main bedroom.

Wind power to supplement

With both my 12 volt lighting and 24 volt PV systems now working I turned my attention to the possibility of wind power to supplement one of them. Most information can put you off wind power as it describes wind turbulence as a problem in built-up areas. On top of that there are often building restrictions imposed by local governments.

It was important to know the wind resource at home before investing in wind power, which involves collecting actual data. Some wind data is available from the Bureau of Meteorology but their data collection points are not in my backyard, leaving one to extrapolate wind speed. Collecting wind data requires patience, with a full data set taking around 12 months, and even then one of the seasons may not be representative.

It was quite a temptation to rush in and buy a wind turbine. After all, I justified to myself that I could make the wind turbine my data collector. Resisting such temptation I instead purchased a wireless weather station for $90 from eBay that was capable of recording weather then sending data wirelessly back to my computer. I mounted the collating station device with its anemometer on my shed at the rear of the house.

After seven months I had a large amount of raw data on wind speed for my very own location. But disappointingly the data

↑ Low cost MR16 LED bulbs are readily available on eBay, as is a range of 12 volt control gear like the passive infrared sensor at the left of the photo.

showed average wind speed to be less than three metres per second, way below that required for most wind turbines to even start up, let alone generate any sort of power.

Grateful I hadn't spent a lot of money on a wind turbine I was ready to give the idea of wind power away. In addition, my approaches to my local government authority, City of Swan, became tangled in red tape. City of Swan required submission of a development application, a location plan, building plans, hours of operation and a survey of the site by a licensed building surveyor before approval by council would be considered.

The fees they wanted exceeded the price of the Chinese wind turbine I was considering. An application didn't guarantee approval as it was intimated that the noise concerns of neighbours may have to be taken into account. It seemed local government was more concerned about ratepayers' visual amenity than the environmental outcomes I was attempting to achieve.

Vertical wind turbine solution

Even more dispirited I backed off and almost gave up on the idea of supplementing my system with wind power. Yet one day I received an email advertising a vertical wind turbine that claimed a wind start speed of 1.5 metres per second and was a bargain price of US$350.

My local government authority said there was no requirement for planning approval if I mounted a single vertical wind turbine on the roof of my house as distinct from the regular propeller type I had previously discussed with them.

I wasted no time getting this in writing and immediately ordered a wind turbine from China along with a special combined solar/wind controller that would allow connection of both my existing PV and the wind turbine.

The wind turbine, with its special combined solar controller, cost me under $400, was shipped, and arrived within three weeks of my order being placed. A large box of parts with no instructions on how to assemble it turned up at the Post Office. Sadly it had been fabricated, drilled and bolted together, then disassembled without marking which blade was from where.

After a long and painstaking process of trying every possible combination to put it together I managed to assemble the turbine without re-drilling any of its parts. Then I added lock nuts to all bolts and set all threads using Loctite to ensure integrity of the whole assembly.

The next job was to replace the original low cost solar controller of the 24 volt system with the new special combined controller to accommodate both wind and solar inputs. To do this I built a larger panel to replace the existing one and added an extra bidirectional ammeter in the lead to the battery so I could observe both charge and discharge to my 24 volt battery bank. The original ammeter was retained in the PV lead.

To mount the wind turbine above my roof I built a 50mm galvanised steel pipe into my roof space extending about one metre above the ridge line to be sure it was clear of any turbulence. The top of the pipe was threaded to take a galvanised flange that matched the base plate on the wind turbine.

The lower end of the galvanised pipe has a wooden mast step and is resting on a large sheet of marine ply on top of the ceiling joists. The sheet of plywood allows me to work safely in the roof space around the pipe and without falling through my ceiling.

I clamped the galvanised pipe using three U-bolts to a 50 x 100mm piece of timber set vertically inside the roof space and bolted that to the existing roof beams. The vertical piece of timber was braced in four directions to the rafters and hip beams to ensure the structural integrity of the existing roof structure was not put at risk. To prevent ingress of moisture a rubber corrugated boot used by plumbers for vent pipes was put over the galvanised pipe, sealed with silicone and screwed to the corrugated iron of the roof.

The three conductors for the 3 phase AC of the wind turbine were run down inside the galvanised pipe through the roof space to the battery racks in the garage and terminated on the special combined controller on the new panel. The AC from the wind turbine is rectified by the combined controller before it is mixed with the 24 volt DC from the PV panels.

It hasn't been possible to measure the individual contribution of the wind turbine, however, I am able to say that the turbine blades have been turning almost every day and true to its published specifications, it starts turning at wind speeds as low as 1.5 metres per second.

I have purchased some current clamp sensors and an Arduino board, hoping to set up a monitoring system for AC from the turbine in 2012. There is also the possibility of using the CurrentCost system to monitor the AC if that device can be recalibrated for 24 volts instead of its normal range of 210-240 volts.

↑ The data from the anemometer showed that a regular wind turbine was not going to work as wind speeds were too low.

Busy year ahead

I hope to install a 24 volt garage door lifter this year, operating from my 24 volt battery bank, so my car does not get stuck in the garage if there is a blackout and to save even more energy. I am also building a split system vacuum tube solar hot water system that can be monitored via the internet and I also plan to replace my 3 phase 2hp mains-operated reticulation bore with a solar-powered system. ✷

Visit Martin Chape's website www.sustainabilitysolutions.net.au for updates, including details on his new online power monitoring at home.

Be careful in the roof

A licensed electrician isn't needed to wire up this low voltage set up, yet there are a number of hazards entering the roof space that you need to be aware of. Merely in cutting a hole through the ceiling plaster or gyprock for a down light you could hit a ceiling joist, or worse, a live 240 volt wire. Some of these things could result in a fatality so don't undertake this work if you aren't sure what you are doing!