Ecohomes workshop: DIY solar lighting
With Chris Brooks
19 September 2020

Chris has a number of solar installations at home:

1. He started with an 80W solar panel (1x0.8m) connected through a standard charge controller to his diesel campervan battery to keep it charged
2. He has a commercial solar installation on his roof which pays £1800/y (in Feed In Tariffs) and saves £300/y on electricity bills
3. He designed and built his own solar system for the house to provide off-grid power for LED lighting for the whole house (all lighting runs off 12V). These are fitted vertically as easier and for space reasons. They pick up the sun when it is low in the sky which better for evening/winter sun which is when the light is needed.
4. He built a standalone system on various sheds and a portable system which is also used by the Scouts/Cubs when they go camping (at their first camp, they were the only leaders who's phones were charged and proper lighting for their tents) consisting of a solar panel, battery bank and LEDs.
5. He also uses solar to water the garden with a bilge pump connected to his water butts
6. He also has a small inverter (output 300W) which you can use to run a laptop or motors (note these come in two types pure sine wave or modified sine wave and only the pure sine wave inverter is suitable for small motors and sensitive electrical equipment).

Chris noted that he doesn't run the whole house from the battery solar system as the draw is so high. He would only run motors or the fridge off the battery bank if there is full sun. The solar mains system has an inverter which exports to the grid and which runs all the other items in the house – freezer, computers. He also charges his electric car when the sun is shining.

He explained the different types of solar systems (for power):

1. Garden lights – cheap batteries which have a limited cycle that can only discharge around 300 times so last under a year, and use amorphous solar panels which are cheap but only last around 5 years
2. Solar panels on houses – blue or dark blue. Either monocrystalline (most efficient when sunny) or polycrystalline (sparkly, work better at low light but not as efficient)

Chris explained the components and costs of a DIY solar lighting system:

1. Solar panel (he bought his locally as a job lot). A 100W solar panel costs around £80 to £100.
2. Recommends using proper Solar cable (which is more expensive) – as it withstands the sun and remains flexibility at all temperatures
3. Charge controller need to be matched to the Solar Panel. Ie. 10amp, 20amp or 30amp] (costs from £5-12)
4. Battery – he uses a lead acid battery (a leisure caravan battery) (cost around £70) which will output for hours and run 15m of LED lighting strip for 3-4 hours

5. LED lights – he uses a reel of strip lights (cost around £5), but there are also 12V B22 lightbulbs like a standard light bulbs but which run at 4W instead of 80W (also known as Corn Cob if search for them), and 4W LED spotlights. Note if as B22 12V bulbs are hard to find it may be necessary to use a B22 to E27 adaptor.

How to assemble:

1. All panels have an MC4 connector on the back. They have metal inserts which crimp to the cable. The tricky bit is crimping the cable in properly at the beginning which took a bit of practice.
2. The charge controller has outlets for positive and negative wires – he uses a cheap multimeter which tells you whether you have them the right way round.
3. The charge controller has 6 outlets. Two wires (one positive, one negative) go to the solar panel cable, two (positive/negative) go the battery and two (positive/negative) go to output.
4. On the Portable Battery boxes, Chris has a 12v socket.

Q&A

Q: *Is it true that solar panels require more energy to produce than they save?*
A: This was true 15 years ago but now that solar panels are mass produced (and the manufacturing more efficient), the output is higher and they last longer (most now are guaranteed to have a minimum output of 80% after 20 years) are more eco friendly and easily output more power than is used to produce them.
The only problem is with the batteries. Lead acid batteries are not eco-friendly but the next generation of Lithium Ion batteries (used in electric cars) are very expensive (approx. £70 for lead battery vs approx. £850-1000 for a lithium one). The lithium batteries are much better but big jump in price.

[**post meeting note** – life cycle emission study of electric cars shows that they use far less energy/carbon over 5 years than a petrol/diesel car even when the higher energy of producing the batteries is taken into account. www.carbonbrief.org/factcheck-how-electric-vehicles-help-to-tackle-climate-change
Aside from carbon/energy, mining for battery minerals is very polluting and so batteries need to be properly recycled]

Q. *Can you provide a list of suppliers*
A. The solar charge controllers are all made in China so it doesn't really matter which supplier you use. If prepared to wait you can order direct from China (Banggood.com or ebay) but avoid Amazon due to higher mark-up.

Q. *How do you secure the panels to the roof/wall?*
A. You either buy panels which are flexible and which can be glued down or aluminium edged ones which you bolt to the wall or roof using angle brackets. For a flat roof make a frame and angle in the right direction. However they need to be bolted down (to avoid theft as well as blowing away if flat roof)

Q. *Do you need to be a qualified electrician?*

A. No but it good to put a fuse on all of the positive wire runs to and from the charge controller which takes the risk of fire out

Q. *What is the correct angle for the panels*?
A. Anything between 30-60 degrees

A brief overview from Chris

I started simple. A Solar Panel, Charge Controller and Leisure Battery all for an Motorhome (RV)

I then changed all the internal lights to be LED strips. The 12 x 8 watt fluorescent tubes replaced with strips of LED's. It was at this point I realized the savings. All the LED's on consumed less current than 1 tube.

Move on 7 years and the RV battery was still working well, where as I had had to replace it every 12 months before. Solar panels have dropped in price. Original 80w was £250 down to the 230w panels at £100 (New panels)!

Now was the time to look at the house, I had already changed most of the bulbs to mains LED ones but these didn't last as long as expected or rather the early ones didn't. We used the these original mains LEDS to work out what coloured light we liked and where. LEDS come in Day light/Cool white and Warm white.

Cool light in Bathroom, kitchen and office and warm white in bedroom and lounge.

I started on the house, by lighting our large conservatory with 12V LED strips 3 x 5m long white up the centre and round the edge 3 x 5m Multi Coloured (mainly set to Blue now). Also some coloured LEDs in the bedroom and under cupboard LEDs in the kitchen. These were powered from a couple of Leisure batteries (2 x 125amp lead acid). The batteries were charged by 2 x 230w Solar panels mounted on a south facing Porch roof.

It worked for a winter but the batteries needed to be bigger. The next step was to add 6 more 230w panels and 6 more 110amp batteries now all running at 24V. ie 8 12V in four pairs. This allowed me to use a cheap solar charger to handle the current. To light the house I used a step down device to supply 12.4v (at upto 40amps) and fused every thing everywhere.

My house has 3 separate lighting circuits and I was able to phase the change over. To put it simply I pulled the wires out the consumer Unit (fuse box or breaker box) and attached them to the 12.4v adapter. I then went round and changed all the bulbs on that circuit to 12v Led Corn bulbs or MR12/GU5.3 spots. At first I thought I needed 12W LED bulbs but theses were too much for some rooms and ended up with 9w LED Corn bulbs. I also added a Voltage display of the Battery bank and 12v circuits. Good to do sanity checks on the battery bank without finding out the multimeter.

This meant no change to any light fitting or light switches, so no ear ache form the wife and no one can tell.

The Wife is now waiting for the predicted "Brown outs" so we can leave the lights on

So the house is lit off grid.

I did more than this and I have yet to complete it all.

The next first thing I did was use the output from the Solar charge controller to control a Mains Battery charger. ie. If/when the battery bank voltage drops to 50% (see latter as to why 50%) it shuts off the 24v supply from the batteries and turns on the battery charger. As this is independent of the 12v supply the lights stay on.

I also have an Arduino attached to the battery bank to monitor the voltage and this give me a web page with a nice dial gauge. On a test bed I have a relay bank that is also attached to an Arduino along with the software mocked up.

The idea here is that the monitoring watches the voltage and if the bank gets too low it turns off un-necessary circuits (Coloured Conservatory LEDS, Bedroom Coloured LEDS, Under Kitchen Cupboard LEDS, Garage lights etc).

I also have the ability to control circuits via the web page. Meaning I can remotely turn off the lights. The idea behind this is that I would set-up more independent lighting circuits that would allow for a security light display. ie. Bedroom light on, Landing /hall Light on, Bathroom light on, then reverse, you get the idea.

My house also has 4KW of solar that is grid-tied, this is not uncommon in the UK, I try to charge my Electric Vehicle (Twizy) from these to keep the electric bills down and works well enough. Only saves 40p compared to Economy 7.

Now some technical bits

I'll try to explain the size of my battery bank.

It runs at 24v nominal.

It consists of 8 110amp leisure batteries.

So these are in pairs. But with lead acid you only discharge to 50%

12 x 8 x 110 = 10.56kw but can only use half therefore 5.2kw.

I said it runs at 24v nominal. Therefore charge at 27.8v, maintain at 27.2v expect off charge voltage to be 25.4v 100% and 50% 24.4v all measured at no load.

A lot depends on how fast the discharge is, the quality of the battery (Not all will last at 50% soc for many cycles) and how quick they can be charged after discharge.

I believe my batteries will do 1000 discharges to 40% SOC. So should last approx 8 years. Therefore at present this may not be a viable money saving exercise. But in the brown outs we will be laughing and still watching TV etc.

Why these batteries?

As anyone who has had a flat starter battery will know the batteries are never as good afterwards and the more often it goes completely flat the weaker the battery becomes. Lead Acid, unlike Lithium batteries; become damaged if taken below a round 50%. This is why the G-WIZ and Aixam EV's (Electric Vehicles) need to change the batteries often.

I would be surprised if your car battery holds anywhere near as much charge as it did before it was left to go flat. Leisure battery construction will withstand a higher discharge (not high current) when compared to starter batteries, however it will still suffer the same damage.

Car starter batteries deliver high currents for short periods, Leisure batteries deliver low current for long periods. Leisure batteries are rated on a C rating (usually C20) and this gives the capacity the battery when new can supply ie. an 80amp hour battery will supply 4 amps for 20 hours (C20) before becoming empty (and damaged). The same battery cannot supply 8amps for 10 hours it would be nearer 8 hours.

The future

With the need for more electrical power in modern cars, people are now looking at having Super capacitors for starting ICE and Leisure type batteries to run the car electrics.

I'd love to have done it with Lithium based batteries, but there is a big leap in costs and availability of the chargers etc.