Autonomous Energy at Brave New Brum

Saturday 1st	Sunday 2nd
12.00 Introduction	12.00 Introduction
12.30 Autonomous Energy	12.20 Autonomous Energy
1.15 *Get the Candles In!*	1.00 Batteries and PSUs
2.00 Autonomous Economics/ *Buying Collectively*	2.00 (break)
2.45 (break)	2.30 Lighting & Daylighting
3.00 Energy Beyond Oil	3.30 (break)
	4.00 Small-scale Power
5.00 (finish)	5.30 Conclusion/review
	6.00 (finish)

(this is an approximate running order – times may wander a bit)

Further information

Energy Beyond Oil web site – http://www.fraw.org.uk/ebo/

Autonomous Energy materials (*not like to be online until December!*) – http://www.fraw.org.uk/ae/

The "Autonomous Energy" materials

The purpose of the book, *Energy Beyond Oil*, is to identify future problems with our energy supply, and the effects this might have on modern society. It's essentially a book on 'energy futures'. *Autonomous Energy* is a new project that aims to move beyond the end point of *Energy Beyond Oil* to look as practical, low tech., self-build options to address the problems identified in the book.

The 'Free Range' Energy Beyond Oil project began as a series of workshops in late 2002. By 2003 we had developed a range of information and by 2004 a book - *Energy Beyond Oil* (finally published in June 2005). We're intending to run the development of the Autonomous Energy materials using this same type of process. Brave New Brum is in fact only the third 'outing' for the information we have developed so far.

Apart from the book itself (which we have to charge for in order to recoup the production costs) all the Energy Beyond Oil/Autonomous Energy materials are given away free online. They are issued under a non-commercial open license, which means you can copy, distribute, extract and use the text as you will providing the source is acknowledged, and you don't make a profit out of doing this.

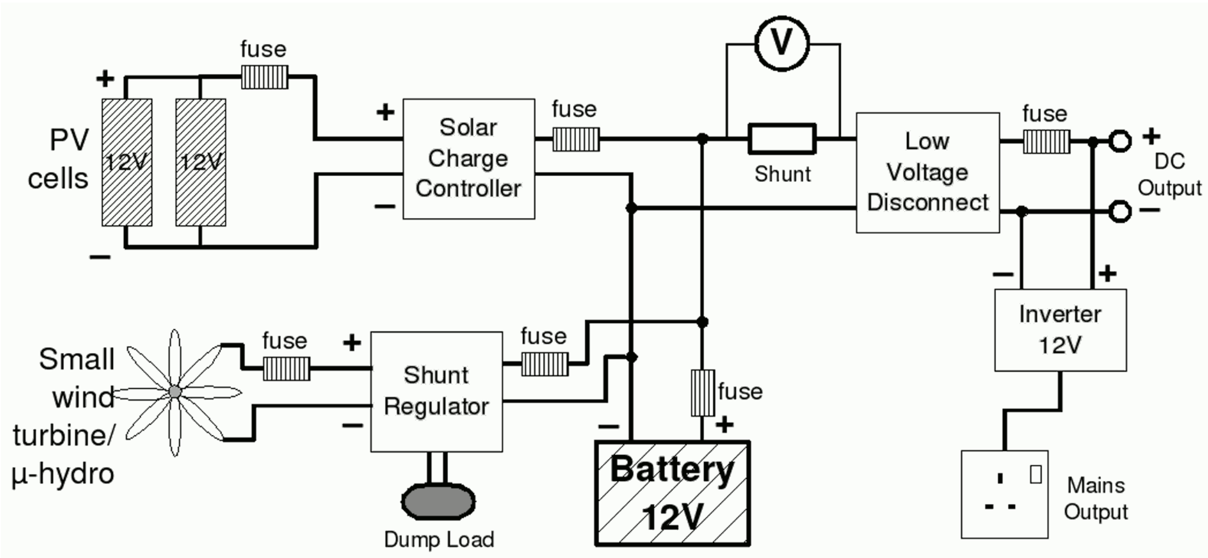
As we develop the Autonomous Energy materials we will be issuing "draft" copies of the units under open licenses. The information will still be under open licenses, but if you do extract information from the units be aware that the information may not be wholly correct, and may change over the next year or so as we finalise the content of the project.

When the units are finalised they'll be available online, for free under open licenses. We're also likely to produce a book from the pool of material developed by the project.

The Small-Scale Power System

As yet there is no 'small scale power' unit in a form suitable for publication – even in draft. For this reason the following sheet gives you the bare essentials, as outlined in the workshop. Note that both the draft *Batteries* and *Lighting* units contain a lot of information that you'll find useful when planning small power systems.

The Schematic



The above is an example of a small power system:

- Most importantly, when you send power down a wire you must fuse the wire AT THE BEGINNING of the current path. Fuses prevent damage to the wiring, not to the equipment (which should, theoretically, look after itself). A wire is a long resistor, and so the current at the end is lower than the beginning. If you fuse at the end of the wire you could still overheat the wire before the fuse blows – e.g. if the two wires are shorted together before the fuse. If you fuse at the beginning you ensure that any over-current, caused by too much current from the PV/wind generators or because of a short in the wiring, doesn't cause heating that will damage the wiring.
- PV cells produce power. E.g., a 15W PV module in bright sunlight will produce about 1 Amp of current at 12 volts [to work out the exact current divide the power in Watts by the nominal system voltage]. Other options to produce power – such as small wind turbines or micro-hydro turbines – will generate varying amounts of current. **What's important is that your power generation source create as much power in a certain period of time as the amount of power you use times 1.2 or 1.4** [e.g., if you use 10 Amps of current for five hours, or 50 Amp-hours, you'll need to produce 70 Amp-hours to maintain a constant battery capacity].
- PV cells MUST be connected to a solar charge controller. Wind or hydro turbines should be connected to a shunt regulator. If you don't include either of these your power sources could keep charging the battery when it's full – this will seriously damage it! Charge controllers monitor the battery voltage and at certain point disconnect the PV array to prevent overcharging. Shunt regulators monitor the voltage and then dump the excess power into large resistors or water heaters. You can use a charge controller with a turbine because if you disconnect the turbine it will “run away” (because, in effect, you've taken the brakes off) and damage itself (e.g., ripping the blades off).
- The battery stored power in order to meet the demands of the system over whatever period you want it to operate. E.g., for most off-grid (no mains backup) systems you would normally build in 7 or 8 days of capacity so that if you got a few cloudy/windless days one after another you could keep running the system. Batteries are rated in Amp-hours (see the *Batteries* unit). The state of the

battery can be determined from its voltage. For a 12 volt system (for 24 volts, double these figures), when under charge the voltage can rise to 14.8V. When not charging, but at full capacity, the voltage will be somewhere around 13.0V to 13.4V. As the capacity of the battery is drawn upon the voltage falls. Normal car batteries can only produce about 5% of their rated capacity before damage to the cells occurs – never let them drop below 12V. Ordinary seal lead-acid batteries can produce 20% to 25% of their capacity before damage occurs – they can run down to 11.5V to 11.0V. 'Deep cycle' lead-acid batteries can produce 40% to 50% of their rated capacity, and so you can run them down to 11.0V to 10.7V. HOWEVER, IF YOU REGULARLY DISCHARGE A BATTERY YOU ACCUMULATE DAMAGE THAT SHORTENS ITS LIFE.

- To measure the output from the system you can use a high current meter (if you use inverters, you could easily draw 50 to 80 Amps from the system). The alternative is to use a current 'shunt'. This is a very low value resistor, and the difference in voltage across the resistor is proportional to the current flowing through it – the actual current value is obtained by dividing the voltage flowing through the voltmeter by the value of the resistor in Ohms.
- The low voltage disconnect monitors the battery voltage and in the event it falls too low it disconnects the loads from the system. This prevents damage to the battery through over-discharging it.
- Inverters convert low voltage DC from the battery into high voltage AC – like the power in conventional mains sockets. HOWEVER, EVEN THE BEST INVERTERS ARE ONLY 60% to 70% EFFICIENT, SO IF POSSIBLE USE LOW VOLTAGE DC DIRECTLY.

Sizing the system

Sizing a system is an art, not a science. You can calculate everything, but in reality you never use the system as designed and so in the end you'll always have to vary something.

You have to measure the loads that you want to power. Multiply the average current drawn by the length of time, per day or week, that you want to use them. This produces a load figure in Amp-hours.

Batteries are rated in Amp-hours, but as outlined above you can only use a fraction of that capacity. E.g., for (non-deep cycle) seal lead acid cells it's about 0.8 (80%) of the rated capacity. The amount of battery capacity you need to supply the load will therefore be the load (in Amp hours) times 1 divided 1 minus the usable capacity (e.g., 1/(1 – 0.8) = 5). To ensure you don't discharge your batteries too much, so shortening their lifetime, would out how much power, in Amp-hours, that you need in a week and triple it, for deep cycle batteries, or quadruple it, for ordinary sealed lead-acid batteries – this will give you a guide to how much battery capacity you'll need.

You have to balance the power taken out of the battery with your power sources. However, as charging batteries uses about 20% to 40% of the power you put in, you actually need to supply 1.2 to 1.4 times the amount of power that you want to take out. E.g., if you want to use 50 Amp-hours per day, you'll need to put in (50 x 1.3) 65 Amp-hours.

A small 90 Watt turbine (let's say a Rutland 913) will produce it's rated power output in an urban area for about 20% of the time (or use 15% to be safe). A 90W at 12 volts is about 7.5 Amps. Taking a week as our assessment period, a week is (24 * 7) 168 hours, time 0.2 (20%) is 33.6 hours. So 7.5A x 33.6 hours is 252Ah/week. Assuming you lose 30% (0.3) of this charging the battery you have to multiply this figure by 1 divided 1 + 0.3 – which means the amount of power available will be 194Ah.

For an optimally angled PV you do the same, but the 'availability' will vary. Assume that you can get 2 times the rated capacity as Amp-hours (e.g., a 15 Watt PV panel will produce 30Ah per week) in Summer. In Winter assume that you'll only get 0.25 times the capacity (e.g., 15W x 0.5 is 3.8Ah/week).