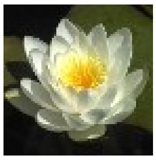
batteries



what are they?

They're units containing combinations of metals and chemicals, between which occur reversible reactions to store, then provide electrical power on demand. Some of the metals and chemicals can be quite nasty and toxic (e.g. cadmium).
Alessandro Volta (who gave his name to the volt) invented the first electric battery in 1800. His plates were of copper and zinc, and the electrolyte was brine. The most common battery chemistries are lead-acid and lithium-ion.

Lead-acid batteries are used in industry and in many off-grid, or hybrid renewable energy systems. They're still popular, because of affordability, availability, and the fact that it is so robust if looked after. A battery comprises 3 elements: some positive plates, negative plates and a liquid or gel electrolyte. The active material of the plates is lead oxide; the electrolyte is dilute sulphuric acid. In a discharge situation (giving out energy), the electrolyte reacts chemically with the plates to release energy as electrons. The flow of electrons through a conductor is electricity. When charging, the reaction is reversed and the battery absorbs electrons.
There are 3 kinds of lead-acid battery:

- gel: the electrolyte is in a gel form. They are used mainly for emergency standby, and are no good in a cycling (charge/discharge) situation.
- glass mat: electrolyte is held in a soaked glass mat between the plates. Better than gel batteries for cycling, but over time, anomalies develop between the individual cells as regards voltage and state of charge. They are used in situations where a liquid electrolyte might spill.
- flooded battery: contains liquid electrolyte that can spill; best for a renewable energy system; topped up with distilled water from time to time.

4 leisure batteries and an inverter on a vehicle with 12 x 80-watt PV panels on the roof, plus a 350-watt wind turbine.

A collection of 600 amp-hour, 2-volt cells wired in series (a 48-volt battery pack); 600 x 48 = 29kWh, and so the available power is 50% of this (you should never discharge a battery to less than 50% of its capacity), or 14.5kWh.

Leisure/deep-cycle batteries (for caravans, boats etc.) or traction batteries (forklifts) are best for renewable energy systems, as they can be repeatedly discharged / recharged. Car batteries provide short bursts to start an engine, and are unsuitable for charge/discharge cycles.
Fast charging / discharging reduces battery life. Lead-acid batteries shouldn't be discharged to below 50% of capacity and the electrolyte has to be kept at the right level to cover the plates.

Lithium-ion batteries are more expensive, but are becoming more popular, as they are used in electric vehicles, and in 'power walls' (units, about the size of storage heaters, comprising a lithium battery pack, a charger, an inverter and some software to control it), that can be added to a home power system. Power is stored during the daytime, and then used in conjunction with a power-sharing inverter to provide electricity to the home in the evening (lead-acid batteries can be used in the same way, but you'd have to set up a separate charger and inverter yourself. In a power wall, it's all there already).
The two main benefits over lead-acid is the huge improvement in energy density (batteries are much smaller than lead-acid for a given amp-hour rating); and the lack of any maintenance requirements. This form of power wall storage is expensive and has a huge payback time, but as electric vehicles develop, availability and cost will improve, as second-hand units become available.
Lithium-ion batteries must not go above or below set voltage parameters, so a BMS (battery management system) is needed. Some batteries have this fitted in the top of the cell.

Lithium-ion battery.

what are the benefits?

The main benefit of batteries is for people who wish to generate and use their own electrical power whether on or off grid. If you're building a renewable electricity system, you're not looking to use electricity as it's generated – the sun won't be shining all the time, and the wind won't be blowing all the time (although if you've got micro-hydro, your stream is probably going to be flowing all the time), and you're going to want more electricity at some times than others. So you'll need to store your electricity.

If you're not on the grid, you're going to need batteries. There's a strong environmental case for saying that if you're in an area where you can have a grid connection, then you should have one, and use the grid like an enormous battery, as the infrastructure is already there. Also, batteries contain lots of noxious metals and chemicals – so the fewer of them the better.

A second benefit, however, is about energy independence. Many people want to be sure that they are in control of their own energy supply all the time. They don't want to involve themselves with giant electricity companies, or risk everything going down if there is a power cut, especially as they have generated their portion of the grid electricity themselves. There's also a case for saying that with loving care, renewable electricity enthusiasts can be responsible for extending the life of second-hand batteries that would otherwise have died in scrap yards.

The third benefit of batteries is transportability – rechargeable leisure batteries allow the use of renewables in boats and vehicles.

what can I do?

Battery capacity is based on amp-hours and volts. A 12-volt bulb drawing 1 amp from a 12-volt battery will use 1 amp-hour per hour. So a 50 amp-hour battery will run the bulb for 50 hours. Don't discharge a battery below 50% of its capacity, so here you can safely run for 25 hours with a fully-charged battery. To run something bigger (e.g. a fridge) you have to think about wattage. If the fridge takes 150 watts, and it runs for 3 hours per day, that's 450 watt-hours (150×3) per day. So you'll need almost 40 amp-hours per day (450/12, because watts = volts x amps). With extra current (to start the fridge) and inefficiency, it's more like 70 amp-hours. Then, because batteries are c. 80% efficient, you'll need to put 80 amp-hours into your battery every 24 hours. Extrapolate from this for other appliances.

Next get your batteries. Traction batteries are tougher than leisure batteries and designed to be cycled. Get them from scrap yards, but only if you know what you're doing. The price will vary with the scrap price of lead. If an average house requires 3.5kW-hours a day, this equates to 150 amp-hours a day from a 24-volt battery bank. So for enough power for 2 days without discharging the battery below 50%, you need 600 amp-hours. This represents 12 cells, each weighing around 25kg, so you'll need a bit of space. Make sure their box/housing is locked and vents to the outdoors. NB: to reliably run a system using 3.5 kWh per day, you need at least 3kW of installed capacity. You'll need a charge controller to make sure you don't overcharge and damage your batteries, and to run standard 240-volt appliances from a 12-, 24- or 48-volt battery bank, you'll need an inverter. You can buy 12-volt appliances, but they're more expensive, so perhaps focus on getting a really good inverter.

resources

- see lowimpact.org/batteries for more info, courses, links & books, including:
- Miner Brotherton, *the 12-volt Bible for Boats*
- Dell & Rand, *Understanding Batteries*
- Micah Toll, *DIY Lithium Batteries*
- trojanbattery.com/multimedia – video tutorials
- batterycouncil.org: info on battery use/recycling
- batteryuniversity.com – technical resource