Electricity for Camping.

On an extended trip it’s good to have some of the comforts of home. Electricity is pretty obviously one of them and a good system can make all the difference. – good camp lighting, a cold beer, battery charging for the laptop, camera, phone, ipod, hf and uhf radios, gps, torches…….We’ve met some people on the track with no idea of the power drawn by the gear they "need". To put this in perspective, 20 watts will provide good camp lighting but a hair dryer or microwave will demand about 40 times that much. While it’s theoretically possible to run these “essentials” from an inverter driven by vehicle electrics, it is not practicable to do so.

But what do you actually need?

The vehicle’s own battery has only one critically important function – to start the engine. After that the engine will meet virtually all (sensible) electrical demands made of it. You will need electrical storage (batteries) for the times the engine is not running.

While it’s reasonable to take a little from the vehicle’s own (cranking) battery, for general camping use, a dedicated auxiliary battery is really called for. Not only does this avoid the problem of running down the cranking battery perhaps to a point where it can’t start the engine, but a proper deep cycle battery will perform much better at long slow jobs than the cranking battery.

Just how much electric power do we actually use in camp each day?

Fridge (compressor type) running about 1/3 of the time: 3.6 Amps x 7 hrs = 25 Amphours
Camp lights : 1.7 Amps x 3 hours = 5 Amphours
Laptop: 4Amps x 1 hour = 4 Amphours
Charging camera, torches etc: 1 Amp x 1 hour = 1 Amphour
Hf radio (12A peak, 2A avg): 2 Amps x 0.25 hours = 0.5 Amphours
Uhf radio: 1 Amp x 0.5 hours = 0.5 Amphours
Am/fm/cd: 1 Amp x 0.5 hours = 0.5 Amphours

TOTAL: 36.5 Amphours

In 2 days this will use 2/3 of the capacity of a 100 Ah battery. (2/3 is about as far as we wish to discharge the battery. A 100Ah battery is typical for this application.)

Clearly the fridge is the power hungry item and accounts for 2/3 of daily requirements. (This assumes a small compressor style fridge, not a 3 way type which would be far more demanding. Some of the newer compressor fridges take less power than suggested here.) [A very comprehensive review of compressor fridges by 4wd Monthly may be found here.]

Managing the fridge is important – add the beer in the morning when the beer is cool, not late in the afternoon when it is as hot as it can be, and don’t run the fridge too cold. Of course if we run the fridge as a freezer, the power requirement gets much much higher.

If we are going to run a fridge, saving an amp or 2 on more efficient lighting doesn't count a lot in the daily energy budget. Don't stint on lighting. LEDs and fluorescents are certainly more efficient than halogen lighting, but dichroic halogen lamps produce white light of far better quality.

Deep Cycle Batteries.

For auxiliary battery use, a deep cycle type is called for. All of the batteries we are concerned with here use lead-acid chemistry, which pretty much defines their voltages. Trace amounts of other elements, notably calcium, may be included to produce particular characteristics and these will change the basic voltages a little. A standard 12V lead-acid battery consists of 6 cells, each with a voltage of close to 2.1V. Six cells connected in series provide a nominal 12.6V. When charging, we may apply up to about 14.4V to force current into a standard wet cell battery, but must limit the current (amps, A) to a reasonable level, meaning less than about 20A in the case of a 100 amphour (Ah) battery. (This is typical of what we'll need for our auxiliary battery. We'll discuss battery sizing, Ah, etc below.)

Historically, the electrodes in batteries were immersed in a bath of concentrated sulphuric acid, dangerously corrosive stuff. Most cranking batteries and the cheaper deep cycle batteries use this arrangement. Now generally available and much more friendly are gel and absorbent glass mat (AGM) batteries. These are based on much the same chemistry and same acid, but the acid is contained in a gel or absorbent mat. (AGM has now largely superceeded gel in larger sized deep cycle batteries.) With this construction, the battery may be fully sealed and even used upside down. Because the acid is captive, gel or AGM batteries may be safely carried inside a vehicle. (Wet cell batteries should not be carried inside a vehicle. Not only is the acid a hazard if you accidentally go upside down, but wet cell batteries may give off small amounts of explosive hydrogen when charging.)

Battery capacity figures can be a mystery. Cranking (starting) batteries usually have a CCA (cold cranking amps) rating. They are required to deliver high currents for short periods. For a big 4WD we'd look for the highest CCA rating that will fit in the space available. While a CCA rating of 400 might be ok in the Holden, we'd look for at least double that, and maybe use two batteries, to start a 4 litre diesel.

Deep cycle batteries on the other hand are required to supply fewer amps, but for longer periods. They are usually rated in amphours (Ah), specifying the number of amps, multiplied by the number of hours we can expect. So a 100 Ah battery might deliver 5 amps for 20 hours, or 20 amps for 5 hours, and that's roughly what happens. The capacity is given in Ah at a particular rate of discharge (usually the 20 hour rate), and varies a bit with the rate of discharge. Often overlooked is the fact that fully discharging a battery will seriously shorten its life, especially if it's left discharged for very long. Generally it is recommended that a battery should not be discharged more than half, 2/3 at the most if it is to have a good life span. So while our 100 Ah battery might deliver 5 amps for 20 hours to be totally flat, if we value it, we shouldn't discharge it at this rate for more than 10 or 12 hours.

How do we charge an auxiliary battery in the vehicle?

In the simplest case, by switching it in parallel with the cranking battery while the engine is running. This switching can be manual, but far better to use a proper controller ($100-200) which makes the connection only after the cranking battery has been recharged, and will reliably disconnect the batteries from each other when the engine stops. Disconnecting is important, since otherwise the “household” electricity will be drawn partly from the cranking battery. It is essential too that the batteries be disconnected from each other when starting the engine so as not to damage the auxiliary battery and wiring.

Alternators fitted by the vehicle manufacturer are usually rated at 55 amps. Higher capacity ones (100, 150A) are also available, but will seldom be required for our auxiliary purposes.

These simple systems have limitations, but are often adequate. One major limitation is that the charging voltage should preferably be a little higher than that available for charging the cranking battery. This is especially so when the auxiliary battery is mounted some distance from the cranking battery, perhaps in the back of the vehicle or in a trailer, as voltage is lost in the wiring. In addition, the chemistry of most deep cycle batteries will be slightly different from that of the cranking battery (due to calcium doping) and call for higher charging voltages (at least 14.4 and some over 15V instead of 14 –14.4V). Manufacturers usually state charging requirements on the batteries, and their recommendations should be adhered to.

Special chargers (referred to as "12V to 12V" or "DC to DC" chargers) are available ($150+ for a 10A one such as this and double that for others such as this one to step up the available voltage to overcome wiring losses and match the requirements of the auxiliary battery. Another one (Australian), with the advantages of a 3 stage charger is this one. Note that these are switchmode devices and hence capable of generating significant radio interference.

Regardless of what charging controller is used, it is essential that heavy wiring and good connectors be used to minimise resistive losses.

Any battery in the system MUST be fitted with a fuse close to the battery to protect the wiring and minimise the risk of fire. Because of the currents involved a 30A fuse is usually suitable here. To protect individual outlets and loads, smaller fuses, say 10A, are preferred.

Charging from the 240V mains

Different types of batteries, Gell, AGM, wet, calcium..., require different charging regimes. Good chargers are not cheap, but cheap chargers can cost battery life. The better chargers provide constant current charging (the bulk charge) as the battery voltage rises to a predetermined level. (This current should not exceed 20% of the battery's amphour rating and should preferably be less - the maximum rate for a 100 Ah battery is 20 amps though I favour 15A.) The voltage is then held constant at this level during the absorption phase while the charging current slowly drops to a low level. It is the voltage at which the change from constant current to constant voltage occurs that differs between battery types; around 14V for Gel, 14.4V for AGM, 14.4 to 14.7V for wet and calcium batteries. The better chargers also allow for long term float charging at lower voltages (usually about 13.5-13.7V) to maintain the battery for extended periods. Good readily available chargers include the Australian Projecta (details here) and Swedish Ctek.

Generators and Solar Panels

If you find the perfect camp spot and stay there for more that a few days without running the engine, some other way of charging the auxiliary battery will be needed, especially if you are running a fridge. Solar panels are expensive ($500 - $1200), and big and awkward to carry. Another option is a small generator. Too often, you get what you pay for with the small cheap ones. A respectable generator may cost over $1000, and will usually not be satisfactory as a battery charger (no matter what the brochure says). You will then need a suitable mains powered charger to run from the generator. This should be a 3 stage one (more below) and will probably cost at least another $200. (A $20 charger is about as useful as a $20 compressor!)
A generator may have other applications – you might carry a power hungry hairdryer or microwave, which would embarrass a battery based system. Don’t forget though that in many campgrounds and national parks, generators are not welcome, and the noise is a selfish intrusion on other’s peace and quiet.

Another option worth considering - Some travellers run their engine on fast idle for a while (say an hour) each day when stationery just to put some charge in the auxilliary battery. This costs fuel, but doesn't require any expenditure on extra gear, so may be a very cost effective way to go.

Solar panels from about 100W upwards can usually meet the needs of an energy frugal campsite. About 150W capacity should handle a less frugal camp. It should be noted that no solar panel will deliver DIRECTLY to a 12V battery the full wattage claimed by the manufacturer. Their rating is based on the panel operating at its optimum voltage, about 17-18V, but for charging a 12V battery we can’t use voltages as high as this. The rated current is available, but we are limited to no more than about 15volts. Watts=Volts x Amps, so with the reduced voltage and a simple controller we can deliver to the battery only about 70 - 80% of the panel's rated wattage.

We need a controller between the panel and the battery to prevent overcharging. The controller should preferably be at the battery end (not the panel end) of the cable in order to minimise losses. There are essentially two types of controllers, the simple ones and the MPPT ones, which until recently were considerably more expensive. Both types are used to prevent the battery being overcharged, but in addition the Maximum Power Point Tracking (MPPT) ones convert the panel's output voltage to that required by the battery. In this way, most of the rated power of the panel can actually be used. Details may be found here.

To achieve maximum power, the panels must be aimed reasonably well at the sun, so must be moved a few times a day as the sun moves across the sky. (Purists might argue that it’s the Earth that moves, but that’s another story!) Then of course solar panels don’t work too well under cloud either. On the other other hand they do provide an alternative when all else fails, and given time can charge a battery sufficiently to start the engine if the alternator fails, or to call for help by hf radio.

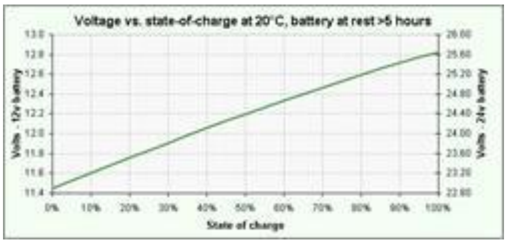
Charging constraints.

In a perfect world batteries would be charged by a three (or more) stage charger. These deliver a constant current (amps) while the voltage slowly rises to a predetermined level. After this the voltage will remain constant and the charging current will slowly fall as the battery approaches maximum charge. When the current has dropped to a low value, around 1 or 2 amps for our batteries, the charging voltage is reduced a little and the battery may then remain in this state for months. Different chemistries lead to differences in these threshold voltages and currents. For our purpose though, the constant current phase should use a current no higher than 1/5 of the battery’s Ah rating (e.g 20A for a 100Ah battery). The constant voltage phase may be 14.4V for flooded batteries, usually a bit higher (14.7V, sometimes up to 15V) for AGM types. The particular battery will carry the manufacturer’s recommendations, which should be observed. This applies particularly to AGM, gel and calcium doped batteries.

In the real world, the battery will be charged by the alternator which delivers a voltage which varies with alternator temperature and is intended to suit the cranking battery. The voltage will be a bit low for charging the auxiliary battery. (Note that while the alternator is running, it will be powering the fridge and all the other gear too. This load can cause a voltage drop which further limits the voltage available for charging the battery. Heavy cabling is essential to minimize this drop.)

The most critical factor is that the charging voltage supplied by the alternator is too low to fully charge the auxiliary battery. A few hundred dollars will buy a 3 stage charger running from the alternator to charge the auxiliary battery. Or quite a few more hundred dollars will buy a solar panel which will deliver the required higher voltage. It is important that a solar controller be use to cut off charging when the battery is full. Otherwise, once the battery can no longer absorb the current from the solar panel, the solar voltage will rise excessively and can damage the battery.

The question often arises "Can I measure how much charge is in the battery by measuring its voltage?"
The simple answer is NO. The more accurate answer is YES BUT.... where the BUT is like this -



Battery State of Charge V's Measured Voltage - Indicative only

When a battery is being charged or discharged, the measured voltage depends largely on the rate of flow of current in or out. The battery voltage doesn't stabilise for hours after current flow ceases, so Yes, you can get some idea of the state of charge if you let the battery rest for a few hours before taking a measurement. Because of the different chemistries, different batteries will show different voltages at the same state of charge, so the measured voltage will give an idea, but not a good indication of state of charge. The curve in the graph applies to many wet cell batteries, but don't treat it as being reliable and note that it calls for a 5 hour rest period before measuring.

A few back-of-envelope calculations:

According to the table above, if we could input about 40 Ah, we could replace one day's drain, so we'd gain an extra day's use. If we could do this every day from solar panels, we'd be fully self sufficient while ever the sun shone. Assuming 7 hours of strong sunlight per day, we'd need about 6 amps, which would call for a panel with a nominal output of about 100 watts.

An 80 watt panel will supply close to 5 amps, which isn't quite enough to meet daily demand with 7 hours sunshine. With good sunshine though, it would take a week or more before the cumulative daily loss became a problem. A 60 watt panel will deliver about 3.5 amps, or about 25 Ah per sunny day, so can meet only 2/3 of the daily demand. It will extend our stay from 2 days to 3 days before the battery is 2/3 discharged.

To harvest enough sunshine for a long term stay, allowing for some cloudy days, a 120W panel (or 2 x 60W) should be good.

This is confirmed by our own experience. A 60W panel didn't help a lot, but adding an 85W panel to it to give 145W capacity was excessive.

What about 240V ?

The need to have 240V power when camping can be largely avoided. 12V chargers for camera, phones, gps, laptop etc are readily available and more efficient than using an inverter from 12V to supply 240V to be changed back to some low voltage to charge the batteries.

An inverter has basicly two functions – to provide an alternating current (ac) voltage rather than the direct current (dc) available from the battery, and to raise the voltage up to an average of 240V. There are several types of inverter. The most expensive provide a pure sine wave which is preferred for any sensitive equipment, especially laptops. The cheapest simply provide a square wave ac, which is satisfactory with motors and some small chargers for cameras, phones etc, but not for most laptop computers. There are also intermediate types, "modified sine wave", which combine a number of square waves to approximate a sine wave shape. These are usually satisfactory for laptops, but, like the square wave types, often create a lot of radio interference. Some details of the three types may be found here.

Inverters are about 80% efficient. They come in different sizes. A 150W unit will handle most camp requirements, but may have trouble starting a laptop (even though the average drain by the computer is much less than this.) A 300W unit is probably a sensible minimum. Bear in mind that Watts = Volts x Amps, so, if we draw the full 300 watts, we will require 25 amps from the 12volt battery, plus 20% to account for inefficiency. That's 30 amps. This will draw from the battery in 1 hour about the same as all other loads discussed above take in a day. There are also many larger inverters. A 2000W one will provide enough power to run power tools or even an electric jug, but at full output they will draw from the battery about 150-200 amps. That's as much current as the winch when fully loaded, and way outside the comfort zone of any deep cycle battery. When drawing big power from these big inverters it is essential to run the engine so that the alternator can shoulder part of the load.

A final point not to be overlooked – the 240 volts from an inverter is just as lethal as the 240 volts in your home.

Some useful links:

A very comprehensive article covering vehicle electrics and solar power may be found here on ExploreOz

Another excellent source for detailed information on deep cycle batteries is this one.

Other useful electrical sites include these, concerning the selection and use of meters Meter usage tutorial and this more detailed one

What sized wiring should we use? These links refer to AWG sizing, but note that AWG and B&S sizing is the same. These sizes refer to the amount of copper in the cable, not the outside size of the insulation. Be careful - some wire sold as say 6mm is 6 mm diameter (outside the insulation!) not 6 square mm of copper. Best to buy by B&S (or AWG) sizing.
Wire gauges, sizing in mm, square mm, resistance per metre
Maximum recommended current as a function if wire size and length

Can we measure the net flow of charge in and out of our battery to get some idea of the state of charge? Yes, BUT..... Batteries are generally about 90% efficient, so we need to put in at least 10% more than we take out. The efficiency gets worse if we take charge out fast - if we discharge at say 20 amps for a certain time, it will take much more than twice as long to recharge at 10 amps. So yes we can measure net in and out, but it isn't very useful. A detailed discussion of the various factors involved may be found here.

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