EFFECTIVE ON-BOARD POWER MANAGEMENT

A guide to getting the most from your on-board energy system.

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Introduction

From the engineer's side of the fence, it seems that something in the order of 80 or 90% of reported problems with electrical systems come down to installation faults (such as undersized cables or poor connections) or misunderstanding and inappropriate expectations of how a system works. Few problems relate to genuine faults with equipment.

One common issue is that of well meaning but technically flawed advice picked up in the yacht club or the local pub. Confused stories about how to look after your batteries are amongst the most common types of misinformation.

This publication sets out to dispel those old wives tales and give you the facts about managing your batteries and using your power system so that you can get on with the business of enjoying your time on board rather than putting up with endless aggravation.

The first and most important point is that you must understand the fundamental difference between what happens at home and on your boat. At home you have an endless ever-ready supply of energy without limitations. On your boat you have a limited resource in two respects; firstly there is only a certain amount of energy available before you have to replenish and, secondly, you have a maximum level of power you can use at any given instant.

With these principles in mind, power management becomes a straightforward mathematical equation – what you take out you have to put back in. Understanding how much energy you have and how to use it most effectively requires a little know-how and providing the necessary basics of this knowledge is the aim of the exercise.

A great deal of this knowledge centres around one of the most technically complex components in your system – your batteries. Understanding enough of how they work and how to treat them is crucial and so is the best place for us to start.

You and your batteries

In marketing terms a battery represents the typical distress purchase – there is absolutely nothing exciting about batteries, you can't show them off or watch them perform, they don't look at all exciting and for some they can be an endless source of trouble. Yet you simply can't do without them. If your batteries don't perform then you can't do anything on your boat. So the relationship you have with your batteries really needs to be a good one.

To get straight into it, there are a number of key facts that you have to know about your lead-acid domestic battery bank (NB: Wet, flooded, spiral, gel & AGM are all types of lead acid battery). Forget everything you may have otherwise been told, this is how it is:

- Life expectancy for domestic batteries is defined by the number of times you charge and discharge them – this is called cyclic life.
- Cyclic life then relates to depth of discharge i.e. The more deeply you discharge your batteries the shorter their life will be. Anyone that tells you that your battery needs to be flattened now and again is plainly wrong – that is something you do to prevent memory effect in old style nickel-cadmium cells.
- Optimum average depth of discharge is 50% of capacity. Managing your battery around this target delivers the best relationship between cost, usability and life. A more shallow regime will be inefficient and result in frequent and disproportionate recharging; a deeper regime will cost significantly in life.
- Prolonged exposure to high temperature significantly reduces battery life and will also lead to overcharging that further reduces life.

- Batteries left for longer periods in a semi-charged state will deteriorate more rapidly than a battery that is fully charged – always leave your batteries fully charged when you leave your boat or ensure your battery charger is switched on.
- Battery capacity reduces with higher rates of discharge.
- You can have too much battery capacity as well as too little – adding an extra battery or two because they don't last long enough may well be fuelling problems rather than solving them. Check and address any problems with your charging systems before adding further battery capacity.
- Avoid mixing batteries of different capacities or ages – the whole bank will only be as good as the smallest and/or oldest block.

These factors need to be kept in mind as you manage your batteries on a day to day basis. Be aware of your energy usage and get into the habit of an appropriate charge/discharge regime. Be conscious of temperature and allow your batteries to get cool air especially in the height of summer. The worst scenario for batteries is for them to be in an engine compartment with your engine running to charge your batteries with the covers shut and on a hot day whilst moored up. They won't thank you for it.

Stay in touch with what's happening

You don't have a chance of effective management of your systems if you don't know what is happening. Batteries don't give you any obvious clues as to what is in them. You learn nothing by kicking or shaking them and you can't look in the top to see how much electricity is left. Nonetheless, knowing accurately what is in the battery has to be the starting point.

A good analogy is to compare things with driving your car. You wouldn't dream of going on even the shortest journey without a fuel gauge. If you did you would have to guess how much fuel you have in the tank. So then you would have to guess when it was time to fill up. If you got it wrong, you would have no advance warning and by the time you know you'd run out of fuel it would be too late with, if you're unlucky, a long walk to the next petrol station or worse.

It's the same for a battery. Using voltage as an indicator of what's left in your battery is unreliable. It's a common misconception that the voltage a battery shows has a linear relationship to capacity. The reality is that a battery will quickly drop to a nominal 12 Volts, give or take a few tenths, once in discharge. If load is modest, the battery will sit at that voltage until it is nearly 75-80% discharged when the voltage would quickly start to drop. By the time this happens, it's too late and things will start to go wrong – and the battery will be damaged as a result.

Further complication is added when you understand that a well charged, healthy battery under heavy load might show a very low voltage and then recover to normal just as soon as the load is removed, Equally, a heavily discharged but otherwise healthy battery will display a deceptive nominal 12V if not being discharged.

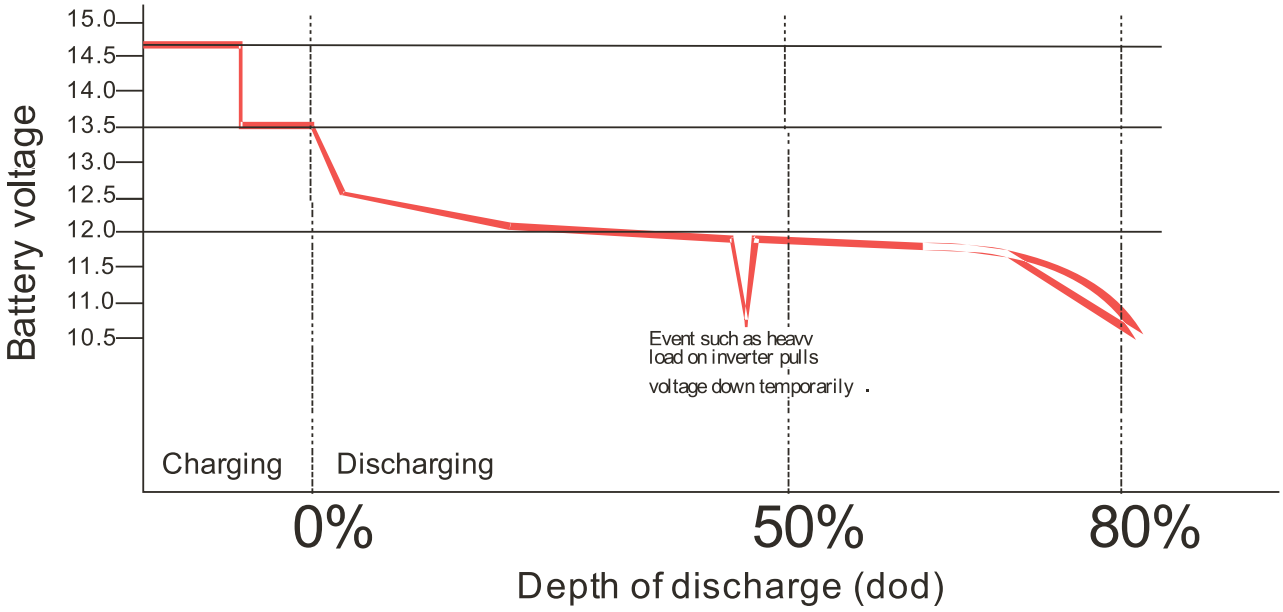


Illustration of how the voltage of a battery drops gradually under modest load until roughly 70% discharged when voltage starts to fall off rapidly. At about 80% dod battery becomes unusable and the point of excessive discharge and potential damage is reached. At any point a substantial short term load may result in voltage dip that then recovers after load is removed. So, reducing battery voltage is not linear and cannot be relied upon as an accurate indicator of state of charge.

Spending a couple of hundred pounds on the purchase and installation of a decent battery monitor that gives you a reading of ampere-hours could then be the best investment you make. The chances are that you'd save that over a few years in replacement batteries; quite apart from the potential of solving your battery problems overnight once you learn exactly what is happening and you are armed with the right information.

The saying goes that knowledge is power and these words couldn't be more accurate when it comes to managing your on board systems.

Effective charging

The next step is to ensure that you can effectively charge your batteries. The two key issues here are i) having the appropriate capacity in terms of how much current your charger or alternator can deliver and ii) being able to apply that energy in a sophisticated way so as to get the battery charged fully, quickly and safely.

The rule of thumb used for assessing the best capacity for charging is to aim for between 10% and 20% of battery capacity. The 10% rule is defined as being what a battery needs to effectively charge. If you anticipate the need to run loads at the same time (i.e. that you expect to be on board rather than plug in and clear off) then the 20% rule gives you that additional capacity.

Alternators are a slightly different case as the actual output relates to engine speed – a 100A alternator, for example, might only give you 30 or 40 Amps when the engine is at tick-over. So the science tends to go out of the window and you are well advised to get the biggest alternator you can fit – particularly, for example, when you have big loads that you want to run from an inverter supported by having the engine running.

Given the appropriate charge capacity the next issue is charge characteristic. This, in simple terms, is how the charger goes about it's business. To get a battery fully charged you have to change how energy is applied to the battery. There is a well established 'multi stage' process that achieves this. Most battery

chargers follow this process with each manufacturer adding their own particular slant on things.

Alternators are less sophisticated, however. In fact, you could go so far as to say that a standard alternator is a power supply not a battery charger. To get your alternator to perform like a mains battery charger you need to 'enhance' the characteristic either by manipulating the regulation of the alternator itself or by taking the output of the alternator and manipulating it between the alternator and the battery. Messing about with the alternator is a hassle and, with the increasing sophistication of engines, it is becoming less desirable. So a device that manipulates the output separately to the alternator is a far better prospect.

A final word on charging is to say that charging a battery is not a linear process. It takes as long to charge from 80 to 100% state of charge as it does to get from, say, 20% to 80%. This is because a battery's resistance increases as it charges and it is therefore increasingly difficult to get the last bit in. Also, as the risk of overcharging is greater, the charge process has to slow down once you get much above 75 to 80% charged. In part, this factor relates to why it makes sense to allow your battery to run down to a 50% average discharge before starting the charge process.

So, now you can charge your batteries effectively and you have accurate information on what they have in them, you're ready to go.

Where the energy goes

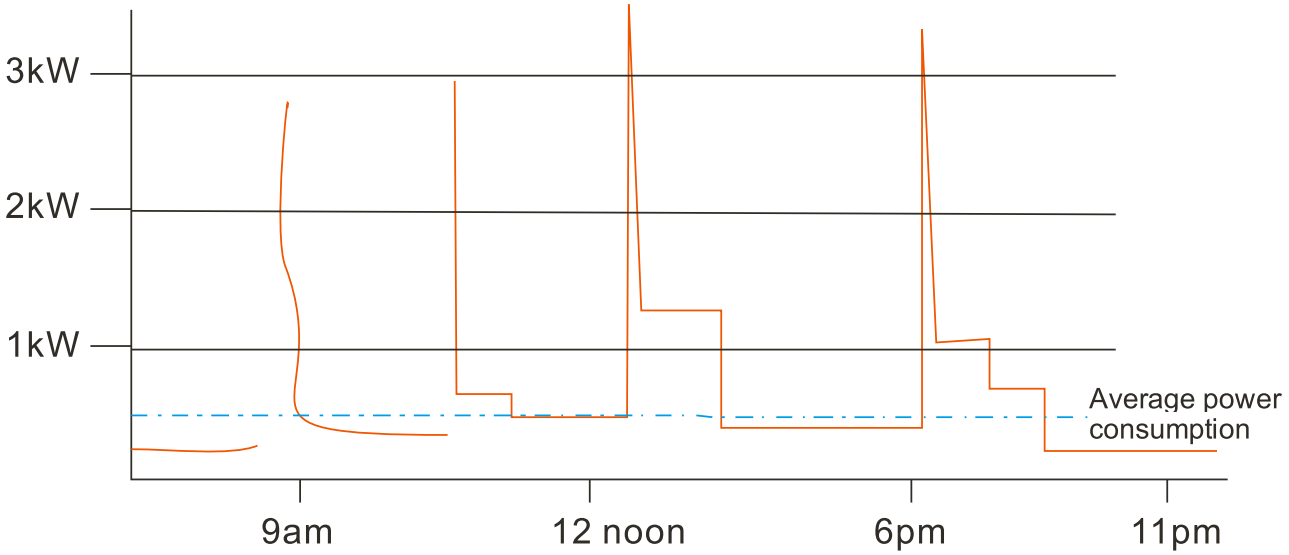
It helps to understand how we use power; something it is not necessary to worry about in domestic life. The reality is that we generally have short periods of high power use that occur infrequently, separated by longer periods of low power use.

Knowing the subtle difference between power and energy is crucial. Power is the instantaneous magnitude at which energy (or electricity) is used. Energy is then the quantity of power that is used over a period of time. In electrical terms we measure power in watts and energy in watt-hours.

A useful illustration is to consider the use of a travel kettle. Typically, such an appliance has a power rating of 1800 watts (or 1.8 kilowatts). To boil the kettle might take, say, 3 minutes which is one twentieth (0.05) of an hour. Whilst the *power* used is significant at 1800 Watts, the *energy* consumed is 0.05 x 1800 = 90 watt hours. From a 12V battery this equates to a rather modest 7.5 Amp hours (Ahrs). By comparison, a 50 watt light, (using 36 times less *power*), on for 2 hours will, in fact, use more *energy* at 8.3 Ahrs.

So this illustrates well the difference between short term high power appliances (like a kettle) and low power long term devices (such as lights). It might surprise you to know that we use more energy for lights and fridge/freezers than anything else. This is more significant in a situation where we need to be careful with the energy we use so efficiency savings for lights and fridges can have significant impact.

As a very general rule of thumb, the table below gives an idea of the power used by a variety of common appliances and devices in their typical pattern of use on a boat.



The diagram aims to illustrate typical power usage over a day. The main issue to note is how power is used in peaks and troughs. There will be a base load, consisting of lights, fridge and pumps, that represent a couple of hundred watts. In the evening you might add the TV or computer to this. Then we have occasional loads, perhaps of several kilowatts, when a kettle is switched on, something is heated up in the microwave or the washing machine is heating it's water.

The most significant observation is that average consumption is comparatively low. Also, it is apparent that the base loads are those that consume the energy – boiling a kettle (with just enough water to make a cup or two of tea of course) powered by an inverter or using a hair-dryer for a couple of minutes, has very little impact on battery capacity despite what is commonly perceived.

Over time you will learn how much power you use to perform specific tasks or to have particular appliances or devices switched on. The battery monitor will be a significant aide in this regard, giving you information on how much energy is being used at a particular time and the capacity taken from a battery. You can complement this by having an instrument that shows you how much power is being used in kilowatts for both AC and DC systems.

Tips on Energy Efficiency

There is a great deal of buzz about energy efficiency in many aspects of our lives. In the context of a boat you want to be energy efficient for selfish reasons as much as anything else and the usual rules apply with regard to not having lights on that you don't need, switch the TV off properly (not just on standby), only boil the amount of water you need to make the number of cups of tea/coffee you want, etc., etc.

There are a few choices you can make with regard to appliances and fittings that will make significant impact. The first thing to visit is lights. Conventional filament lamps are hugely inefficient with more energy being given off as heat than light. Low energy compact florescent lamps are a superb alternative, of course, and can now be found in a variety of styles including GU10's (a replacement for 230V halogen types). LED fittings are another alternative but they are yet to prove themselves in terms of light output watt for watt. Energy savings are considerable in either case, however, and the lack of heat dissipation is an added safety issue of course.

Energy saving compact florescent lamps & LED's get better and better and, whilst they may not be perfect in all applications, they do the job perfectly well. Mixing these with a few halogens, for example, where the need is greater (e.g. a reading light or under the cabinets in the galley) might be a good compromise.

There are significant savings to be made with different approaches to refrigeration; this is a subject that might command a book all of it's own so this is left to the fridge experts. Suffice to say that you should investigate the pros and cons of different products and their energy consumption before making your choice.

Then there are other things to consider. If you want to get rid of gas altogether, induction cooking is well worth consideration. Induction hobs perform better than gas in terms of controllability and are accepted as the most energy efficient type of hob compared with conventional electric types, halogen or gas. Cooking electric is not as energy hungry as you might expect but, even so, it's not a decision to be taken lightly as you need to be sure that you have enough power available to do the job.

Conclusions

Putting all of this together gives you a basis for managing your power on an informed basis – not just in terms of the information you can take from your instruments but also the knowledge you have accumulated reading this pamphlet.

With a bit of planning, conscientious use of energy and the basic knowledge to make the right decisions, there is no reason why you can't use anything you want, regardless of where you are, what time of day it is or what you are doing.

Enjoy!

If the material here has whetted your appetite for more knowledge and you are planning a specific project then we are happy to help. Contact us with an outline of what you are planning and we will be happy to help with specifying what you need for your application.