



## Using Solar Power for Off Grid , Vehicle & Backup Power Systems



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## HELPFUL GLOSSARY

### **WATTS (W)**

This is the measurement of the amount of power each of your devices use.

### **kW HOURS (kWH)**

This is the Watts multiplied by hours of usage.

### **AMP HOURS (AH)**

This is the combined measure of energy you require to maintain the devices you have input into the calculator.

Results are calculated for 12V 24V & 48V systems.

### **BATTERY VOLTAGE (V)**

Depending on the purpose and size of the system as well as the way it is wired up, 12V batteries can be used for 24V & 48V systems and results are calculated for all three size systems.

### **INVERTER EFFICIENCY (set at 90%)**

Your final calculation is adjusted to account for general inverter inefficiency.

### **DEPTH OF DISCHARGE (DOD)**

Calculator results are based on 100% and 50% discharge rates.

DOD will vary according to your particular battery and your usage requirements.

Acceptable DOD will usually range between 30% for continued use to 70% occasional use to ensure longevity of your battery. For more information you will need to download PDF Specifications on your particular battery.

### **MAX PEAK LOAD**

This result gives you a Watt calculation of ALL listed items as if you were running them at THE SAME TIME. This is a good contingency method, but you may wish to manually adjust this on your printout to reflect a more accurate maximum load at any given time.

NB You will need to ensure the size of your inverter can supply the surge (max power load requirements) of your system.

### **AUTONOMY**

This is the length of time your system will supply energy when there is no input from external eg no PV Panels, no input from the grid or any other power generators. Results are calculated for 24 or 48hr periods to help you calculate requirements for backup systems.

### **AMP HOUR RATING**

The AH rating on the battery you select should be **equal to or greater** than the AH you have calculated.

### **C-RATING**

Your next criteria for selection is your C Rating which will determine the peak load in Amps that your



battery can supply continuously for a specific period of time. The C Rating for the battery you are looking at can be found on the downloadable PDF Specifications sheet.

## STAND ALONE OFF-GRID SOLAR SYSTEMS



It seems like a lot of people are starting to think going “off-grid” is the smart choice, and internationally the phenomenon of the stand alone solar power system is catching on like wildfire.

All over the internet are pages and videos devoted to living off-the-grid and what it takes to set up a totally sufficient area of the home such as office, workshed, cabin and even up to complete residential systems which require remarkable and creative lifestyle changes.

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### APPLICATIONS FOR OFF GRID (STAND ALONE) SOLAR POWER SYSTEMS

- Holiday Home / Cabin / Shack
- Sheds & Barns
- Off-grid residential power system
- Off-grid stand alone commercial/industrial solar power systems
- Specific solar powered off-grid applications
- Outdoor and farm use

### BENEFITS

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- Autonomous Power - not reliant on national power grid
- Renewable Energy - Less damage to environment
- Cost Efficient - One time investment, no power bills





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## PLANNING YOUR SYSTEM

If you are looking to set up an independent stand alone system there are a variety of things to keep in mind:

### WHICH KIND OF APPLIANCES ARE YOU USING?

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There are many power economical whitegoods hitting the market these days, a little research will go a long way into finding home appliances that have been redesigned to either work directly into a 12V system or by using an inverter you can enjoy a lot of 240V items which have become extremely power efficient with advancing technology.

See our online energy calculator or view our Appliance Table further on in this ebook.

### TIMING YOUR USAGE

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The best kind of system is an economical system. It is a good idea to schedule your large appliance usage so that you are not trying to use everything at the same time which would drain your energy storage very quickly and if you exceed your maximum load would result in a system shutdown. By scheduling your usage, you can keep a consistent power supply as well as recharge most effectively to replace the power you have used.

### SPLIT YOUR SYSTEMS

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If you know there are going to be conflicts between aspects of your setup, eg home and workshed, or if you just want to start small and grow, an efficient and cost effective method is to break down specific areas of your system so that they are self reliant and responsible for a particular job which can make it easier to calculate and manage.





## DO YOUR PRODUCT SUPPLIER & INSTALLER HOMEWORK

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- If you are going to be relying on your solar power system for survival and important applications you want to steer clear of cheap products and negligible suppliers.
- Ensure your supplier offers a clear warranty... Inside Australia! Some well known brands can be bought cheaply from overseas online, but because of international regulations all warranty may be invalid.
- Ensure your system configuration is designed by a qualified Stand Alone Power System Designer and that you will be supplied with correct custom drawings for your system.
- Do not attempt to install the system yourself without support from a qualified tradesperson. System safety is paramount and incorrect wiring can lead to dangerous and potentially life threatening situations. All fully accredited off-grid electrical installers will have a S.A.P.S Installer Licence number which can be verified via [www.orer.com.au](http://www.orer.com.au)
- Check if you are eligible for rebates. Government rebates are slowing down in terms of solar installation bonuses, but depending on your circumstances and access to power in your location, you may still be eligible for remote grants. You can check your eligibility at [www.orer.com.au](http://www.orer.com.au)





VENTURE FURTHER THAN YOU THOUGHT POSSIBLE  
– AND STAY AS LONG AS YOU LIKE...

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Imagine the freedom of travelling the countryside with complete autonomy. Having solar installed on camping and touring vehicles is becoming more and more popular as so many people are enjoying the flexibility that solar power provides.

Having your own renewable power supply not only allows you to enjoy those extra creature comforts, such as running lights longer, maintaining contact with the outside world by running computer devices, and a valuable backup service, there are a whole range of other benefits from having solar on the road.

With the autonomy of solar you can venture further to find the most peaceful and idyllic spots Australia offers; stop wherever you like for as long as you want and really enjoy the tranquility provided by our native landscape without needing to interrupt the peace with noisy generators to maintain your preferred power levels.

So with everyone raving about the benefits of solar on the road, how to know where to start, and ensuring you get quality products that won't cost the earth, with qualified advice from a reputable company can be a major concern.

Marsol Industries is an Aussie owned and operated wholesale solar supplier. We specialise in all the components you need to set up your mobile solar system. With one of the largest and best priced online solar stores in Australia, the Marsol warehouse is based in Noosaville on the Sunshine Coast. We import our own products which are backed up with solid back to base warranties and have a growing and dedicated team to offer our customers expert and personalised service with selecting products, including the ability to customise systems to your needs.

We have a lot of happy campers around Australia using our own Hurricane Solar Products and to make it even easier for newbies to solar we have developed Complete DIY Vehicle Roof Installation Kits with a step by step video guide and suggested wiring diagrams to streamline your installation process.

So now there is no reason not to hit the open road as your own power generation unit, and truly enjoy the freedom of clean, renewable power on tap!

## SYSTEM EFFICIENCY

The common perception when it comes to using solar power as a backup power supply is that power supply is calculated by the size and amount of solar panels you have on your vehicle, when in actual fact, the amount of backup power you will have actually relies on the size and quantity of your storage batteries.

The job of your solar modules is to charge your battery or batteries. When you have established your energy usage, and storage needs you would then determine how quickly you want your battery bank to recharge.

You can use our energy audit calculator or fill in our online quote form to list all your appliances, lights (power rating), fridge, microwave & music players/tv etc their power ratings & usage, total them up and this will tell you the total power needs for your caravan or motor home, measured in amp/hrs.

This figure will need to be less than the total storage of your batteries as it is important to keep use a minimum charge of 30% in your battery at all times, using a maximum load of 70% charge from your battery for general use. For consistent everyday use it is preferable to take a maximum of 30-50% load off your batteries to extend battery life.

You will also need solar capacity greater than the minimum power drawn from the batteries to effectively recharge them & keep them fully charged. The amount of power generated by the solar panels varies as well, cloudy conditions can reduce the power generation output by approx 10-50%, so many factors can affect the solar power production.

Inverter efficiency (usually 90%) and solar panel efficiency should also be factored in as well as battery temperature de-rating for extra cold or hot environments. All these factors will have an impact on the amount of stored battery energy needed. It is always better to have slightly more energy storage than not enough.

The voltage of your system will also influence your system efficiency, 12V being the least economical but great for small power systems, with 48V systems being the most power efficient especially in cases of stand alone off grid solar systems.







### THE BIGGEST DRAIN ON YOUR BATTERIES IS YOUR FRIDGE OR COOLING SYSTEM.

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The best way to reduce this drain is by installing a quality solar system which will ensure your batteries stay charged and allow more autonomy when on the road.

Frequently we are asked by customers what do I need and can we give a generic solution. Unfortunately this is not possible, as requirements can vary dramatically. Your system requirements will depend on the size of your fridge or cooling system, the battery storage system you currently have, and the desired time you wish to use these appliances away from a 240 volt power source. We can however share some suggestions that may be helpful when setting up solar to power your refrigeration and cooling so you can maximize your performance.

### TIPS FOR MAINTAINING ECONOMICAL REFRIGERATION & COOKING:

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- Keep seals cleaned to ensure good contact with frame
- Make sure your thermostat is set to an economical level
- Avoid ice build up; some fridges are not automatically defrosting
- Where possible using gas for your fridge and cooking will save you a massive load on your solar and battery bank, in turn, saving you in your setup costs
- When using solar a compressor style fridge is preferable
- Ensure your fridge has a low voltage disconnect
- Choose a fridge that is the appropriate size don't over-compensate!



## BACKUP & ALTERNATIVE POWER SUPPLY

Using Solar as an alternative power supply or backup supply is not specific only to your vehicle and travel needs but can also include a variety of general and maintenance uses including:

### TRICKLE FEED BATTERY MAINTENANCE

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A lot of people leave one or more cars at home when they head off for a few months. There are lots of vehicles both farm & recreational that we use infrequently, and we all know the disappointment of getting all ready for a day of adventure or challenge to find a flat battery in the shed. Boat / vehicle / motorbikes / quad bikes / farm & machinery batteries benefit greatly from keeping a constant charge, ready to go when you are. Look to our 40W Battery Maintenance Kits, or our Enerdrive or Projecta wall plug battery chargers that will charge and regulate the levels of your battery.

**These are also great to maintain your vehicle batteries left at home when you are away!**

### PORTABLE CCTV CAMERA SYSTEMS

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Sometimes it would be great if security was portable. Marsol have teamed up with BBA Protective & Electronic Services to power their remote portable video monitoring security systems. Looking for a custom security system, or a package to solar power your existing system? Give us a call and we can help design your portable/self-sufficient system.

### 12V HOME SECURITY LIGHTING

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I spoke to a customer the other day who said when he goes away for periods of time he has all of his outdoor and “security” lighting set up to run from a 12V solar powered battery bank. This means his lights are always on and there is no excess on his electricity bill! This is great in combination with LED high efficiency lighting.

### LAPTOP & COMPUTER BACKUP

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Terrified of entering the dark ages within hours of pulling the plug? Marsol have recently created a Solar Laptop Charging Kit that will keep your computer running whether you are on the road or just want to be sure no matter what the weather you can stay connected!

### BACKUP POWER FOR MEDICAL EQUIPMENT

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Don't have the constant worry of relying on power close by, or the power grid to ensure immediate access to essential medical equipment. Maintain the correct size battery for your



equipment using solar or a wall powered battery charger and you will always have an emergency power supply dedicated to medical backup.

## IRRIGATION & PUMPS

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Some things like a fresh air or water supply without requiring much extra effort, but what happens to the fish pond or water pump when there is a power outage? It can be worth considering running these items independently on 12V with solar to keep your battery charged whether you are home or away.

**Marsol Industries** solar energy products store specialise in solar panel kits for all kinds of applications and also custom designed kits to suit your alternative or backup power supply needs. Give us a call and have a chat to our friendly team on 1300 627 765 or visit our website for comprehensive information on solar applications at [www.marsol.com.au](http://www.marsol.com.au)





### HOW TO COMPARE PV PANELS

Key factors when to check when buying panels:

- ☐ Warranty terms for the panel and is this serviced within Australia?
- ☐ Panel construction - strong frame construction & toughened glass
- ☐ Cost per watt of the panels?
- ☐ Performance data and specifications
- ☐ Reliability of supplier

### THE DIFFERENCE BETWEEN PV SOLAR CELLS – MONOCRYSTALLINE VS POLYCRYSTALLINE

Solar cells are commonly square and approximately 12cm x 12cm. They are made of a crystalline compound and are connected together to form panels that produce convenient voltages and currents. On this page we will attempt to explain the differences between solar panel cells in basic terms for newcomers to understand.

### IDENTIFYING THE DIFFERENCE

#### POLYCRYSTALLINE

Poly-crystalline silicon solar cells are blue, with a visible crystal texture. The original solar cell, still performs well, but not as efficient as monocrystalline

#### MONOCRYSTALLINE

Single crystal silicon solar cells (monocrystalline) are dark grey, matte appearance, while Australian field tests have shown monocrystalline panels generally produce more power than polycrystalline both under test conditions and normal operating conditions.

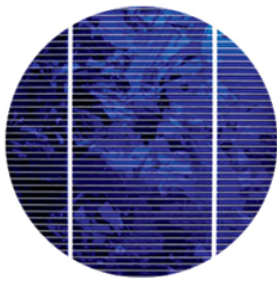
#### MULTICRYSTALLINE

This new technology combines the benefits of poly and mono crystalline to produce extremely high efficiency especially in shaded conditions or where panels are not direct to sun. Looks similar to polycrystalline, with a bluish tinge, but the visible crystal texture is much less pronounced.

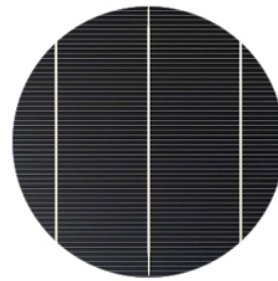
#### DIFFUSED GLASS FRONT COVER

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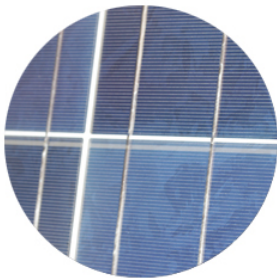
The texture in the diffused glass allows higher efficiency of monocrystalline panels at varying angles to sun by reflecting angled light into panel cell.



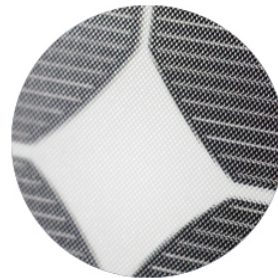
POLY-CRYSTALLINE SILICON SOLAR CELL



MONO-CRYSTALLINE SILICON SOLAR CELL



MULTI-CRYSTALLINE SILICON SOLAR CELL



DIFFUSED TEMPERED GLASS  
ON FRONT COVER

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#### AUSTRALIAN STANDARDS & TESTING

Australia is a leader in setting standards for PV systems including PV panels, inverters and installation practices. The Clean Energy Council provides lists of pre-approved PV panels and inverters for use in Australia. Panels and inverters must be certified by approved testing laboratories to meet both International and Australian Standards. [Clean Energy Council of Australia](#)



## SOLAR REGULATORS



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### WHAT IS A SOLAR CHARGE CONTROLLER?

A charge controller, or charge regulator is similar to the voltage regulator in your car. It regulates the voltage and current coming from the solar panels going to the battery. Most "12 volt" panels put out about 16 to 20 volts, so if there is no regulation the batteries will be damaged from overcharging. Most batteries need around 14 to 14.5 volts to get fully charged.

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### DO I ALWAYS NEED A CHARGE CONTROLLER?

Not always, but usually. Generally, there is no need for a charge controller with the small maintenance, or trickle charge panels, such as the 1 to 5 watt panels. A rough rule is that if the panel puts out about 2 watts or less for each 50 battery amp-hours, then you don't need one.

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### WHY 12 VOLT PANELS ARE 18 VOLTS

The obvious question then comes up - "why aren't panels just made to put out 12 volts". The reason is that if you do that, the panels will provide power only when cool, under perfect conditions, and full sun. This is not something you can count on in most places. The panels need to provide some extra voltage so that when the sun is low in the sky, or you have heavy haze, cloud cover, or high temperatures\*, you still get some output from the panel. A fully charged battery is around 12.7 volts at rest (around 13.6 under charge), so the panel has to put out at least that much under worst case conditions.

\*Contrary to intuition, solar panels work best at cooler temperatures. Roughly, a panel rated at 100 watts at room temperature will be an 83 watt panel at 110°C.



The charge controller regulates this 16 to 20 volts output of the panel down to what the battery needs at the time. This voltage will vary from about 10.5 to 14.6, depending on the state of charge of the battery, the type of battery, in what mode the controller is in, and temperature. (see complete info on battery voltages in our battery section).

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### USING HIGH VOLTAGE (GRID TIE) PANELS WITH BATTERIES

Nearly all PV panels rated over 135 watts are NOT standard 12 volt panels, and cannot (or at least should not) be used with standard charge controllers. Voltages on grid tie panels varies quite a bit, usually from 21 to 40 volts or so. Some are standard 24 volt panels, but most are not.

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### WHAT HAPPENS WHEN YOU USE A STANDARD CONTROLLER

Standard (that is, all but the MPPT types), will often work with high voltage panels if the maximum input voltage is not exceeded. However, **YOU WILL LOSE A LOT OF POWER** - from 20 to 60% of what your panel is rated at. Charge controls take the output of the panels and feed current to the battery until the battery is fully charged, usually around 13.6 to 14.2 volts. A panel can only put out so many amps, so while the voltage is reduced from say, 33 volts to 13.6 volts, the amps from the panel cannot go higher than the rated amps - so with a 175 watt panel rated at 23 volts/7.6 amps, you will only get 7.6 amps @ 12 volts or so into the battery. Ohms Law tells us that watts is volts x amps, so your 175 watt panel will only put about 90 watts into the battery.

### CHARGER CONTROLLER TYPES

Charge controls come in all shapes, sizes, features, and price ranges. They range from the small 4.5 amp control, up to the 60 to 80 amp MPPT programmable controllers with computer interface. Often, if currents over 60 amps are required, two or more 40 to 80 amp units are wired in parallel. The most common controls used for all battery based systems are in the 4 to 60 amp range, but some of the new MPPT controls go up to 80 amps.

**Charge controls come in 3 general types (with some overlap):**



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### SHUNT/RELAY CONTROLLERS

**Simple 1 or 2 stage controls** which rely on relays or shunt transistors to control the voltage in one or two steps. These essentially just short or disconnect the solar panel when a certain voltage is reached. For all practical purposes these are dinosaurs, but you still see a few on old systems. Their only real claim to fame is their reliability - they have so few components, there is not much to break.



## PWM CONTROLLERS

**3-stage and/or PWM** such Morningstar, Xantrex, Blue Sky, Steca, and many others. These are pretty much the industry standard now, but you will occasionally still see some of the older shunt/relay types around.

Quite a few charge controls have a "PWM" mode. PWM stands for Pulse Width Modulation. PWM is often used as one method of float charging. Instead of a steady output from the controller, it sends out a series of short charging pulses to the battery - a very rapid "on-off" switch. The controller constantly checks the state of the battery to determine how fast to send pulses, and how long (wide) the pulses will be. In a fully charged battery with no load, it may just "tick" every few seconds and send a short pulse to the battery. In a discharged battery, the pulses would be very long and almost continuous, or the controller may go into "full on" mode. The controller checks the state of charge on the battery between pulses and adjusts itself each time.

The downside to PWM is that it can also create interference in radios and TV's due to the sharp pulses that it generates.



## MPPT CONTROLLERS

**Maximum power point tracking (MPPT)**, such as those made by Xantrex, Outback Power, Morningstar and others. These are the ultimate in controllers, with prices to match - but with efficiencies in the 94% to 98% range, they can save considerable money on larger systems since they provide 15 to 30% more power to the battery.

A MPPT, or "**Maximum Power Point Tracker**" is an electronic DC to DC converter that optimizes the match between the solar array (PV panels), and the battery bank or utility grid. To put it simply, they convert a higher voltage DC output from solar panels (and a few wind generators) down to the lower voltage needed to charge batteries.

(These are sometimes called "power point trackers" for short - not to be confused with PANEL trackers, which are a solar panel mount that follows, or tracks, the sun).

Most controllers come with some kind of indicator, either a simple LED, a series of LED's, or digital meters. Some newer ones, such as the Outback FM60/80 and others now have built in computer interfaces for monitoring and control. The simplest usually have only a couple of small LED lamps, which show that you have power and that you are getting some kind of charge. Most of those with meters will show both voltage and the current coming from the panels and the battery voltage. Some also show how much current is being pulled from the LOAD terminals.



All of the charge controllers that we stock are 3 or 4-stage PWM types, including the MPPT units. (in reality, "4-stage" is somewhat advertising hype - it used to be called equalize, but someone decided that 4 stage was better than 3). And now we even see one that is advertised as "5-stage" ....

#### MPPT'S ARE MOST EFFECTIVE UNDER THESE CONDITIONS:

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- Winter, and/or cloudy or hazy days - when the extra power is needed the most.
- Cold weather - solar panels work better at cold temperatures, but without a MPPT you are losing most of that. Cold weather is most likely in winter - the time when sun hours are low and you need the power to recharge batteries the most.
- Low battery charge - the lower the state of charge in your battery, the more current a MPPT puts into them - another time when the extra power is needed the most. You can have both of these conditions at the same time.
- Long wire runs - If you are charging a 12 volt battery, and your panels are 100 feet away, the voltage drop and power loss can be considerable unless you use very large wire. That can be very expensive. But if you have four 12 volt panels wired in series for 48 volts, the power loss is much less, and the controller will convert that high voltage to 12 volts at the battery. That also means that if you have a high voltage panel setup feeding the controller, you can use much smaller wire.

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#### USING AN MPPT CONTROLLER WITH HIGH VOLTAGE PANELS

The only way to get full power out of high voltage grid tie solar panels is to use an MPPT controller. See the link above for detailed info on MPPT charge controls. Since most MPPT controls can take up to 150 volts DC on the solar panel input side, you can often series two to four of the high voltage panels to reduce wire losses, or to use smaller wire. For example, with the 175 watt panel mentioned above, 2 of them in series would give you 66 volts at 7.6 amps into the MPPT controller, but the controller would convert that down to about 29 amps at 12 volts.



## SOLAR BATTERY BANKS



Your solar battery bank may be the most expensive component of your stand alone power system. Battery types and Voltages can vary dramatically and the amount you use your batteries as well as how much you drain from your battery will impact the battery life.

The best case scenario is to make sure you have plenty of power to charge your batteries and the minimal levels possible.

Your battery bank can be designed from 2V, 6V or 12V batteries, when connected correctly giving you a 12V, 24V or 48V supply. Standard 12V AGM or Gel batteries are great for mobile/camping systems, where for larger off-grid systems 2V Cells will give you the best results and extend your battery life with correct use.

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### HOW DO SOLAR BATTERIES WORK?

Lead acid batteries are commonly used as an energy storage medium for solar backup battery banks. The 'energy' or electron flow is the result of a chemical reaction occurring within the battery between the electrolyte and the lead plates inside the battery.

The amount of solar energy a battery can store and release when needed is limited to the batteries design capacity rating. Batteries are rated according to their voltage, amp hours (AH) of storage and their ability to deliver the stored energy over a given time period, known as the C rating, i.e. C5, C10, C20, C100.

A 280 amp hour battery with a C5 rating, will deliver 56 amps per hour, for 5 hours at its specified voltage ( $280 \text{ AH} / 5 = 56 \text{ amps per hour}$ ). The service life of the battery maybe affected adversely if these ratings are exceeded.

Battery longevity is also dependent on the number of cycles and the depth of discharge per cycle.





A 280 AH battery may have a design cycle life of 1650 cycles to 30% of depth of discharge (DOD). If more than 30% of the stored energy in the battery is used before the battery is recharged, battery life will be reduced.

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## TYPES OF BATTERIES

Deep cycle flooded lead acid batteries are commonly used for solar energy storage in stand alone solar power systems. There are different types of deep cycle lead acid batteries designed to suit different applications; these include fully serviceable type lead acid batteries, maintenance free AGM and AGM VRLA (absorbed glass mat valve regulated lead acid.) AGM VRLA batteries can be operated in any position and they often last at least 2 to 3 times longer than ordinary so called ‘sealed maintenance free batteries’, as these are not 100% sealed, there are hidden vents through which the electrolyte can spill. Also, the lead plates risk not being immersed in the electrolyte, which can cause battery damage especially while current is being drawn.

**AGM VRLA batteries** have the following characteristics;

- No gassing because of the recombinant effect inside the glass matting under slightly elevated pressure.
- Lead plates are housed in a pressure regulated container with pressure regulating relief valves. These valves only open under severe overcharging conditions. Under normal charging almost 100% of the generated gases recombine inside the glass matting and only a tiny amount of gas escapes.
- Originally designed for the military, this is a robust battery and extremely suited to the storage of solar energy. The plates are made of a lead/tin/calcium alloy with other proprietary additives to increase their deep cycle capabilities. The active material on the plates’ surface is held in place by the glass mat, so that it cannot be ‘shed’ under high current conditions.

**Our Hybrid Gel batteries** are valve regulated lead acid (VRLA) batteries with a crossbreed of GEL & AGM technologies blended together.

This technology provides better service life, especially deep cycle life and high rates of discharge compared to standard AGM batteries. Especially suited to solar, marine and recreational vehicle use.

- Reliable cold cranking (starting power)
- Maximum power supply with a superior cycling performance
- Continue to work through the most extreme conditions
- High resistance to vibration • Exceptionally clean & safe to handle
- Completely leak-proof • Battery can be stored on an angle of up to 180°
- No gas or acid vapours • Maintenance free • Slow self-discharge rate
- Capable of recovery after deep discharge
- Ideal for seasonal or infrequent use



**Ordinary flooded batteries designed for cranking purposes in vehicles are not deep cycle batteries.** They have thin lead plates and are more susceptible to positive plate corrosion which reduces their lifespan faster, unlike the thick plates inside an AGM deep cycle battery. They also suffer from the effects of ‘active material shedding’ which sinks to the bottom of the battery container where it builds up and may cause premature battery failure. This does not happen in AGM designs due to the glass matting between the plates.

**Beware of ‘maintenance free deep cycle batteries’ which are not specified VRLA, AGM or Gel** as these are ordinary flooded lead calcium batteries and their electrolyte level is unable to be topped up with water.

Also, these batteries do not have a means of recombining the hydrogen and oxygen, which is produced during the charging process. This chemical reaction is responsible for loss of the electrolyte through the vents and is unable to be replaced manually. A very short battery life is the result.

#### CALCULATING YOUR BATTERY BANK AUTONOMY

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The amount of batteries needed to supply you with enough energy for your needs will be dependent on how much energy you are consuming over a given time period and the design battery depth of discharge. Energy consumed is the total Watts of the appliances multiplied by the time they are used.

#### Example:

If you are using approx 120ah per day (for which you would need a minimum requirement of 160ah battery bank) and you would like to store enough power for two days, you would need 320ah battery bank.



*Use our [online solar energy calculator](#)  
to estimate how much solar battery bank storage  
you need for your application.*

#### WHAT IS A "BATTERY SYSTEM MONITOR"?

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Battery system monitors, are not controllers. Instead, they monitor your battery system and give you a pretty good idea of your battery condition, and what you are using and generating. They keep track of the total amp-hours into and out of the batteries, and the battery state of charge, and other information. They can be very useful for medium to large systems for tracking exactly what your system is doing with various charging sources. They are somewhat overkill for small systems, but are kind of a fun toy if you want to see what every amp is doing.



## WHAT IS AN INVERTER?



An Inverter will change DC current to AC current. Most common household appliances run on AC current. Solar Panels create DC power which can be stored in your Battery Banks. An Inverter can then be used to convert the stored DC Power into AC Power to power your 240V appliances.

Car, truck, golf cart and boat batteries all give DC. Attach an inverter up to any of these batteries and you will get AC power. There are smaller Inverters (the Projecta Power-Can) which will plug into your lighter socket and will give you portable power for electrical equipment including iPads and Mobile Phones.

Because we have 240volts at home, we already have many appliances that run off 240 volts, whether it's a very low power charger for a mobile phone or a camera, or a very high powered microwave oven. An Inverter allows you to use the appliances you already have when you are away from Mains power - provided you have an Inverter that puts out enough power to suit the loads and enough power stored in your battery.

### INTERPRETING THE NUMBERS

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An Inverter only changes the voltage and current - the output power (in watts = voltage multiplied by current in Amps) is always less than the input power, due to Inverter Efficiency being less than 100% - usually between 80% and 90%. The power that is lost as electrical energy escapes as heat energy in the Inverter.

## MEASURING THE POWER

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Electrical power is always measured in Watts (1000 W = 1 kilowatts, 1 kW).

You may see Inverter output rated in VA (VoltAmps) rather than Watts and for many appliances this will equate to the number of Watts, but for those appliances with motors in them, the VA needed can be up to 50% more than the Watts needed.

## PEAK AND CONTINUOUS

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Two numbers are used to describe the output of an Inverter - Peak and Continuous.

Peak (or surge) describes the output deliverable for several seconds during initial startup required by many 240V appliance - the Inverter components won't blow up at that amount of load, but they will heat up quickly. Continuous ratings are related to the load draw when running continuously after initial start up. Ideally you would find out the Peak and the Instantaneous ratings of your appliances and check that they were less than the Inverter output, but you can't rely on this because most appliances don't state the start-up or peak power - and the length of the peak really needs to be known too. Unfortunately, the only way to be sure, is to test the appliance with the Inverter!

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## THE DIFFERENCE BETWEEN MODIFIED AND PURE SINE WAVE INVERTERS

There are generally two types of inverters on the market for residential and recreational use. These are pure sine wave and modified sine wave inverters. The differences between the two are quite substantial in overall usefulness and cost.

Pure sine wave are designed to replicate and even improve on the quality of electricity from traditional sources (ie. a power socket in your home or at a campsite). Sensitive electronics will run much better with a pure sine wave inverter with more efficient processes and less audible noise. There are usually no compatibility issues with appliances run from a pure sine wave power inverter and for that reason they are well worth the extra investment.

Modified sine wave power inverters will power basic household appliances and tools and are generally less expensive than the pure sine wave inverter. However, the price reduction comes with a loss in efficiency and noise reduction and they may generate an electrical hum or distort sounds in some manner. A modified sine wave inverter will not run certain types of electronics (such as laptops, laser printers, optical hard drives, microwave ovens and a great deal of medical equipment such as oxygen concentrators (C-Pap Respirator)).



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## WHAT SIZE INVERTER DO I NEED

First, you need to determine which devices you plan to power with the inverter. Each device will have a label somewhere which will tell you the wattage it requires to operate.

You can use our easy [online solar energy calculator](#) to work out your total wattage required and calculate your maximum power requirement. The wattage rating of your inverter must exceed the total wattage of all the appliances you plan to run at the same time. For example, if you wanted to run a 600-watt coffee maker and a 600 watt microwave at the same time, you'd need an inverter capable of roughly 1,200-watt output. However, if you plan not to be making coffee and using the microwave at the same time, you would only need to cater for a 600W draw from your inverter. You also need to take into consideration that your battery must be able to supply the surge power

There are other considerations depending on the type of the appliances. For example, some televisions draw more than their normal operating wattage rating when they first start up. This is known as peak or surge, and this information will also be listed on the label. Most inverters also have a peak rating, so you need to make sure the inverter's peak rating is higher than the peak wattage of the device you intend to power. Microwaves are a special case. As an example, you may know that your microwave is a 500-watt microwave. This is actually the cooking wattage. The power wattage might be twice that amount. Again, check the label on the device to make sure.



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## GETTING THE MOST OUT OF YOUR INVERTER

You can add or remove items from your calculations if you don't need to be using them all at the same time. You can use our handy calculator to work out your maximum load requirement – you can then start to think about choosing an Inverter. Our Inverters range in size from 120W to 2000W and a general rule of thumb is to take your maximum load requirement figure and then go to the next size to allow for load variation.

As well as using the right appliances with your inverter, you also need to make sure that your battery or battery bank is the correct size and can supply the required power. Different batteries have different maximum draw currents that they can sustain without damaging the battery. For AGM batteries, the maximum current draw is 30% of their total capacity, while gel batteries use 25% and for wet or flooded cell batteries, it's 10%.

It is also important to remember that inverters draw from batteries if they are left turned on, even if there is no appliance plugged in, which can leave you with a flat battery. You can find out what this draw will be by checking the specifications of your inverter.





## CALCULATING SOLAR PANEL & BATTERY NEEDS:



### ONE SIZE DOES NOT FIT ALL

Planning your independent solar power system requires a little forethought to ensure you have a system that copes with your requirements now and into the foreseeable future. Downsizing and de-cluttering are the current buzzwords and it makes sense to translate this to your domestic, caravan or camping setup.

You need to consider what it is you really need. Bigger is not always better. Theoretically, with a little careful planning and some helpful advice, you should be able to set yourself up to be virtually autonomous with minimal impact on the environment!

The size and variety of current solar systems vary greatly. Marsol's totally portable folding systems range from 120W to 180W. These totally portable panels fold out and are easily placed in the best position for maximum power, they leave no footprint and the larger 180W will even power a fridge, if necessary.

If you have a motorhome or larger caravan with all mod cons (hopefully energy efficient 12V "mod cons") you can tailor an integrated system to suit your requirements. We have DIY kits ranging from 80W all the way up to a 640W Kit if you are aiming for total freedom.

Marsol also offer a range of ready to go off grid solar kits up to 10kWH and can supply larger systems customized to your specific needs. These are designed by qualified S.A.P.S Installers and come with full installation instructions.



## SELECTING YOUR SOLAR BATTERY



It is also very important to correctly calculate your battery requirements. Having excess storage is not only pointless and inefficient, but will cause you to lose some of the power that you already have. The most efficient solar systems are usually designed with a lot of solar capacity but not a lot of batteries. This will ensure the efficiency of the battery and it will substantially recharge on days when there is not a lot of sun. *This also increases the life of your battery.*

## CHOOSING YOUR VOLTAGE - 12V, 24V OR 48V?

If you have an existing system this will determine the best voltage for your battery bank.

However as a general guide 12V is suited to caravans, RV's, backup systems and small stand alone applications. 24V Battery banks are usually suited to larger caravan & RV setups, small to med backup systems and small stand alone systems.

Larger stand alone or back up systems may benefit from using 48V battery banks.

## ESTIMATE YOUR APPLICATION REQUIREMENTS - USE OUR [ONLINE SOLAR ENERGY CALCULATOR](#)

A screenshot of the MarS website's online solar energy calculator. The header includes the MarS logo, a phone number (1300 627 765), and the text 'home of hurricanesolar'. Below the header is a navigation bar with links: HOME, SHOP, GRID CONNECT, OFF GRID SOLAR, VEHICLE & CAMPING, FAQ, SUPPORT, ABOUT US, and CONTACT US. A banner reads 'Wholesale Prices to Public - FREE SHIPPING\* Most Items!'. The main content area has four tabs: APPLIANCES, BATTERIES, VARIABLES, and REQUIREMENTS. The APPLIANCES tab is active, showing a grid of 20 icons representing various household and vehicle appliances. To the right of the grid is a 'DAILY ENERGY USAGE CALCULATOR' form with fields for 'Total Watts Required @ 90% efficiency', 'Total kWh Watts', and 'Max Peak Load'. There is an 'Update Results' button. Below the form is the MarS logo and website address 'MarS.com.au'. At the bottom of the grid is an 'Add Custom Item' button and a 'CONTINUE' button with a green arrow.

## APPLIANCE ENERGY CONSUMPTION GUIDE

Below is a guide to the average consumption of general household and workshed items. Please note that appliances vary dramatically so for an accurate calculation you will need to check the labels of all of your items so you can design the most cost effective and energy efficient system for your individual needs

### TIPS TO REMEMBER:

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When estimating your power needs remember that many factors affect power production. Batteries should never be drained of more 70% of the storage available, if this is happening then you need more panels to increase the speed of charging the batteries.

#### REFRIGERATION

Caravan fridges use on average 50-80 amp/hrs of power a day, so switching to a gas fridge will dramatically reduce your power requirements

#### LIGHTING

LED lights use 1/7th the power of normal lights, appliances that use radiant energy ie; electric jugs, toasters, grillers etc consume huge amp/hrs so factor that in as well.

#### AIRCONDITIONING

In general, air conditioners are way to power hungry, these generally need to be run from a generator. There are however new and extremely efficient systems coming into the market, so if you really want to keep cool speak to your airconditioning specialist.

#### RADIANT HEAT APPLIANCES

These use large amounts of power, toasters, heaters and heated hair appliances have previously been a big no, however technological advances are allowing the manufacture more efficient appliances that can be used if you are careful managing your system. Just check usage specifications to ensure that they are power efficient.

#### WORKSHED TIPS

A great way to get the best out of your power tools in the shed is by using high quality rechargeable tools that use a universal battery system where possible. This will allow you to charge your batteries directly off your solar bank during the daylight hours and not drain your power when in use.



	Approximate Starting Wattage	Approximate Running Wattage
<b>HOME APPLICATIONS</b>		
Refrigerator or Freezer	1200	200
Microwave Oven - 500 Watts	800	500
- 800 Watts	1300	800
Incandescent Lights	Indicated on bulb	Indicated on bulb
LED Lights	3-8	3-8
Coffee Maker (4 Cup)	600	600
Toaster	800-1500	800-1500
Electric Fry Pan	1500	1500
Juicer	35	35
Blender	850	400
Electric Range - 6 inch element	1500	1500
Electric Frying Pan	1200	1200
Electric Grill (tabletop)	1650	1650
Slow Cooker	170-270	170-270
Garabage Disposal	450	450
Dishwasher	540	216
Washing Machine (cold cycle)	225-300	225-300
Clothes Dryer	6750	5400
Radiant Heater	1300	1300
Window Air Conditioner (10,000 BTU)	2200	1500
Ceiling Fan	10-50	10-50
Hot Water Heater	4500	4500
Garage Door Opener 1/4 HP	1100	550
Garage Door Opener 1/2 HP	1400	725
<b>HOME ENTERTAINMENT</b>		
Television - Tube type	300	300
- Flat Screen (20")	120	120
- Flat Screen (46")	190	190
VCR/CD/DVD Player	100-200	100-200
X-Box, Playstation, Wii	40	40
Digital Camera Charger	4-19	4-19
<b>PERSONAL</b>		
Hair Dryer	1300	1300
Steam Iron	1000	1000
Sewing Machine	100	100
Shaver	15	15
Clock Radio	1	1
Electric Clock	3	3



	Approximate Starting Wattage	Approximate Running Wattage
<b>OFFICE</b>		
Computer - Laptop	200-250	200-250
Computer - Desktop	600-800	600-800
Monitor - LCD	30	30
Printer	400-600	400-600
Fax Machine	65	65
Mobile Phone Charger	5-10	5-10
<b>CARAVAN/CAMPING/RV</b>		
RV Air Conditioner 11000 BTU	1600	1010
RV Air Conditioner 13500 BTU	2800	1800
RV Refrigerator	600	180
Water Pump 12/240 volt	50	50
<b>INDUSTRIAL APPLICATIONS</b>		
Air Compressor 1/2 hp	3000	1000
Air Compressor 1-1/2 hp	8200	2200
Bench Grinder (8 inch)	2500	1400
Circular Saw 6-1/2 inch	500	500
Circular Saw 8-1/4 inch	1400	1400
Drills - 3/8 in / 4 amps	600	440
Drills - 1/2 in / 5.4 amps	900	600
Electric Chain Saw (1/2 HP, 12 inch)	1100	1100
Electric Chain Saw (14inch, 2hp)	1100	1100
Hand Drill (1/4 inch)	350	350
Hand Drill (1/2 inch)	900	600
Table Saw (10 inch)	4500	1800
Band Saw (14 inch)	2500	1100
<b>OTHER APPLICATIONS</b>		
Demolition Hammer	1260	1260
Drain Cleaner	250	250
Rotary Hammer	1200	1200
High Pressure Washer	3600	1200
Electric Fence (40 km / 25 Miles)	250	250
Milk Cooler	1800	1100
Milker (vacuum pump, 2hp)	2300	1000
Battery Charger	380	380
Submersible Pump (400gph)	600	200
Centrifugal Pump (900gph)	900	500





## WIRING YOUR SOLAR SYSTEM TOGETHER



When combining two or more solar panels there are two common methods, and selecting the right way will be influential on the outcome of your system.

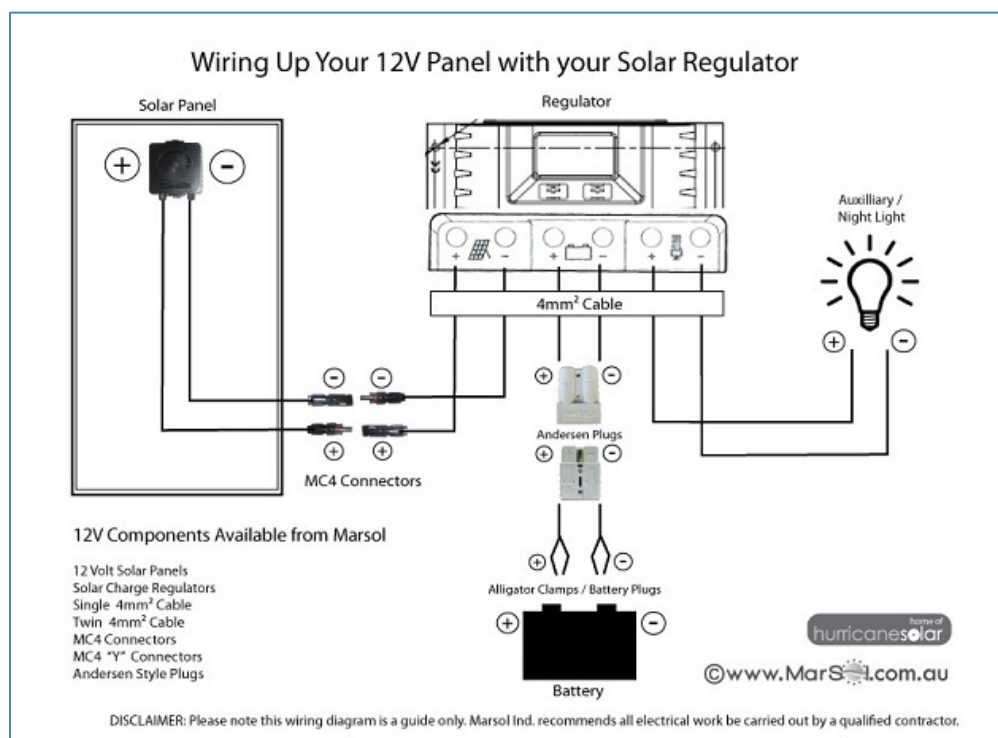
### WIRING IN PARALLEL

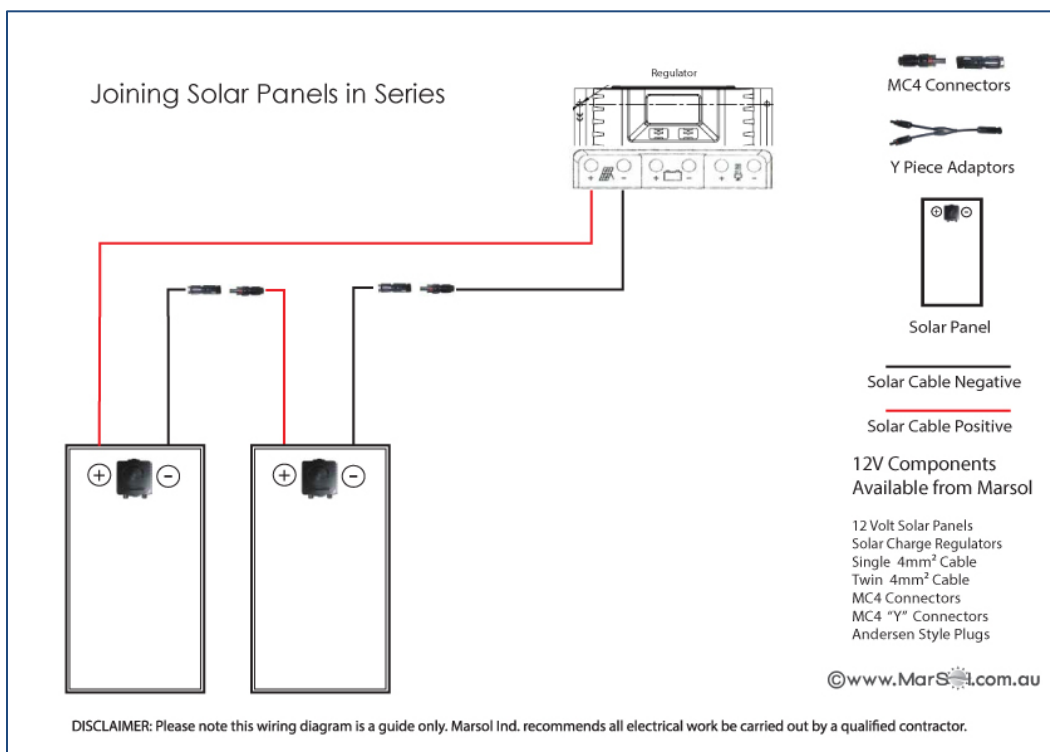
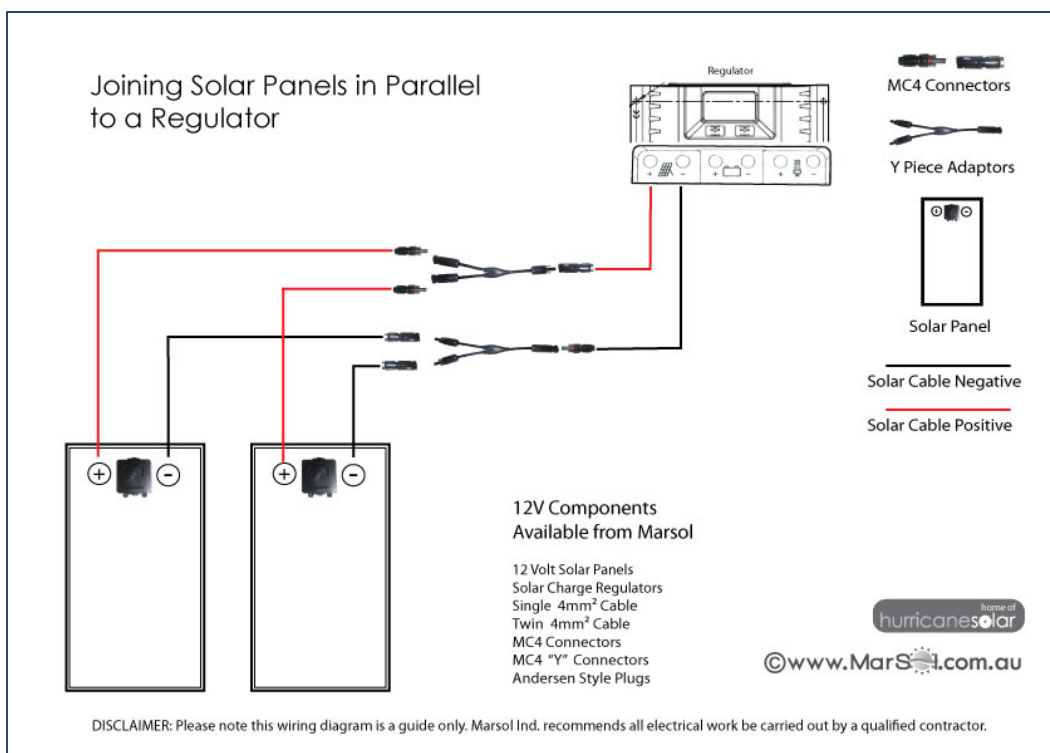
By joining your panels in parallel you will increase the AMPERAGE flowing into your storage bank whilst retaining the panel voltage eg. *If you have a 2 x 12V 200W solar panels and a 12V battery, you would join them in parallel to maintain a 12V Current. (see image)*

### WIRING IN SERIES

By joining your panels in series you will increase the VOLTAGE flowing into your storage bank whilst maintaining the same amperage eg. *If you join 2 x 12V 200W solar panels in Series, you would be outputting 24V current, in which case you would need a 24V battery bank..(see image)*

Below there are basic examples on how to Connect your Array to a Solar Regulator, Parallel wiring and wiring your panels in Series.





[See More Examples of Wiring Diagrams on our Website](#)





### GENERAL CHECKLIST FOR MAINTAINING YOUR VEHICLE SOLAR SYSTEM...

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In the same way that it is important to check all the vitals of your vehicle such as oil, water and tyres before heading off on the road, it can be just as important to check your solar system is all ready to go before you need to rely on it for producing optimum power.

Below is a quick checklist to run through your system from front to back to ensure everything is in the same order as last time you used it.

1. Check your panels are free of obstructions (eg tree litter that may have piled up or become trapped around and under mounted panels).
2. A little dust is fine, but excessive dust or mould could compromise your power output, simply wipe down with warm soapy water if necessary.
3. Check the panels are not loose, and there are no gaps between mounts and surface of vehicle.
4. Check all your battery connections are clean and undamaged.
5. If you have easy access to your regulator, check all connections.
6. Pay attention to wiring connections to ensure no copper has become exposed and there is no evidence of rodents or insect infestation that may have caused damage.

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