# How To Choose SOLAR PANELS FOR YOUR BOAT

Pacific Yacht Systems
marine electronics & electrical

# Table of Contents

# Welcome To Solar

Solar is a great solution to recharge batteries for many boaters. More and more boaters are installing solar panels to charge and maintain their batteries in sunny conditions. Even a small solar array can be the perfect solution to add a few days at anchor or provide an extra day or two without running the generator. During the summer months, most boating locales have long days of sunshine that provide more than enough solar energy.

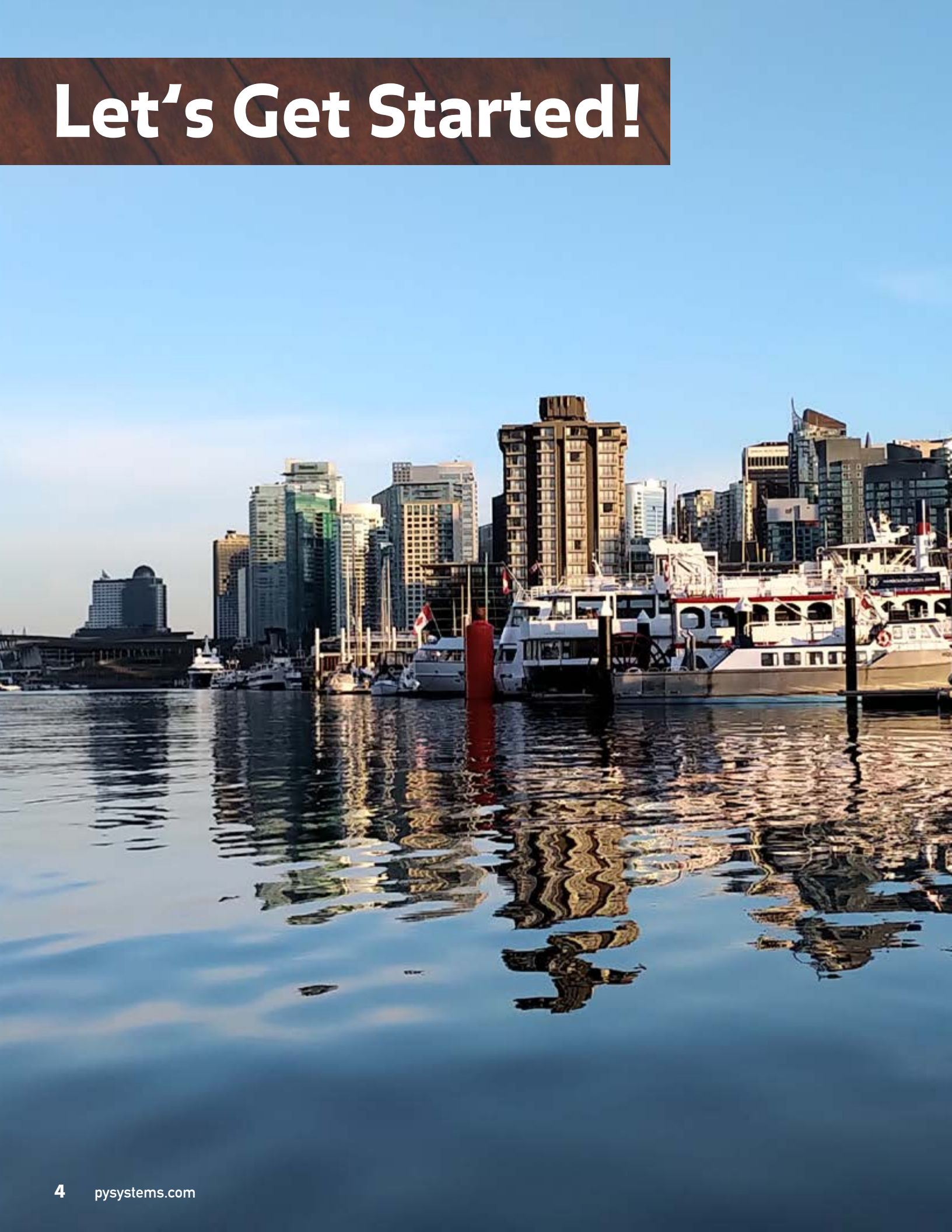
So the first question is, "What do you hope to accomplish by installing a solar array on your boat?" Whether you want to offset refrigeration, stay at anchor longer, or run your engine or generator less, installing solar panels offers a clean, quiet way to charge your boat's batteries.

The next step is to calculate how much power you consume every day. We have attached a complete battery back-to-basics in the appendix that allows you to determine your boat's total battery capacity and your total daily usage.

Here is a very basic outline to give you an idea of typical daily amp-hour budgets:

| Typical Daily Amp Hour Budgets | Ah |
|---|---|
| Beneteau 33 | 85 |
| Catalina 36 | 150 |
| Suncruiser 38 | 225 |
| Grand Banks 42 | 175 |
| Ocean Alexander 48 | 375 |
| Meridian 580 | 500 |

# Let's Get Started!



# Output – What To Expect?

The conservative rule is 25 percent of wattage equals the daily Ah output from a solar array.

**FOR EXAMPLE:**

100W X 25% output = 25 Ah

A 100 watt solar panel will produce 25 amp hours per day
- Optimistic: factor of 3 or 33 Ah per day
- Conservative: factor of 5 or 20 Ah per day

### By-Pass Diode

A bypass diode will prevent a shaded cell from de-powering the entire panel. These diodes effectively split the panel into two independent power sources. Without a bypass diode, one shaded cell can prevent the entire panel from producing any power.

### Monocrystalline vs Polycrystalline

Monocrystalline solar cells are more efficient because they are cut from a single source of silicon, whereas polycrystalline are a blend of silicon. If you have lots of room on your boat for solar panels, opt for polycrystalline to save a few dollars, but if space is limited, monocrystalline will provide more energy in the same footprint.

### Rigid vs Flexible Solar Panels

Rigid solar panels have been around for many years, they can be heavy and usually require a frame of some sort to support them. They also require some space for air to flow under the panel.

Flexible panels are lightweight, super thin and can bend to fit a dodger or bimini. They can be sewn directly into canvas with zippers and do not require a space for airflow underneath. The beauty of flexible solar panels is that they do not change the aesthetic or lines of your boat.

## OPTIONS FOR MY BOAT

### Output

- ○ By-Pass Diode
- ○ Monocrystalline
- ○ Polycrystalline
- ○ Flexible
- ○ Rigid

# Where To Install Your Solar Panel

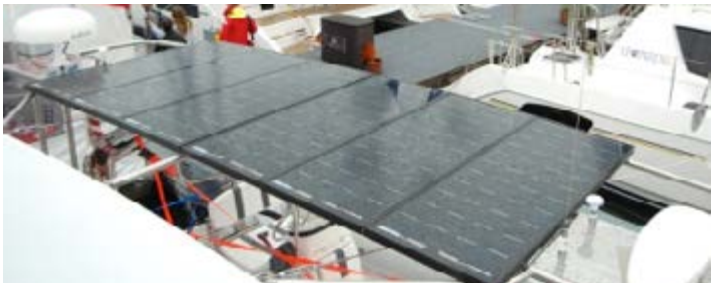
**We get this question a lot and it all depends on what type of boat you have and how much solar "real estate" you have available.**

The first consideration is shadows. If you own a sailboat, your biggest concern will be the shadows cast by the mast, boom and rigging. On a powerboat, you will have to consider the arch and antennas. The best place to start is to determine how much space you want to cover in panels and look for solar panels to fit the space. On a sailboat, canvas dodgers and biminis are a great place to install flexible solar panels as they can be sewn directly into the fabric or adhered to a curved surface.

If you have a large hardtop, it is possible to use a double-sided adhesive to secure flexible panels directly on the surface. If you choose to go with rigid panels, then you will have to build a frame or support to ensure that there is good airflow between the panel and the structure. This airflow is not required for flexible panels.

When the sun is directly overhead, the rays are the most direct and intense. As the sun becomes lower in the sky, the same area of light covers a larger area of earth, the intensity decreases and the solar panel output decreases.

Therefore, we recommend that you eliminate shadows, maximize solar "real estate", and install the panels to take advantage of the most direct overhead rays.



# What Is The Best Way To Attach A Solar Panel?

Flexible solar panels are lightweight and can be attached directly to canvas with zippers, grommets, Velcro or snaps. We don't often recommend Velcro as it can accumulate dust or, in wet climates, can grow algae as it ages and lose its grip. Flexible solar panels can also be adhered directly to a hardtop as they do not require airflow under the panel like rigid panels.


## TEMPORARY SOLAR

Some boaters choose not to permanently install their solar panel and simply attach them to a railing or lay them on the bow. They will actually move the panels throughout the day to get the most exposure to the sun. This is a big responsibility, and many boaters just simply forget.

# The Importance of a Good Solar Controller

Quite often, boaters wonder if their batteries can be overcharged by their solar panels? Or, if they can run the battery charger while the solar panels are charging the batteries? Or, even more common, can they run the engine (and alternator) while the solar array is recharging the batteries? Let's take a look at why choosing the right solar controller is so important.

Solar charge controllers are electronic devices that connect solar panels to batteries and regulate the voltage output of the solar panel array. For instance, some solar panels output 18-22 VDC; connecting those directly to a 12 VDC battery bank would overcharge and damage the batteries. A solar controller ensures that the batteries are properly charged and not overcharged.

A good solar controller has a battery management function similar to that of a three-stage charger, bulk, absorption and float and works in conjuction with other charging sources.


## PWM vs MPPT Controllers

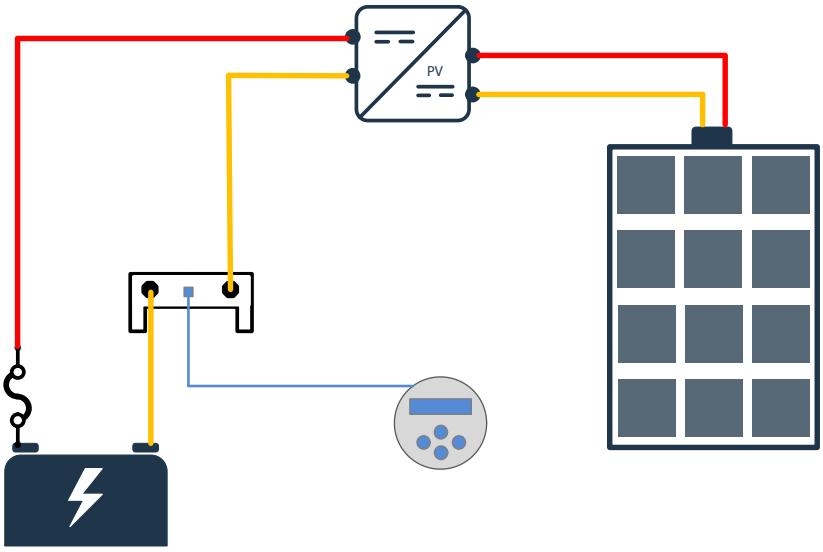
There are two types of solar charge controllers available, a Pulse-Width Modulation (PWM) controller or a Maximum Power Point Tracking (MPPT) controller. The most efficient type of charge controller and the one we recommend is the Maximum Power Point Tracking or MPPT controller, which is quite efficient (i.e., 2 – 3% loss) at solar power conversion.

As its name suggests, the MPPT applies an appropriate resistance to obtain the maximum power output on the current/voltage curve for the sunshine available. Furthermore, many MPPT controllers can be customized to the exact charge curve: flooded lead-acid, AGM, or even Lithium. MPPT controllers, unlike PWM, also allow a higher input voltage and will allow series connections for solar panels.

We often recommend that clients who have older solar panels, which are permanently installed, try installing a newer MPPT controller before replacing the entire array. The controller technology has changed dramatically over the past few years, and many new controllers can get more energy from existing panels than the older PWM controllers.

The second type is the Pulse-Width Modulation or PWM controller, which applies short bursts of higher voltages; this type of charger has the effect of "cleaning" off unwanted build-up on the lead plates in the batteries, extending their life. However, the major downside of a PWM controller is its inefficiencies (i.e., 20% or more loss) in converting the solar panel's energy to a battery charging voltage. Another downside is that a PWM controller can also interfere with radio and television equipment as a result of the pulses that it creates.

## Installing A Solar Controller with a Battery Monitor




If you are installing solar controllers with a battery monitor installed on the house batteries, remember to install the negative from the controller after the shunt (i.e., load side) and NOT directly to the batteries. Otherwise, you will be bypassing the battery monitor shunt, and therefore the solar amps will not be counted by the battery monitor.

## Sizing A Solar Controller for A Solar Panel

The next important step is to ensure that the solar controller is sized for the solar array's voltage and amps. The rule of thumb in sizing an MPPT controller is to look at the maximum wattage of the solar array and battery bank voltage.

For example, an MPPT 75/15 controller, the first number (75 volts) is the maximum PV open circuit voltage. The second number (15 amps) is the maximum charge current.

| Brand | Name | Type | Battery Voltage | Max Voltage In | Rated Charge Current | Maximum Panel Power | Battery Type | Bluetooth |
|---|---|---|---|---|---|---|---|---|
| Genasun | GV-Boost | MPPT | 12 v | 60 v | 8 Amps | 105 Watts | Lead Acid | No |
| Victron | BlueSolar MPPT 100/30 | MPPT | 12/24 v | 100 v | 30 Amps | 440 Watts | Programmable | No |
| Victron | BlueSolar MPPT 100/50 | MPPT | 12/24 v | 100 v | 50 Amps | 700 Watts | Programmable | No |
| Victron | BlueSolar MPPT 75/10 | MPPT | 12/24 v | 75 v | 10 Amps | 145 Watts | Programmable | No |
| Victron | BlueSolar MPPT 75/15 | MPPT | 12/24 v | 75 v | 15 Amps | 220 Watts | Programmable | No |
| Victron | SmartSolar MPPT 100/30 | MPPT | 12/24 v | 100 v | 30 Amps | 400 Watts | Programmable | Yes |
| Victron | SmartSolar MPPT 100/50 | MPPT | 12/24 v | 100 v | 50 Amps | 700 Watts | Programmable | Yes |
| Victron | SmartSolar MPPT 75/10 | MPPT | 12/24 v | 75 v | 10 Amps | 145 Watts | Programmable | Yes |
| Victron | SmartSolar MPPT 75/15 | MPPT | 12/24 v | 75 v | 15 Amps | 220 Watts | Programmable | Yes |

## Boost or Buck Controller?

The controller you need depends on your solar panel's output and your battery's voltage requirements. A buck charge controller will 'step down' the available voltage output of the solar panel in order not to overcharge the battery, whereas if the available output voltage of your panel is lower than the required load voltage of your battery, a boost controller will 'step up' the voltage.

## One Solar Controller or Two?

Boaters often ask us if they should install a dedicated controller for each solar panel, or should they wire multiple panels in series to one single controller? In instances where the solar panels will encounter lots of varying shading, for instance, solar panels installed on a dodger, we recommend a dedicated controller per panel to maximize the efficiency of the array. For boaters who have no shading issues, i.e., some biminis or a hardtop on powerboats, we will wire a couple of panels in series.

# Wiring Solar Panels

## Series or Parallel

The main difference between wiring solar panels in series or parallel is the output voltage and current.

In a series circuit, you add the voltage of each panel to get the overall voltage of the array, but the amperage of the array stays the same.

### (4) 100W panels = 400W divide by 14.4 for a 12 volt system = maximum output amps

The downside of series is that they all depend on each other, so if one panel is shaded, it will affect the whole string.

In a parallel circuit, you increase the amps and keep the voltage the same.

## OPTIONS FOR MY BOAT

### Solar Controllers

**How many?** _____

- ○ **Boost**
- ○ **Buck**

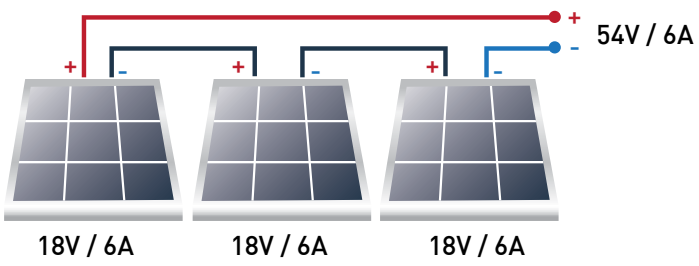
**Popular Sizes:**

- ○ **75/10**
- ○ **75/15**
- ○ **100/30**
- ○ **100/50**

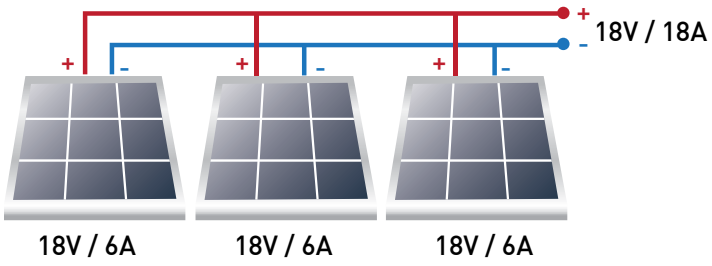
- ○ **12V**
- ○ **24V**

- ○ **Flooded Lead Acid**
- ○ **AGM**
- ○ **Lithium**

### Series




### Parallel



# TOOLS OF THE TRADE

## Solar Wire

When choosing the correct wire size, make sure to consider both voltage drop and amps. We typically recommend using a UV-rated #10 solar cable for exterior wiring to harness as much solar power from the solar panel as possible; for interior wiring, use 10/2 marine cable.

- Measure the distance from the solar panel to the solar controller (making sure not to underestimate and give yourself a good margin of error (i.e., 10% or 20% of wire). Multiply this number by two – you will need a length for both positive and negative.
- Measure the distance from the MPPT controller to the battery. Ideally, the MPPT controller should be no more than 5 feet from the house battery.

## MC-4 Connectors

Ensure that the solar panel you choose comes with a short pigtail lead terminated with an MC-4 connector. These connectors provide a good connection and have a weatherproof seal to withstand the outside elements. They are an interlocking plug-and-play connector that allows you to easily wire solar panels or to disconnect the panel if need to clean or repair your canvas. Remember to cover the panel with a towel while you are disconnecting the wires, or remove at night.

## Crimping Tool

A proper crimp will ensure your connections stay dry, and do not corrode or overheat. We recommend purchasing a pair of terminal crimping pliers. Do not use automotive-style pliers as they do not apply consistent pressure and can crush the strands.

## Cable Clams

Cable Clams, also called cable glands, provide a waterproof pass-through for solar cables without requiring the removal of the factory-installed connector. (Note: only for use above the waterline)

## Fusing

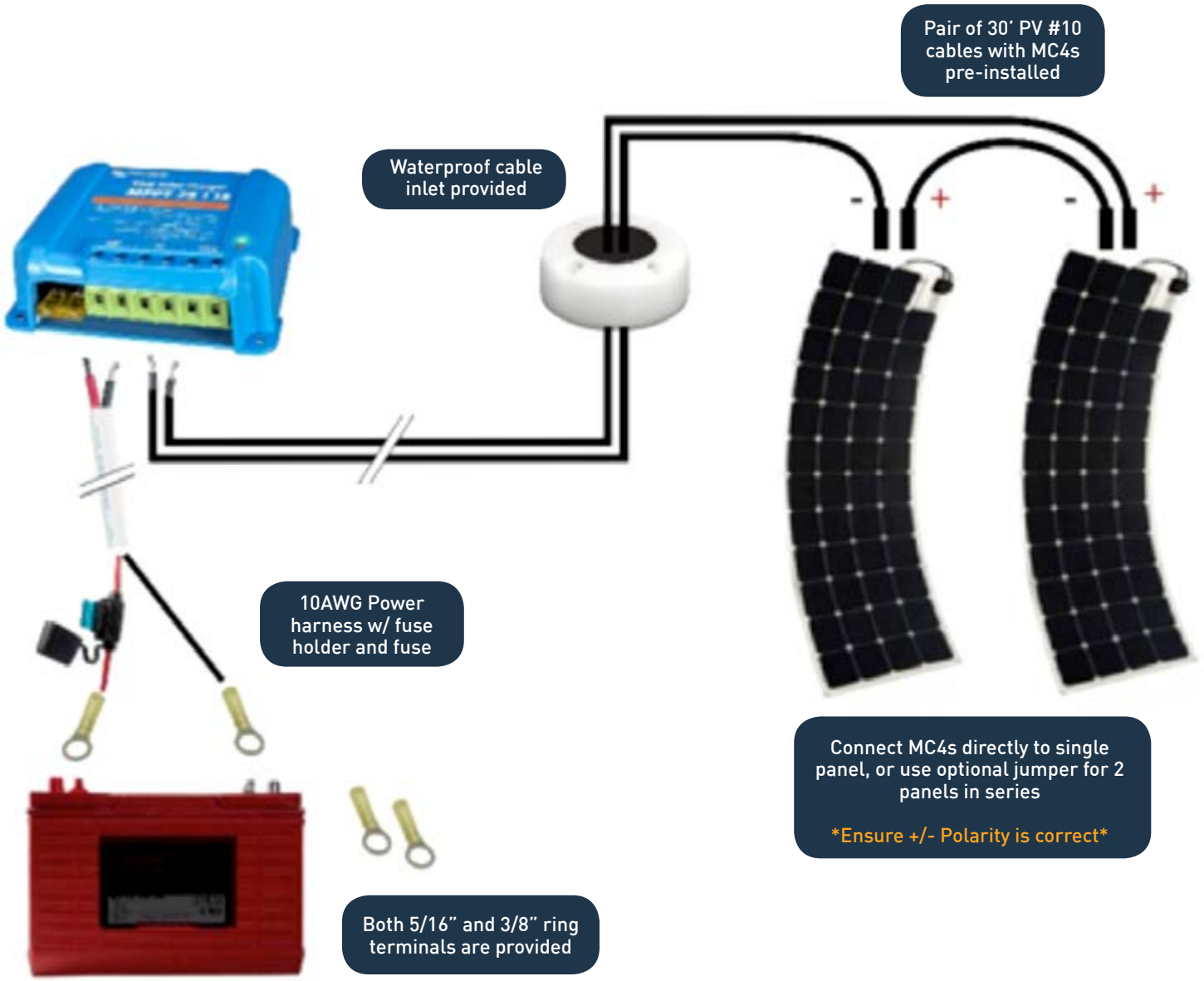
Fuse the solar panel's MPPT wire connection at the battery. Ensure that you choose the correct fuse size for the current (based on the controller rating).

## Monitoring

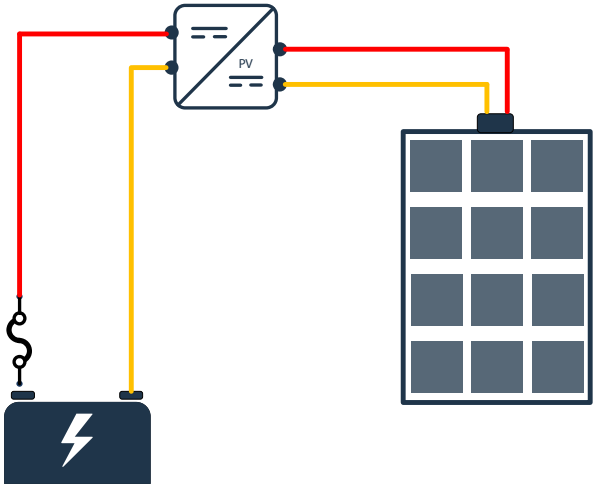
In order to appreciate the output of the solar array, you should also install a solar monitoring device to measure not only the output current of the array at any time but also the daily amp-hour production. Even though many boats are equipped with a battery monitor, a battery monitor only provides you with the net effect at the batteries. This net effect, is the difference between the charge going into the battery (i.e. alternator, battery charger, solar array, etc.) and the draw going out of the battery (i.e. lights, inverter, water pump, fans, stereo, etc.)

A good solar monitor will tell you how much current is going into the batteries at any given moment, plus the daily cumulative benefit from the solar array. We recommend the Victron SmartSolar controllers, which offer Bluetooth connectivity to a smart device.

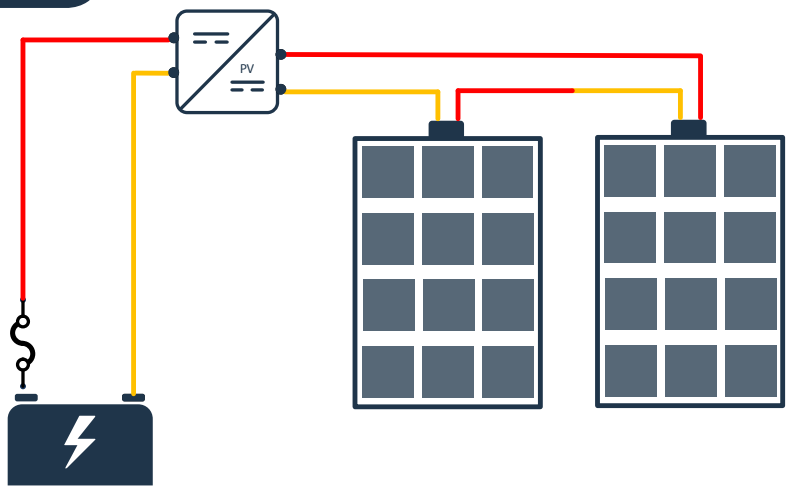
# SOLAR D-I-Y INSTALL KIT



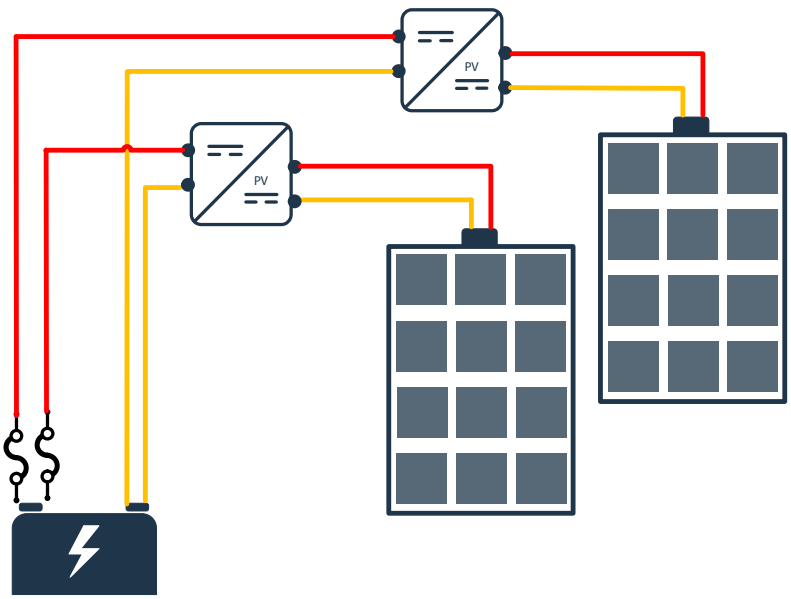
## Single Panel Installation




## Two Panels in Series Installation




## Two Panels with Two Controllers



# Testimonials

*"Our fridge would often run on low and then shut down during the night. The boat does not have enough space to add additional batteries, and there is no generator. Installing just one solar panel kept the batteries charged and the fridge running."* – **Grady 28 with (1) 140W panel**

*"Installing solar has allowed us to go a long weekend without running the batteries down below 70 percent, and we did not need to plug into shore power. We installed the flexible panel on top of the dodger so it is out of sight and out of the way. However, it is subject to shadows from the mast and boom. It was important to us to choose a panel with a bypass diode that would keep working even when a few cells were in the shade."*
– **Catalina 37 with (1) 100W panel**

*"Our boat did not come with a generator; we had been discussing solar for some time, but the expense was a huge barrier. We often boat at a remote, powerless outstation and would end up plugging into our neighbour's boat. We are not winter boaters, so solar was a perfect solution for us. For the first time, we stayed at the outstation for two weeks with no concerns; the solar panels kept up with our consumption."*
**– Grand Banks 36 with (3) 125W panels**

*"We have a total array of 425W, with each panel wired to its own controller and then along a dedicated line to the battery bank. The panels are then monitored by a metre, and we have seen up to 20 amps being generated by the mid-day Sun. It's fun to watch the energy rolling in. The panels have provided a quiet and automatic means to ensure our house batteries remain charged, especially when we are off the grid for several days at a time. We don't miss our diesel generator at all."* – **Beneteau 51 with (4) 100W panels**

# Appendix 1

# Back To Basics – Battery Capacity

If you have watched the PYS YouTube channel, you will know that it is a good idea to separate your house bank from your starter bank. Batteries are sold in different voltages, 6V, 12V, 24V, 48V as well as different sizes.

Battery manufacturers have agreed upon fixed battery dimensions—the most popular being Group 24, Group 27, Group 31, 4D, 8D and golf carts. This universal sizing enables boat owners to purchase batteries from different manufacturers and not have to alter their battery box or compartment. Make sure you do not confuse battery size with battery type. Flooded, AGM, carbon foam and lithium batteries are available in a variety of sizes for different vessel requirements.

There will be a label on your battery that will give you the information for this calculation.

## GROUP 31
AGM (maintenance-free)

**12v DC**
**125ah @20hr**


## GROUP 24
Flooded (requires maintenance - notice caps on top)

**12v DC**
**85ah @20hr**


## HOW TO CALCULATE USABLE BATTERY CAPACITY?

**Flooded Lead Acid →** 4 X 100 Ah = 400 Ah @ 50% DOD
= 200 Ah Usable Battery Capacity

**AGM →** 4 X 100 Ah = 400 Ah @ 60% DOD
= 240 Ah Usable Battery Capacity

**Lithium →** 4 X 100 Ah = 400 Ah @ 100% DOD
= 400 Ah Usable Battery Capacity

A word about battery cycles and Depth of Discharge (DOD). In a perfect world, boaters would only discharge their battery to the recommended DOD. We know that this is not always possible, and so boaters make compromises. Remember that the deeper the discharge (35% of capacity, or 65 DOD), the less the number of battery cycles. Or inversely, shallow discharges (70% of capacity or 30 DOD) the higher the number of battery cycles which means a longer life for the battery.

Flooded lead-acid batteries and AGM flooded lead-acid batteries do not like to be completely discharged or left in a partial state of discharge for long periods of time. Visit pysystems.com for more information on battery sulfation.

## Battery Monitor

Now that you know how much energy you have, the next step is to calculate how much energy you use in a day. The easiest way to do this is with a battery monitor, which is a fuel gauge and a speedometer for your boat's energy consumption.

## How Many Amp Hours Do You Use in One Day?

The largest draw is usually refrigeration which can run 50 – 125Ah per day. And remember, your usage varies on the season, for instance, lights are run earlier in the winter and heat is used during the shoulder and winter seasons.

**A SIMPLE CALCULATION:**

| | |
|---|---|
| Refrigeration 2A @ 24 hours | = 48 Ah per day |
| Charging a Cell Phone 2A @ 12 volts for 4 hours | = 8 Ah per day |
| Anchor Light 1A @ 8 hours | = 8 Ah per day |
| Total | = 64 Ah per day |

| Typical Daily Amp Hour Budgets | Ah |
|---|---|
| Beneteau 33 | 85 |
| Catalina 36 | 150 |
| Suncruiser 38 | 225 |
| Grand Banks 42 | 175 |
| Ocean Alexander 48 | 375 |
| Meridian 580 | 500 |

# OPTIONS FOR MY BOAT

## My Ah usage per day:

Anchor Light _____

Blender _____

Cell Phone _____

Computer _____

Freezer _____

Heater _____

Ice Maker _____

Lights _____

Microwave _____

Navigation _____

Refrigeration _____

Satellite Dish _____

Stereo _____

Television _____

Toaster _____

Wine Fridge _____

**My Total:** _____

## My House Battery Bank:

Battery Type: _____

Total Capacity: _____

DOD: _____

Usable Ahs: _____

# Appendix 2

# Maintenance Of Your Solar Panels

Proper maintenance of your flexible solar panels is important to maximize the energy that the panels produce. Solar panels accumulate dirt primarily from wind-blown dust, sand, pollen and bird droppings. When it rains, the water and dust can pile up on the corners or edges of the panel, causing a significant decrease in output.

Try to clean the panels early in the morning or in the evening. We find the morning is the best time as the dew that has settled on the panels will have softened the dirt. Do not clean your panels in full sun as the water will evaporate too quickly and smear the dirt. Manufacturers recommend that they be washed regularly with a soft cloth, mild soap and fresh water. It is important to rinse them completely as any dried soap will affect the performance of the panel. Do not use any harsh abrasive cleaners or coarse cloths as they will scratch the panels and the scratches will cast shadows which will affect the performance. Denatured alcohol (methylated spirit) can be used to remove grease.

When it comes to cleaning frequency, it is best to monitor changes in the power output of your panels before and after cleaning. Even panels with a light dusting of dirt can lose up to 20% efficiency.


# Pacific Yacht Systems

marine electronics & electrical

For more information or if you have questions,
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