Selecting the Proper Solar System for Your Boat

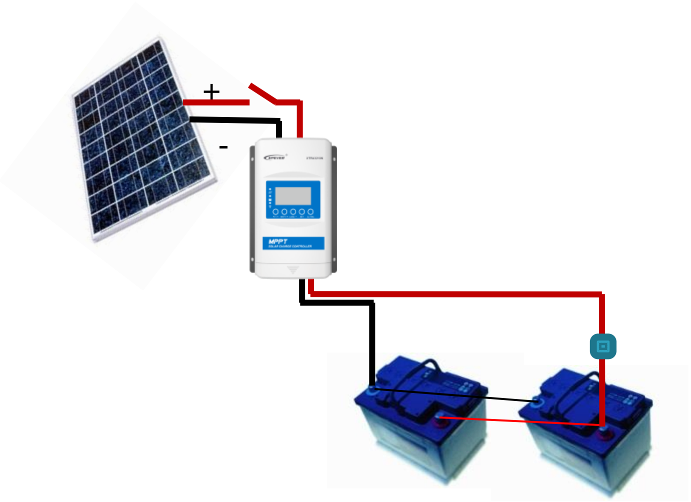
Tom Trimmer

Custom Marine Products

Introduction: I Am a Cruising Sailor -
Having Sufficient Power Onboard is Important

Topics for Discussion

- Introduction to PV solar panels
- Introduction to solar controllers
- What is a balanced solar system?
- Designing your solar system
  - A case study
- Selecting the proper equipment
- Installation ideas
- Q & A



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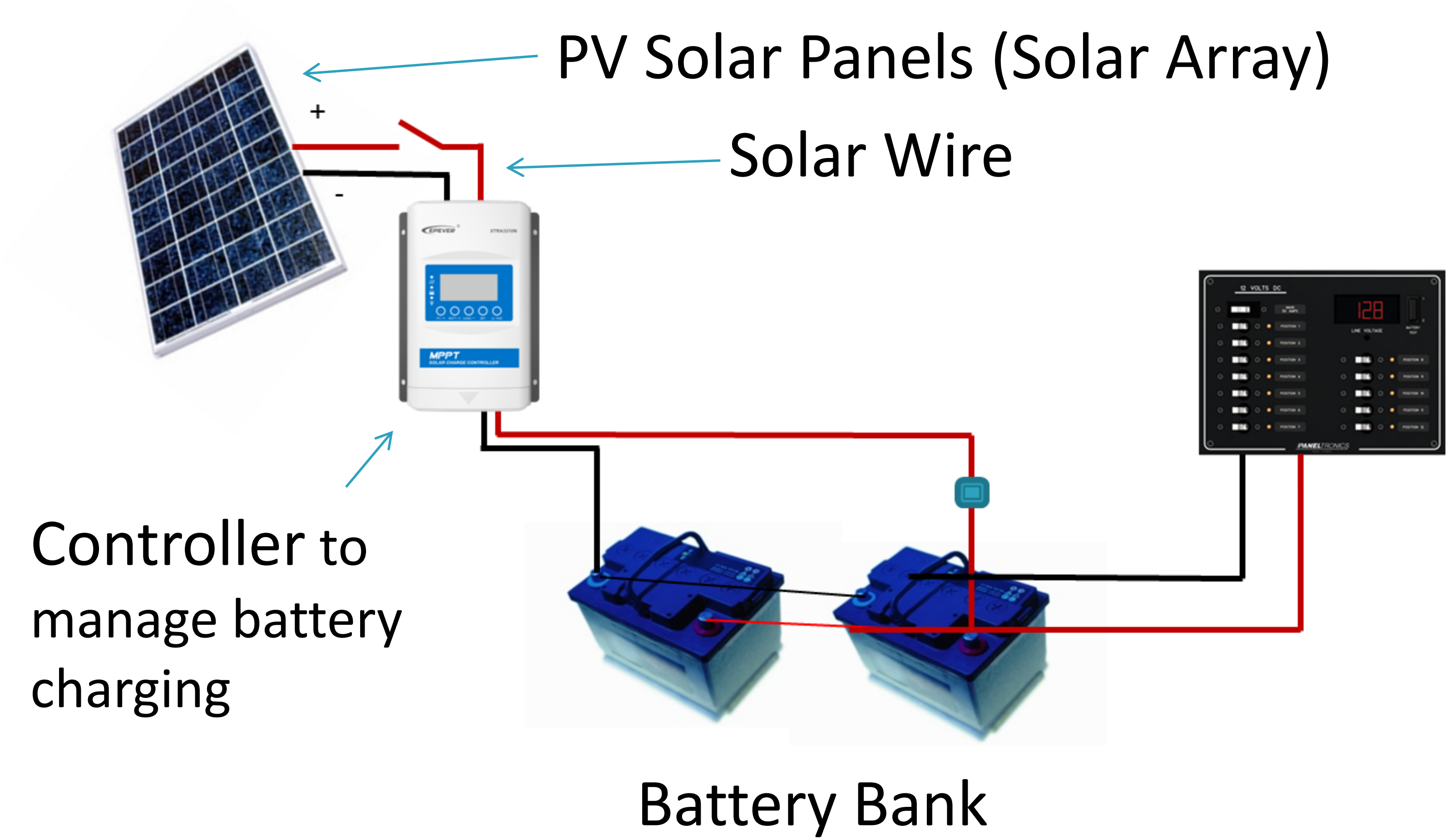
Components of a PV Solar System

(**P**hoto**V**oltaic)



A Few things to Know About PV Solar Panels

(PhotoVoltaic)

Monocrystalline or Polycrystalline?

Grade A or B or C?

Rigid, Semi-rigid or Semi-flexible?

Commercial or Marine?

Monocrystalline or Polycrystalline?

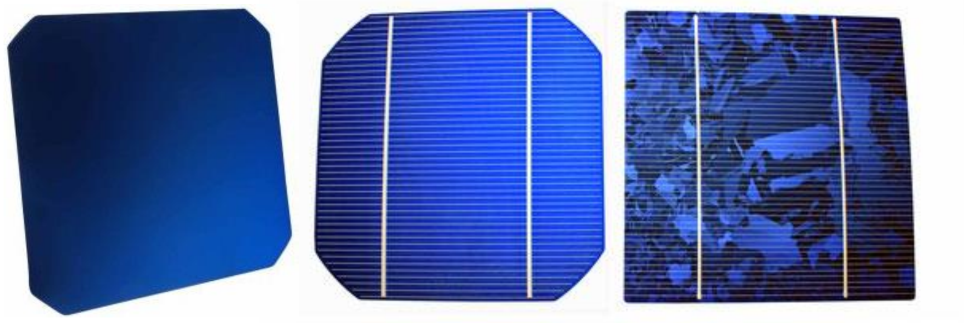
Monocrystalline

- Generally higher efficiency solar cells 16 % to 24%
- Generally higher output than polycrystalline in full sun
- More expensive than polycrystalline ($3 - $8 per watt)

Polycrystalline

- Cell efficiency typically 13% to 16%
- Generally less sensitive to shading and clouds than monocrystalline
- Less expensive that monocrystalline ($2 - $5 per watt)

Monocrystalline or Polycrystalline?



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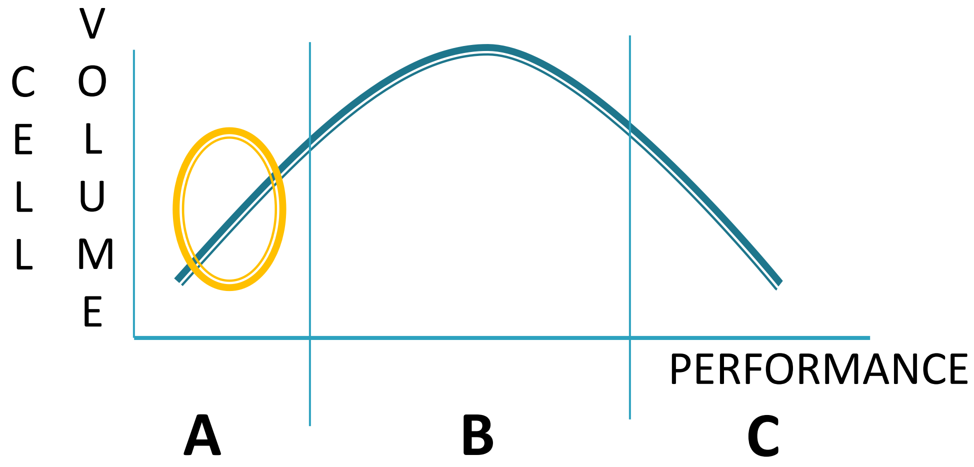
Note: Efficiency of thin-film panels is only 7% - 12%

Grade A or B or C?

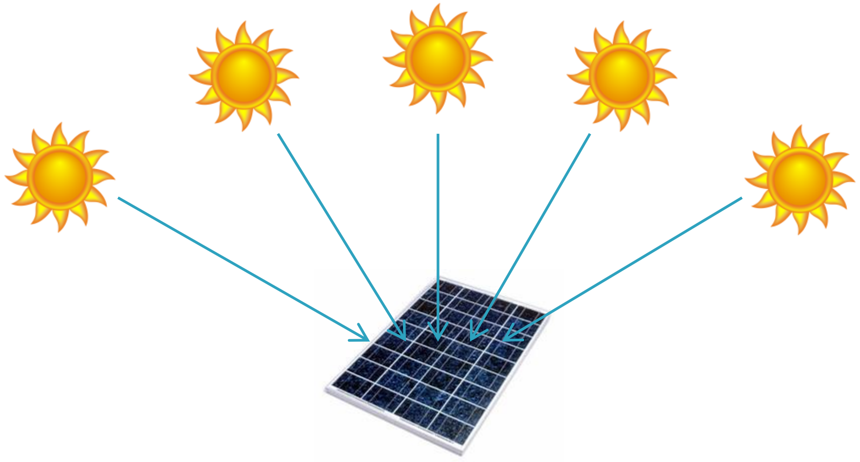


All solar cells are not created equal

- Cells are graded under a standard artificial light and sorted by power output.
- The distribution of performance is a Bell Curve with most cells being a B grade.
- **Grade A will typically perform above rating in full sun light.**
- Grade B is typically used for residential and solar farms.
- **Grade A+ is desirable on a boat where space is limited.**

We want maximum output per square inch.

Why the Quality of Solar Cells is Important



Average sun hours in a typical day
– 5 hours –

It's all about **watt hours**

Higher performance solar cells produce more power at sub-optimal sun angles than lower performance solar cells - up to 30% more power.

A lower performance 100 watt panel will produce up to 100 watts x 5 hours or 500 watt hours in a day.

A higher performance 100 watt panel will produce up to 650 watt hours in a day.

That's 150 watt hours or 12.5 amp hrs. more power

Rigid, Semi-rigid or Semi-flexible?

Rigid panels

- Have a life span >18 years - robust
- Excellent for pole, arch, frame and davit mounting

Semi-rigid panels

- Have a life span >10 years – robust
- Excellent for cabin top, rigid surface mounting
- Can be walked on

Semi-flexible panels

- Have a life span >7 years
- Excellent for canvas bimini and rigid surface mounting
- Light weight
- Some are sensitive to shading

All *CMPower* panels use premium SunPower solar cells and have comparable performance.

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How is a Marine Solar Panel Different from a Commercial Solar Panel?

Marine Solar Panel

- Junction box is filled with inert silicone to prevent corrosion
- Rigid panels have strong frames and extra sealants
- Panels have high output power performance – Grade A+ cells
- Output compatible with 12 or 24 volt battery bank systems
- Panel is wired to accommodate shading

Commercial Solar Panel

- Junction box not filled with inert material
- Frames designed for rack mounting
- Output typically 30+ volts
- Panel cells are typically Grade B or B+

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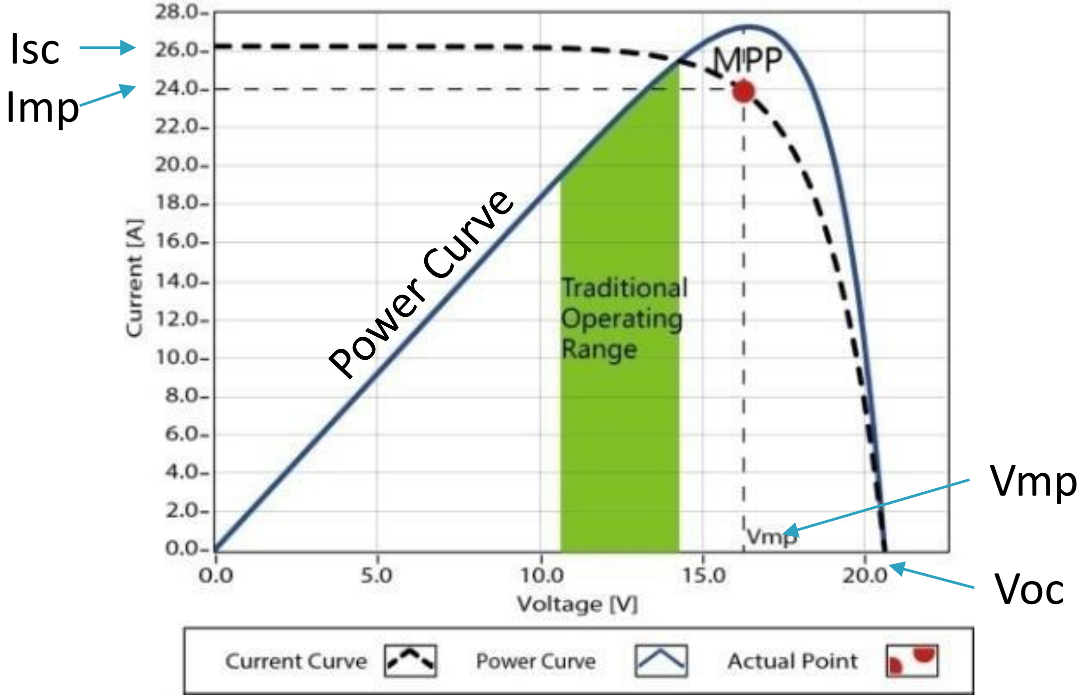
PV Solar Panel Specifications – What to Look For

Nominal Peak Power	(Pmax)	Maximum power point (Watts at STC)	130 W
Nominal Voltage	(Vmp)	Voltage at maximum output power	22.3V
Nominal Current	(Imp)	Current at maximum output power	5.8A
Open Circuit Voltage	(Voc)	Maximum voltage output with no load	26.3V
Short circuit Current	(Isc)	Maximum current (amps) output with no load	6.8A
Cell Efficiency	%	Amount of light energy converted to electrical energy	23.7%
Cell Manufacturer			
Panel Efficiency	%		
Temp. Coefficient *	(%/°C)	% degradation per °C	



STC - Standard Test Conditions

77°F (25°C) light intensity 1,000 watts/sq. meter

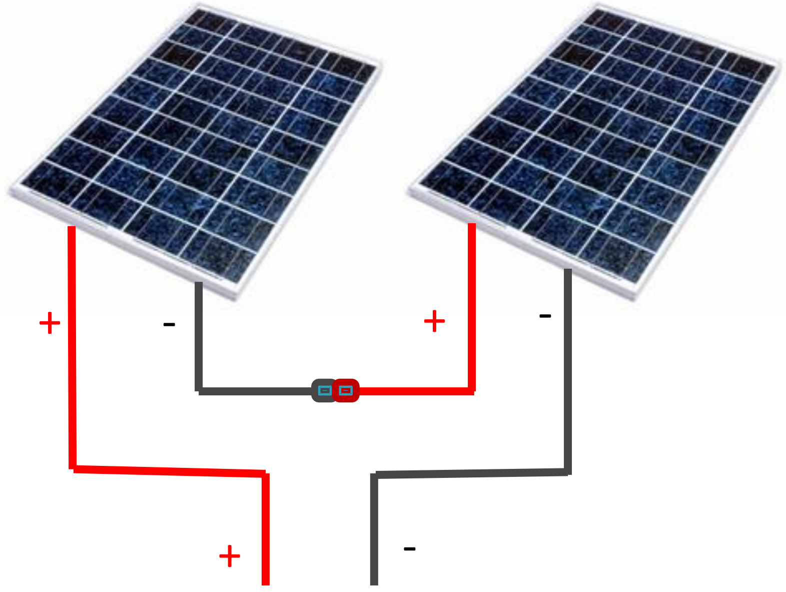
* A panel operating at 55°C with a temp coef. of -.3%

55°C – 25°C = 30°C   30°C * -.3% = 9% power loss

Wiring Multiple Solar Panels

100 Watt, 18 Volt, 5.6 Amp

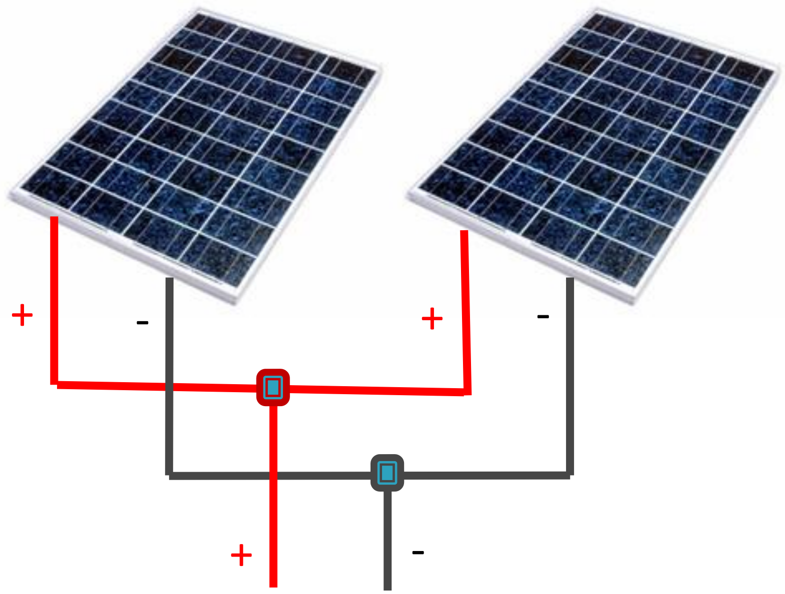
Series



36 Volts

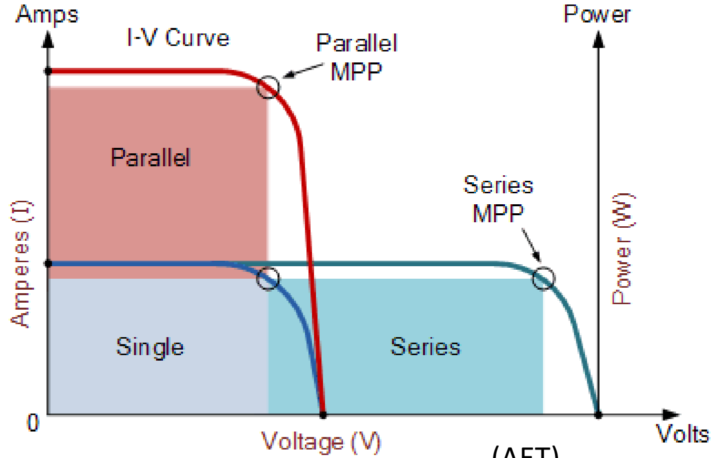
5.6 Amps

Parallel



18 Volts

11.1 Amps

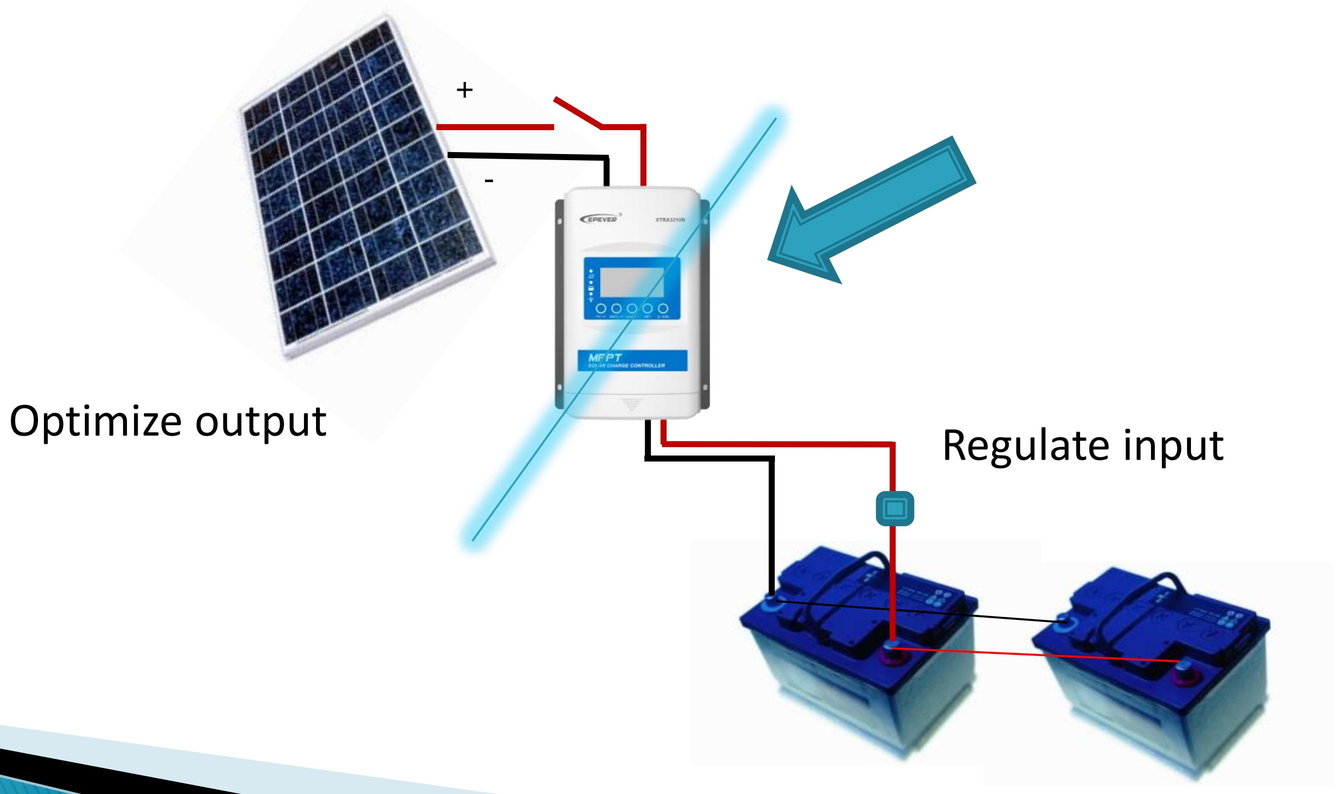


(AET)

A Few Things to Know About Solar Controllers

The purpose of a solar controller is to:

- Optimize the power output of the solar array
- Regulate the amount of power going to the battery bank
- Prevent battery bank overcharging and overheating
- Prevent solar panels from absorbing power at night



There Are Two Types of Solar Controllers

(PWM) Pulse Width Modulation

- Pulse width modulation provides efficient battery charging
- Streams full power to battery bank when bank is low
- Useful if panel voltage is similar to battery voltage
- Less expensive than MPPT controllers

(MPPT) Maximum Power Point Tracking

- Essential to use with commercial solar panels
  (usually above 30 volts)
- Optimizes power from the solar array
- Reduces voltage to 14 volts and increases amperage
  $Pw = V * I$ (Watts = Volts x Amps)
- Of little value for panels rated under 20 volts and for small solar arrays (under 200 watts).
- More expensive than PWM controllers

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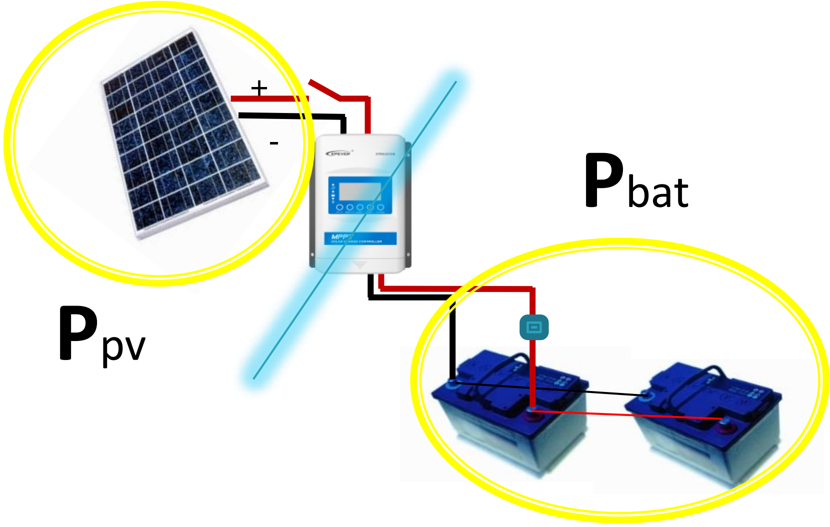
Maximum Power Point Tracking Technology



Input power (**P**pv) = Output power (**P**bat)

200 W = 200 W

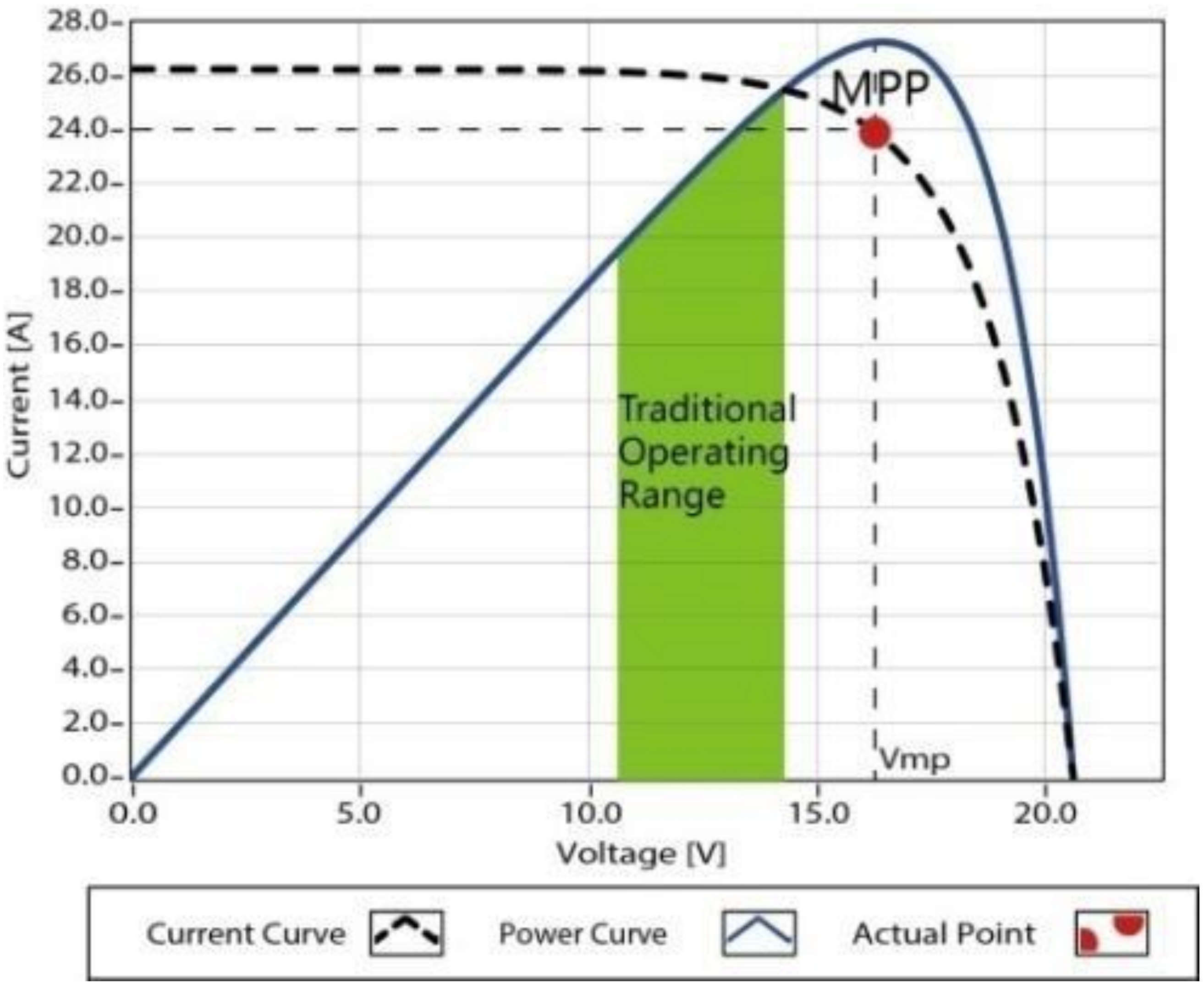
P = V x I Watts = Volts x Amps

Input Voltage (**V**mpp) **x** Input Current (**I**pv) **=** Battery Voltage (**V**bat) **x** Battery Current (**I**bat)

16-22 Volt Panel	18	x	11.1	=	14	x	14.3
25-45 Volt Panel	36	x	5.6	=	14	x	14.3

At 100% conversion efficiency

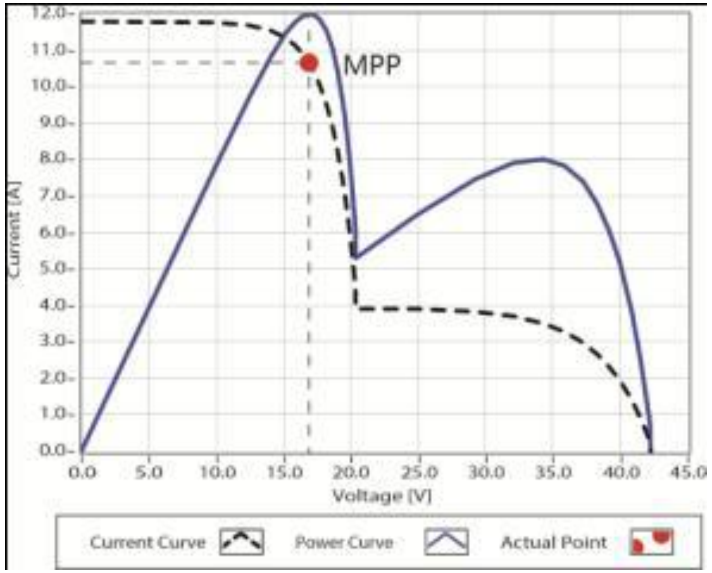
Maximum Power Point Curve

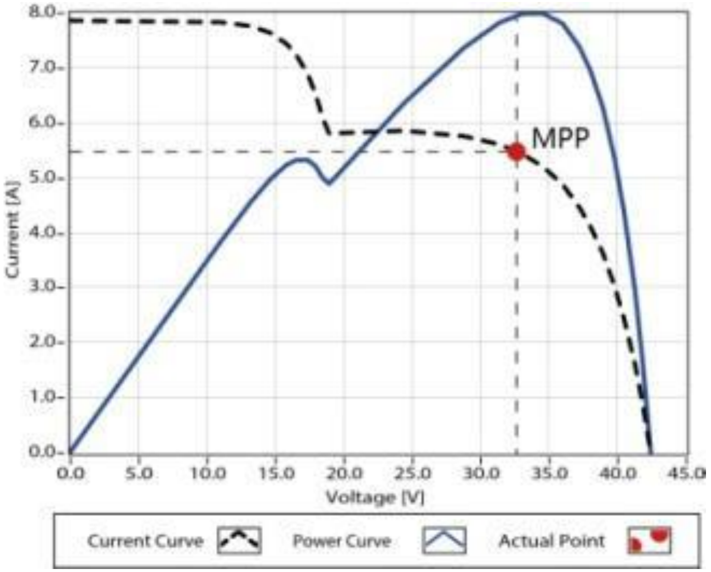


EP Solar

Maximum Power Point Tracking Technology

Impact of Shading and Dissimilar Panels



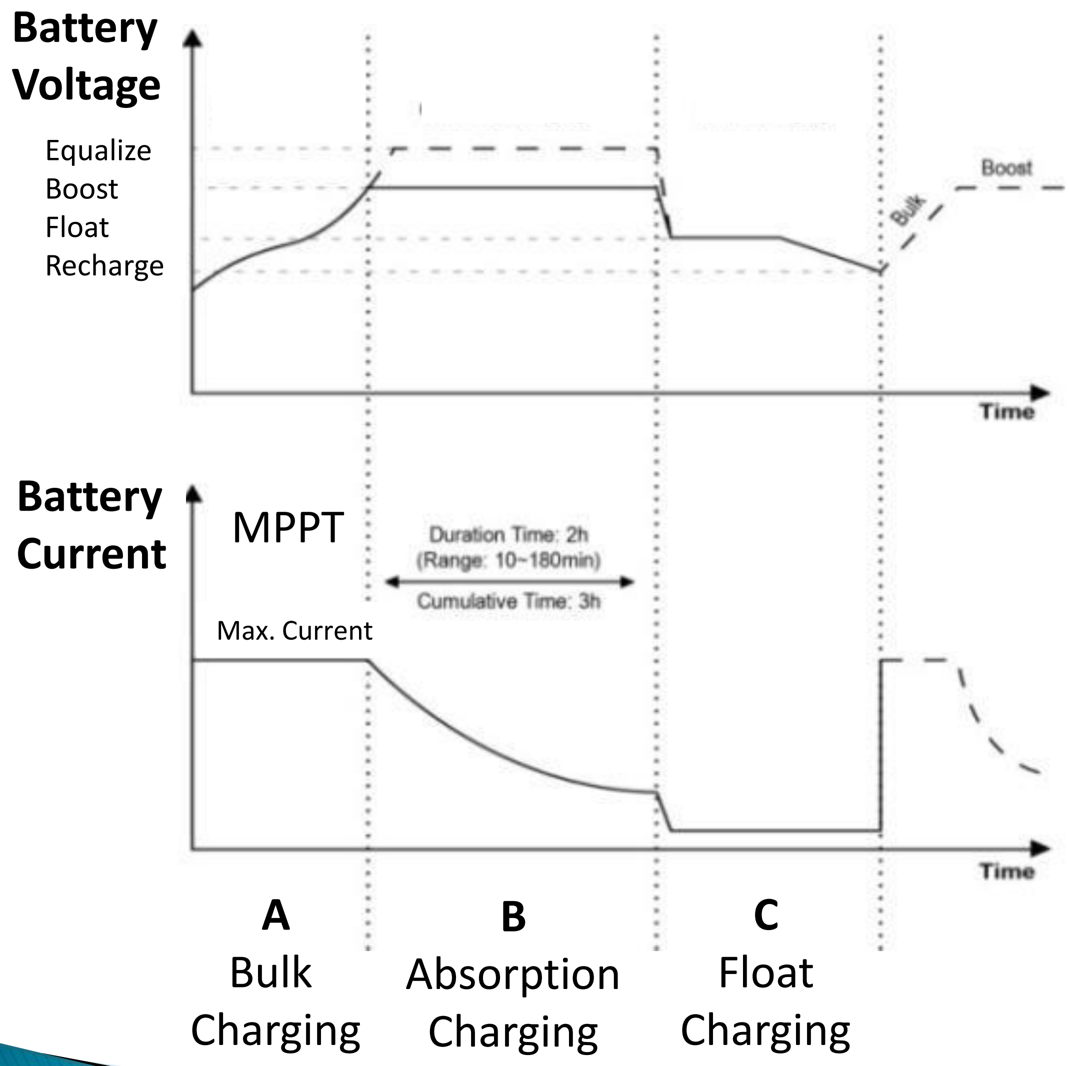


EP Solar

Multi - MPP

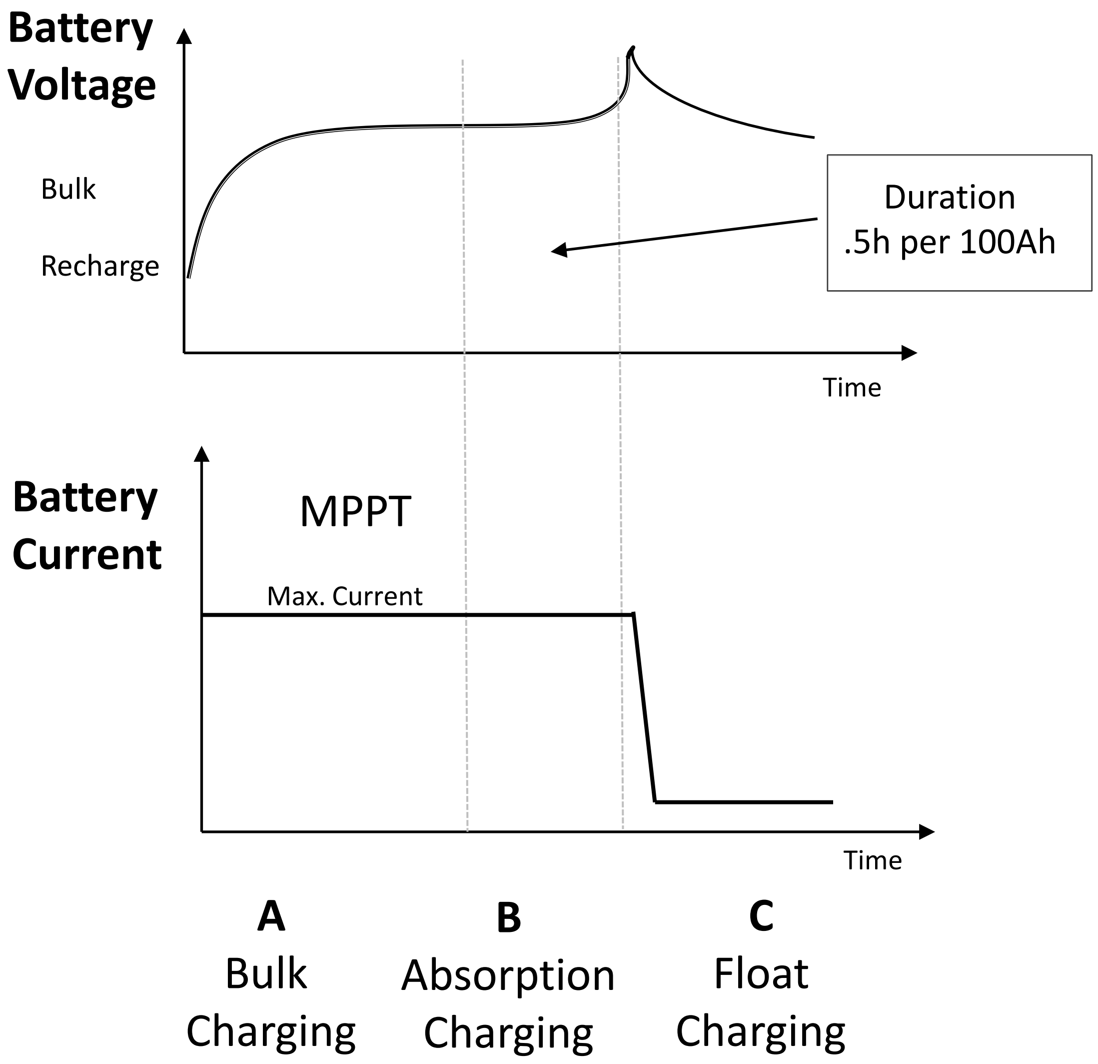
Battery Charging Curves

Lead Acid



EP Solar

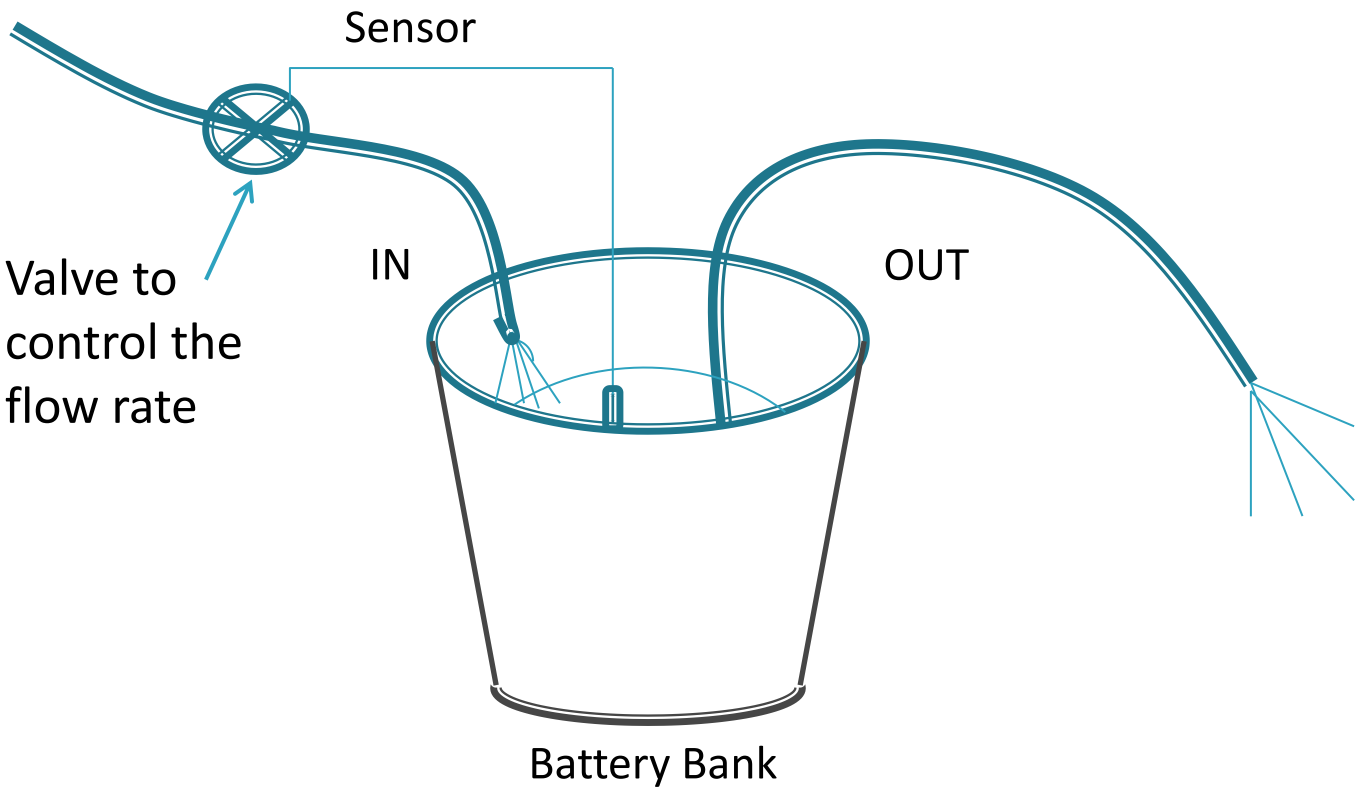
LiFePO4



CMPower

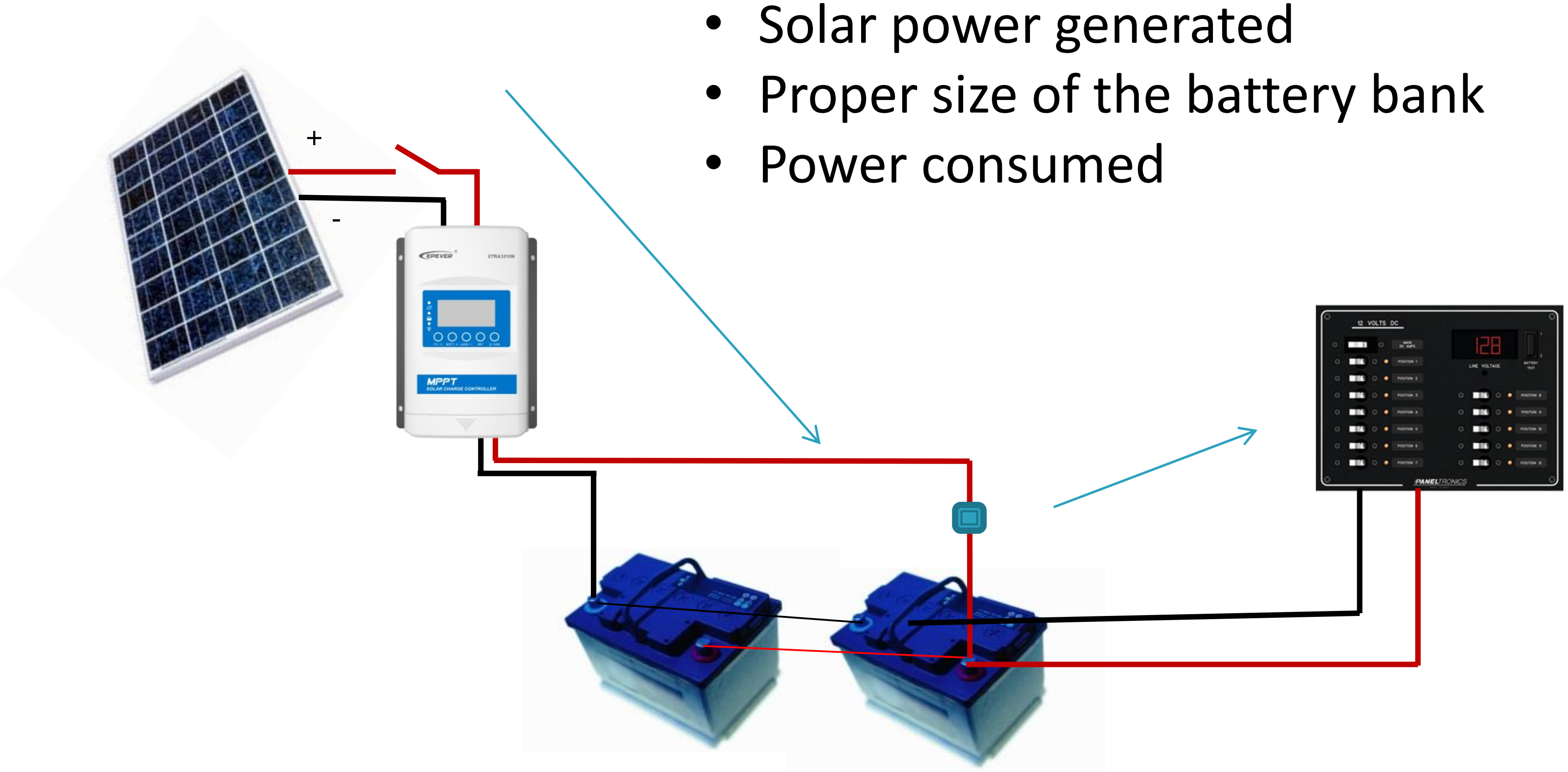
A Balanced System

- Water in
- Size of the bucket
- Water consumed



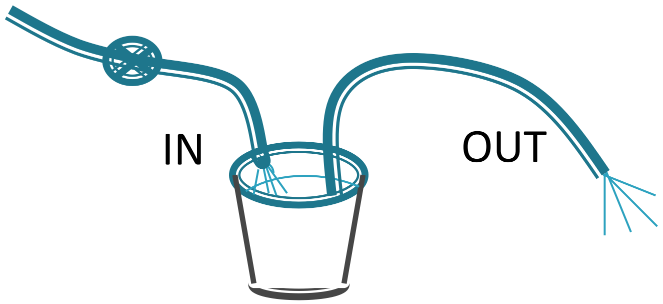
A Balanced System

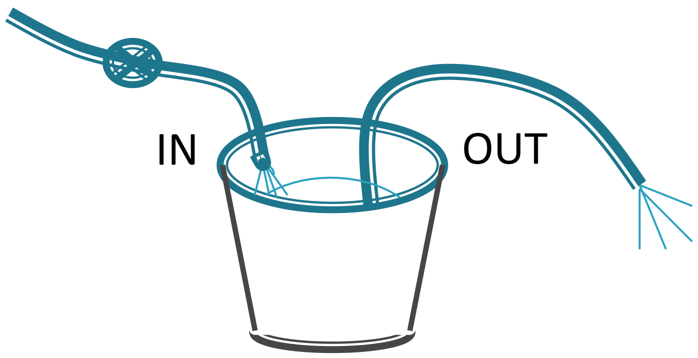
- Solar power generated
- Proper size of the battery bank
- Power consumed



Sizing Your Battery Bank

Battery capacity is measured in Amp Hours (AH)





A limited capacity battery bank

- Unable to store all the power your solar panels produce
- No reserve for cloudy days
- Must always be monitored because continually stressed

Your battery bank should have the capacity to support your boat's power requirements for at least 24 to 48 hours

Designing a Solar System to Meet Your Needs

Our Case Study Boat

What Do You Want to Achieve with Your Solar System?

A. Keep the batteries charged while on a mooring.

B. Supplement current power generation capability.
(Run my engine less to charge the batteries)

C. Generate all the power needed while at anchor.

D. Generate all the power needed at anchor and on passage.

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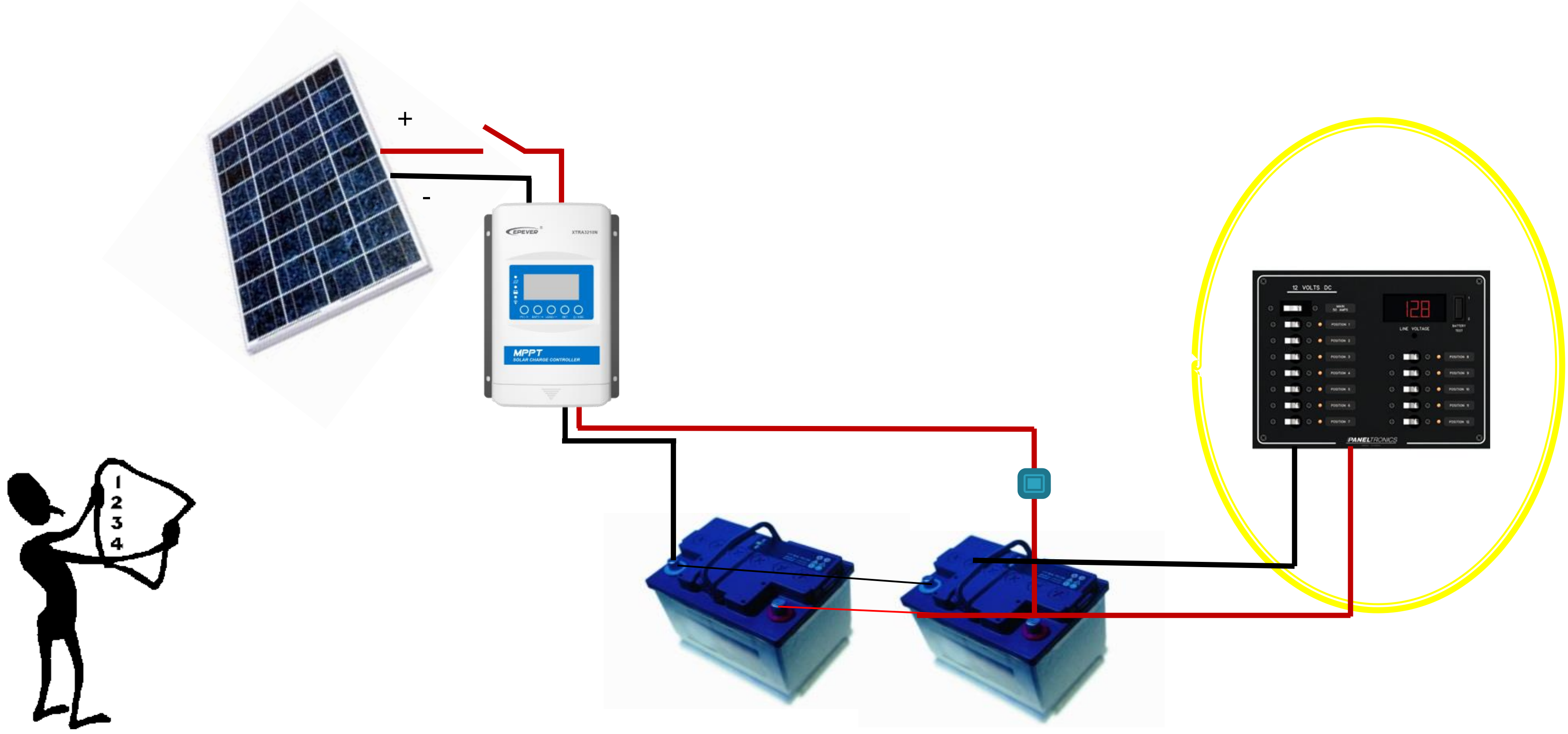
Designing a Solar System to Meet Your Needs

1. Determine daily power consumption



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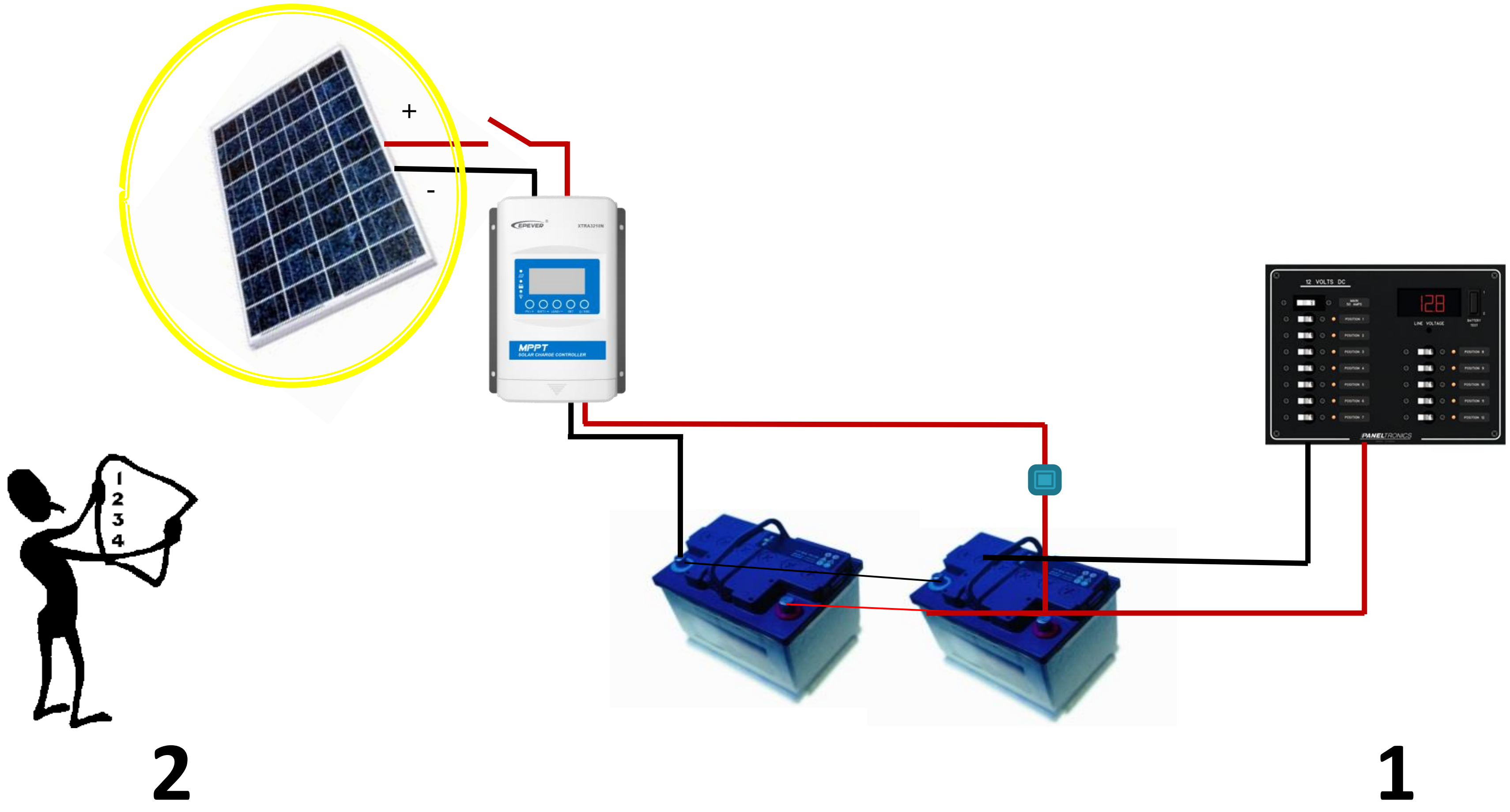
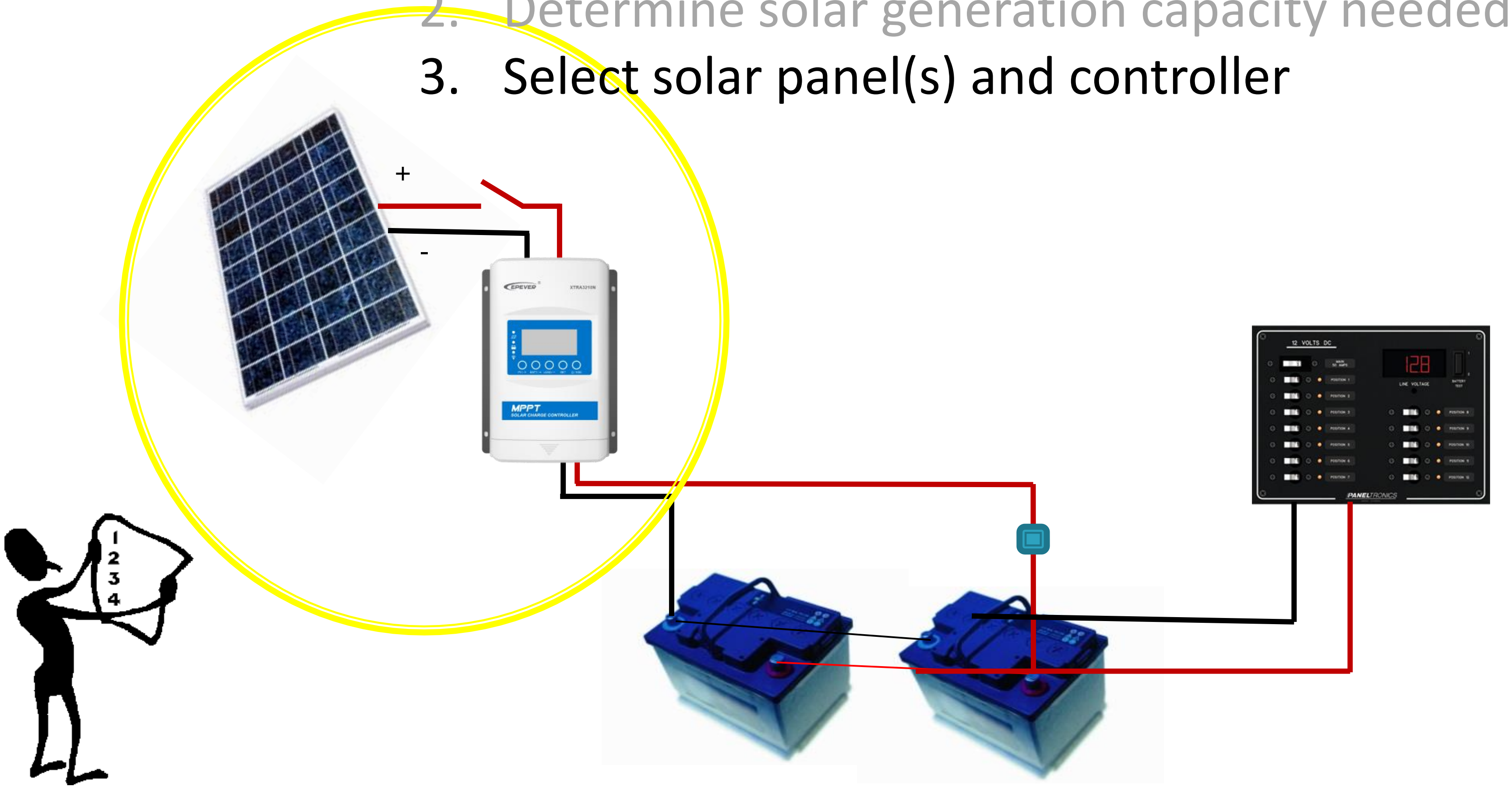
Designing a Solar System to Meet Your Needs

1. Determine daily power consumption
2. Determine solar generation capacity needed



Designing a Solar System to Meet Your Needs

1. Determine daily power consumption
2. Determine solar generation capacity needed
3. Select solar panel(s) and controller



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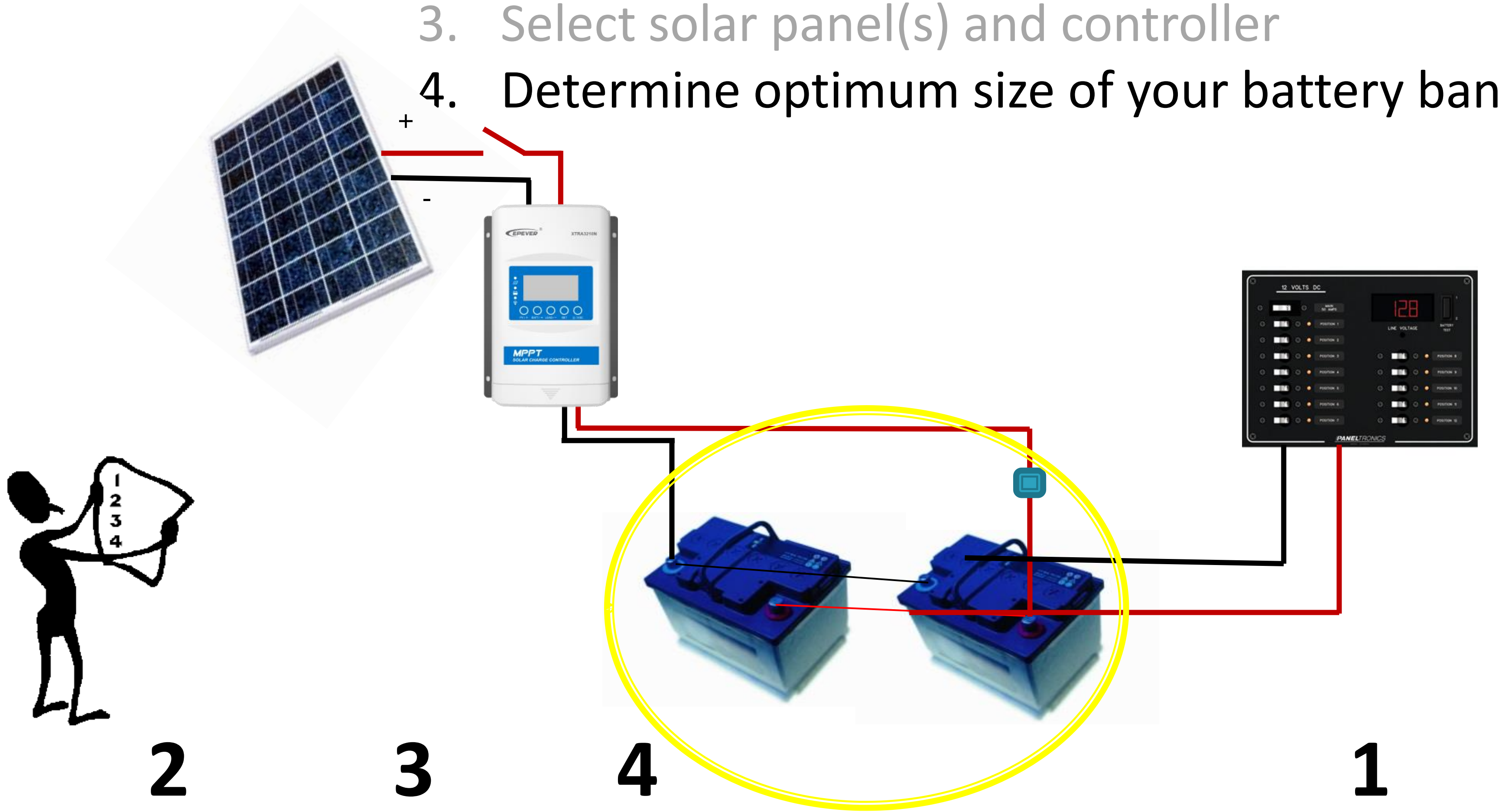
Designing a Solar System to Meet Your Needs

1. Determine daily power consumption
2. Determine solar generation capacity needed
3. Select solar panel(s) and controller
4. Determine optimum size of your battery bank



Worksheet for Designing a Solar System Based on Power Consumption

Input fields in Grey

Daily Power Consumption Analysis					
Appliance	Amps	Hours	Hours	Daily AH *1*	Daily AH
DC		At Anchor	On Passage	At Anchor	On Passage
Refrigeration	5	10	10	50	50
Radar	4		4	0	16
Computer - Laptop	4	1	10	4	40
Autopilot	4		10	0	40
Cabin Lights (LED)	1	4		4	0
Nav/Anchor Lights	0.2	10	10	2	2
Stereo	1	3	3	3	3
VHF Radio	0.5	10	10	5	5
Instruments	1		8	0	8
Pressure Water	6	0.25	0.1	1.5	0.6
Phone Charger	1	2	2	2	2
Other				0	0
Other				0	0
Total Amp Hours				71.5	166.6
AC - Equipment powred by an Inverter (Watts)					
Microwave (Watts)	1100	0.1	0.1	10.2	10.2
Other				0.0	0.0
Other				0.0	0.0
Windlass *2*				0.0	0.0
Total Amp Hours				10.2	10.2
Total Amp Hours Consumed per Day				81.7	176.8
Battery Charging Voltage			13		
Total Watt Hours Consumed per Day				1,061.5	2,297.8

1 AH - Amp Hours - Amps of current consumed in one hour
2 Windlass is often not considered because the engine alternator is running when used
3 5 hours avg. is a good estimate for horizontal panels, 7 for panels with tilt & rotate
See http://www.bigfrogmountain.com/SunHoursPerDay.html for hours in your area.
4 Charge efficiency factor - Lead Acid ≈ 1.2, AGM ≈ 1.1 , LiFePO4 ≈ 1.04
5 Solar efficiency - Partly cloudy ≈ 70%, Mostly cloudy ≈ 50%, Very cloudy ≈ 30%
6 Useable battery capacity - Lead Acid ≈ 50%, AGM ≈ 60%, LiFePO4 ≈ 95%

Steps to use this worksheet
1. Determine the average daily power consumption both at anchor and on passage.
2. Configure the solar system (battery and solar panel inefficiencies are considered).
3. Modify the solar system configuration to accommodate anticipated cloudy days.
4. Analyze the capacity of the battery bank.

Solar Power Requirement Analysis (Full Sun)		At Anchor	On Passage
Average Hours of Sun per Day	5	*3*	
Battery Charge Inefficiency Factor	1.2	*4*	
Watts of Solar to Replenish Battery Bank Daily		254.8	551.5
Solar System Design Analysis (MPPT Controller)			
Capacity of Each Solar Panel (Watts)	130		
Number of Solar Panels Required		2.2	4.7
Number of Solar Panels Installed	3		
Minimum Capacity of Solar Controller (Amps)	30.0		
Daily Useable Solar Power in Full Sun (Watt Hrs)	1,755.0		
Daily Power Drawn from Battery Bank (Watt Hrs)		1,061.5	2,297.8
Excess or (Deficit) of Power (Watt Hrs)		693.5	(542.8)
Factor for Cloudy Days			
Solar Efficiency on Cloudy Days (percentage)	30%	*5*	
Solar Power Generated on a Cloudy Day	526.5		
Power Drawn from Batteries on a Cloudy Day (Wh)		535.0	1,771.3
Number of Continuous Cloudy Days	2		
Sunny Days to Make Up Battery Draw Down		1.5	-
Battery Capacity Analysis		Amp Hrs at Anchor	Amp Hrs on Passage
Scenario 1 - Based on Cloudy Days - with Solar			
Ah Drawn from Batteries on Cloudy Days		82.3	272.5
% of Battery Capacity Useable	50%	*6*	
Rated Battery Capacity Required (AH)		164.6	545.0
Rated Battery Capacity (Ah)	120		
Number of Batteries Required (in parallel)		1.4	4.5
Scenario 2 - Based on Days of Reserve Capacity (no solar)			
Number of Days of Reserve Battery Capacity	2		
% of Battery Capacity Useable	50%		
Rated Battery Capacity Required (AH)		326.6	707.0
Rated Battery Capacity (Ah)	120		
Number of Batteries Required (in parallel)		2.7	5.9

Note: This methodology does not take into consideration power generation from other sources such as engine alternator, generator, wind generator, fuel cell or shore power.

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2

3

4

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Step 1

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Radar	4		4	0	16
Computer - Laptop	4	1	10	4	40
Autopilot	4		10	0	40
Cabin Lights (LED)	1	4		4	0
Nav/Anchor Lights	0.2	10	10	2	2
Stereo	1	3	3	3	3
VHF Radio	0.5	10	10	5	5
Instruments	1		8	0	8
Pressure Water	6	0.25	0.1	1.5	0.6
Phone Charger	1	2	2	2	2
Other				0	0
Other				0	0
Total Amp Hours				**71.5**	**166.6**

1 AH – Amp Hours

Step 1

Sample Power Consumption Worksheet

Appliance DC	Amps	Hours At Anchor	Hours On Passage	Daily AH *1* At Anchor	Daily AH On Passage
Refrigeration	5	10	10	50	50
Radar	4		4	0	16
Computer - Laptop	4	1	10	4	40
Autopilot	4		10	0	40
Cabin Lights (LED)	1	4		4	0
Nav/Anchor Lights	0.2	10	10	2	2
Stereo	1	3	3	3	3
VHF Radio	0.5	10	10	5	5
Instruments	1		8	0	8
Pressure Water	6	0.25	0.1	1.5	0.6
Phone Charger	1	2	2	2	2
Other				0	0
Other				0	0
Total Amp Hours				**71.5**	**166.6**

Amp Draw of Each Appliance

Step 1

Sample Power Consumption Worksheet

Appliance DC	Amps	Hours At Anchor	Hours On Passage	Daily AH *1* At Anchor	Daily AH On Passage
Refrigeration	5	10	10	50	50
Radar	4		4	0	16
Computer - Laptop	4	1	10	4	40
Autopilot	4		10	0	40
Cabin Lights (LED)	1	4		4	0
Nav/Anchor Lights	0.2	10	10	2	2
Stereo	1	3	3	3	3
VHF Radio	0.5	10	10	5	5
Instruments	1		8	0	8
Pressure Water	6	0.25	0.1	1.5	0.6
Phone Charger	1	2	2	2	2
Other				0	0
Other				0	0
Total Amp Hours				**71.5**	**166.6**

Hours Used of Each Appliance

Step 1

Sample Power Consumption Worksheet

Appliance DC	Amps	Hours At Anchor	Hours On Passage	Daily AH *1* At Anchor	Daily AH On Passage
Refrigeration	5	10	10	50	50
Radar	4		4	0	16
Computer - Laptop	4	1	10	4	40
Autopilot	4		10	0	40
Cabin Lights (LED)	1	4		4	0
Nav/Anchor Lights	0.2	10	10	2	2
Stereo	1	3	3	3	3
VHF Radio	0.5	10	10	5	5
Instruments	1		8	0	8
Pressure Water	6	0.25	0.1	1.5	0.6
Phone Charger	1	2	2	2	2
Other				0	0
Other				0	0
Total Amp Hours				**71.5**	**166.6**

Amps X Hours = Daily Amp Hours

Sample Power Consumption Worksheet

Appliance DC	Amps	Hours At Anchor	Hours On Passage	Daily AH *1* At Anchor	Daily AH On Passage
Refrigeration	5	10	10	50	50
Radar	4		4	0	16
Computer - Laptop	4	1	10	4	40
Autopilot	4		10	0	40
Cabin Lights (LED)	1	4		4	0
Nav/Anchor Lights	0.2	10	10	2	2
Stereo	1	3	3	3	3
VHF Radio	0.5	10	10	5	5
Instruments	1		8	0	8
Pressure Water	6	0.25	0.1	1.5	0.6
Phone Charger	1	2	2	2	2
Other				0	0
Other				0	0
Total Amp Hours				**71.5**	**166.6**

Amps X Hours = Daily Amp Hours

Step 1

Daily Power Consumption Analysis					
Appliance	Amps	Hours	Hours	Daily AH *1*	Daily AH
DC		At Anchor	On Passage	At Anchor	On Passage
Refrigeration	5	10	10	50	50
Radar	4		4	0	16
Computer - Laptop	4	1	10	4	40
Autopilot	4		10	0	40
Cabin Lights (LED)	1	4		4	0
Nav/Anchor Lights	0.2	10	10	2	2
Stereo	1	3	3	3	3
VHF Radio	0.5	10	10	5	5
Instruments	1		8	0	8
Pressure Water	6	0.25	0.1	1.5	0.6
Phone Charger	1	2	2	2	2
Other				0	0
Other				0	0
Total Amp Hours				71.5	166.6
AC - Equipment powred by an Inverter (Watts)					
Microwave (Watts)	1100	0.1	0.1	10.2	10.2
Other				0.0	0.0
Other				0.0	0.0
Windlass *2*				0.0	0.0
Total Amp Hours				10.2	10.2
Total Amp Hours Consumed per Day				81.7	176.8
Battery Charging Voltage			13		
Total Watt Hours Consumed per Day				1,061.5	2,297.8

1,100 watts / 13 volts x 1.2 inverter inefficiency factor

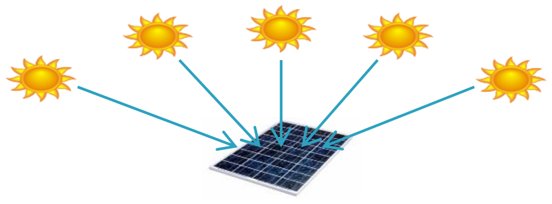
Determine Solar Capacity Needed

Step 2

		At Anchor	On Passage
Total Amp Hours Consumed per Day		**81.7**	**176.8**
Battery Charging Voltage	13		
Total Watt Hours Consumed per Day		**1,061.5**	**2,297.8**

Note: Average hours of sun per day is based on the sun angle throughout the day.

Note: 5 is a good number for horizontal panels, 7 for panels with tilt & rotate



Solar Power Requirement Analysis (Full Sun)		**At Anchor**	**On Passage**
Average Hours of Sun per Day	5		
Battery Charge Efficiency Factor	1.2		
Watts of Solar to Replenish Battery Bank Daily		**254.8**	**551.5**

Charge efficiency factor –

Lead Acid ≈ 1.2, AGM ≈ 1.1 , LiFePO4 ≈ 1.04

Watts of Solar Power Required

Watts = Volts x Amps

Select Solar Panels and Controller

Solar System Design Analysis (MPPT Controller)			
Capacity of Each Solar Panel (Watts)	130		
Number of Solar Panels Required		**2.2**	**4.7**
Number of Solar Panels Installed	3		
Minimum Capacity of Solar Controller (Amps)	**30.0**		
Daily Useable Solar Power in Full Sun (Watt Hrs)	1,755.0		
Daily Power Drawn from Battery Bank (Watt Hrs)		1,061.5	2,297.8
Excess or (Deficit) of Power (Watt Hrs)		693.5	(542.8)
Factor for Cloudy Days			
Solar Efficiency on Cloudy Days (percentage)	30%		
Solar Power Generated on a Cloudy Day	526.5		
Power Drawn from Batteries on a Cloudy Day (Wh)		535.0	1,771.3
Number of Continuous Cloudy Days	2		
Sunny Days to Make Up Battery Draw Down		**1.5**	**-**

Solar efficiency - Partly cloudy ≈ 70%, Mostly cloudy ≈ 50%, Very cloudy ≈ 30%

Step 4

Determine Optimum Size of Battery Bank

Battery Capacity Analysis		Amp Hrs at Anchor	Amp Hrs on Passage
Scenario 1 - Based on Cloudy Days - with Solar			
Ah Drawn from Batteries on Cloudy Days		82.3	272.5
% of Battery Capacity Useable	50%		
Rated Battery Capacity Required (AH)		**164.6**	**545.0**
Rated Battery Capacity (Ah)	120		
Number of Batteries Required (in parallel)		**1.4**	**4.5**
Scenario 2 - Based on Days of Reserve Capacity (no solar)			
Number of Days of Reserve Battery Capacity	2		
% of Battery Capacity Useable	50%		
Rated Battery Capacity Required (AH)		**326.6**	**707.0**
Rated Battery Capacity (Ah)	120		
Number of Batteries Required (in parallel)		**2.7**	**5.9**

Useable battery capacity - Lead Acid ≈ 50%, AGM ≈ 60%, LiFePO4 ≈ 95%

Worksheet for Designing a Solar System Based on Power Consumption

Input fields in Grey

Daily Power Consumption Analysis					
Appliance	Amps	Hours	Hours	Daily AH *1*	Daily AH
DC		At Anchor	On Passage	At Anchor	On Passage
Refrigeration	5	10	10	50	50
Radar	4		4	0	16
Computer - Laptop	4	1	10	4	40
Autopilot	4		10	0	40
Cabin Lights (LED)	1	4		4	0
Nav/Anchor Lights	0.2	10	10	2	2
Stereo	1	3	3	3	3
VHF Radio	0.5	10	10	5	5
Instruments	1		8	0	8
Pressure Water	6	0.25	0.1	1.5	0.6
Phone Charger	1	2	2	2	2
Other				0	0
Other				0	0
Total Amp Hours				**71.5**	**166.6**
AC - Equipment powred by an Inverter (Watts)					
Microwave (Watts)	1100	0.1	0.1	10.2	10.2
Other				0.0	0.0
Other				0.0	0.0
Windlass *2*				0.0	0.0
Total Amp Hours				**10.2**	**10.2**
Total Amp Hours Consumed per Day				**81.7**	**176.8**
Battery Charging Voltage			13		
Total Watt Hours Consumed per Day				**1,061.5**	**2,297.8**

1 AH - Amp Hours - Amps of current consumed in one hour
2 Windlass is often not considered because the engine alternator is running when used
3 5 hours avg. is a good estimate for horizontal panels, 7 for panels with tilt & rotate
See http://www.bigfrogmountain.com/SunHoursPerDay.html for hours in your area.
4 Charge efficiency factor - Lead Acid ≈ 1.2, AGM ≈ 1.1 , LiFePO4 ≈ 1.04
5 Solar efficiency - Partly cloudy ≈ 70%, Mostly cloudy ≈ 50%, Very cloudy ≈ 30%
6 Useable battery capacity - Lead Acid ≈ 50%, AGM ≈ 60%, LiFePO4 ≈ 95%

Solar Power Requirement Analysis (Full Sun)		At Anchor	On Passage
Average Hours of Sun per Day	5 *3*		
Battery Charge Inefficiency Factor	1.2 *4*		
Watts of Solar to Replenish Battery Bank Daily		**254.8**	**551.5**
Solar System Design Analysis (MPPT Controller)			
Capacity of Each Solar Panel (Watts)	130		
Number of Solar Panels Required		**2.2**	**4.7**
Number of Solar Panels Installed	3		
Minimum Capacity of Solar Controller (Amps)	**30.0**		
Daily Useable Solar Power in Full Sun (Watt Hrs)	1,755.0		
Daily Power Drawn from Battery Bank (Watt Hrs)		1,061.5	2,297.8
Excess or (Deficit) of Power (Watt Hrs)		693.5	(542.8)
Factor for Cloudy Days			
Solar Efficiency on Cloudy Days (percentage)	30% *5*		
Solar Power Generated on a Cloudy Day	526.5		
Power Drawn from Batteries on a Cloudy Day (Wh)		535.0	1,771.3
Number of Continuous Cloudy Days	2		
Sunny Days to Make Up Battery Draw Down		**1.5**	-
Battery Capacity Analysis		**Amp Hrs at Anchor**	**Amp Hrs on Passage**
Scenario 1 - Based on Cloudy Days - with Solar			
Ah Drawn from Batteries on Cloudy Days		82.3	272.5
% of Battery Capacity Useable	50% *6*		
Rated Battery Capacity Required (AH)		**164.6**	**545.0**
Rated Battery Capacity (Ah)	120		
Number of Batteries Required (in parallel)		**1.4**	**4.5**
Scenario 2 - Based on Days of Reserve Capacity (no solar)			
Number of Days of Reserve Battery Capacity	2		
% of Battery Capacity Useable	50%		
Rated Battery Capacity Required (AH)		**326.6**	**707.0**
Rated Battery Capacity (Ah)	120		
Number of Batteries Required (in parallel)		**2.7**	**5.9**

Steps to use this worksheet
1. Determine the average daily power consumption both at anchor and on passage.
2. Configure the solar system (battery and solar panel inefficiencies are considered).
3. Modify the solar system configuration to accommodate anticipated cloudy days.
4. Analyze the capacity of the battery bank.

Note: This methodology does not take into consideration power generation from other sources such as engine alternator, generator, wind generator, fuel cell or shore power.

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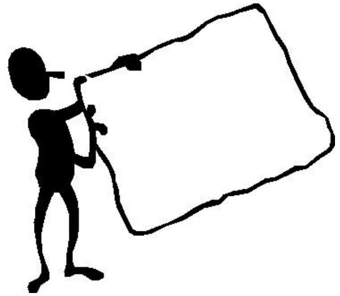
Our Findings

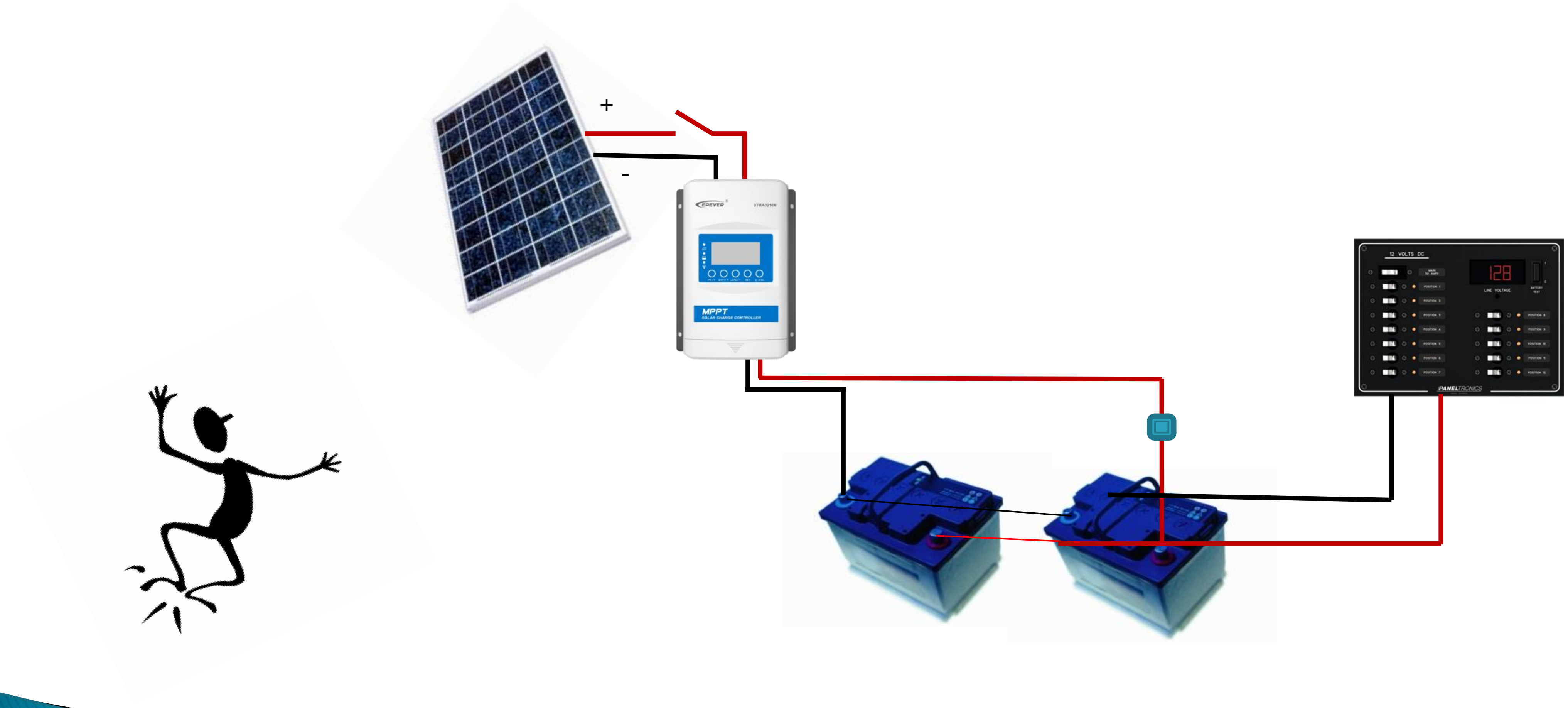
Generate All the Power Needed While at Anchor

Power consumption	82 to 177 amp hours
Optimum battery capacity	300 to 700 amp hours (lead acid)
Rated panel wattage needed	300 to 550 watts (roughly)



Watts = Volts x Amps

A Complete and Balanced Solar Power System

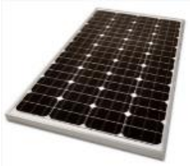


High Performance Marine PV Solar Panel Specifications

Model - Part Number	Nominal Peak Power Watts-Wp	Open Circuit Voltage Voc	Short Circuit Current Isc	Nominal Voltage Vmp	Nominal Power Current Imp	Cell Efficiency %	Solar Cell Mfg.	Cell Layout	Panel Size Inches	Weight lbs.	Amp Hrs per Day @ 6 Hrs Sun	
Semi-flexible - Monocrystalline												
CMP23055FW	55	23.4	3.1	19.8	2.9	22.0	SunPower	4 x 8	21.25x22.8	3.3	25.4	*
CMP23055FB	55	23.4	3.1	19.8	2.9	22.0	SunPower	4 x 8	21.25x22.8	3.3	25.4	*
CMP23070F	70	23.4	3.9	19.8	3.6	22.8	SunPower	4 x 5	21.25x27.75	3.8	32.3	*
CMP23115F	115	21.9	6.7	18.6	6.2	23.7	SunPower	4 x 8	21.25x42.1	4.0	53.1	*
CMP23120F	120	24.0	6.5	20.0	6.0	20.4	SunPower	4 x 10	22.0x52.25	6.1	55.4	*
CMP23130F	130	26.3	6.2	22.3	5.8	23.7	SunPower	4 x 9	21.25x47.25	5.2	60.0	*
CMP23145F	145	27.8	6.8	23.2	6.3	23.7	SunPower	4 x 10	21.25x52.4	6.6	66.9	*
Semi-rigid - Monocrystalline												
CMP24110SR	110	21.9	6.4	18.6	5.9	23.7	SunPower	4 x 8	21.65x42.9	12.0	50.8	*
CMP24120SR	120	24.0	6.4	20.3	5.9	23.7	SunPower	5 x 7	26x38	12.5	55.4	*
CMP24150SR	150	21.9	8.7	18.6	8.1	23.7	SunPower	5 x 9	26x48	13.5	69.2	*
CMP24175SR	175	34.7	6.4	29.4	6.0	23.7	SunPower	7 x 7	36.4x37.6	18.0	80.8	*
Rigid - Monocrystalline												
CMP21105M	105	21.6	6.5	17.5	6.0	17.9	Bosch	4 x 6	26.4x39.4	18.0	36.0	
CMP22110S	110	21.9	6.4	18.6	5.9	22.6	SunPower	4 x 8	21.3x41.7	18.0	50.8	*
CMP22140S	140	28.3	6.3	24.0	5.8	23.7	SunPower	5 x 8	26.6x41.7	20.0	64.6	*
CMP22150SR	150	30.1	6.4	25.5	5.9	22.6	SunPower	4 x 11	21.3x56.9	22.0	69.2	*
CMP22175S	175	34.7	6.4	29.4	6.0	23.7	SunPower	7 x 7	36.2x37	22.0	80.8	*
CMP22200S	200	38.9	6.6	33.0	6.0	23.7	SunPower	5 x 11	26.8x56.9	23.8	92.3	*
CMP22225S	225	46.7	6.1	39.6	5.7	23.7	SunPower	6 x 11	31.1x56.3	32.2	103.8	
Rigid - Polycrystalline												
CMP21100P	100	21.6	6.2	17.5	5.7	16.7	Q Cell	4 x 6	26.4x39.4	18.0	34.3	
CMP21150P	150	21.9	9.2	17.6	8.5	17.1	Q Cell	6 x 6	39x39.5	26.5	51.0	
CMP21160PK	160	21.9	9.7	17.6	9.0	18.0	Q Cell	4 x 9	26.3x59	26.5	54.0	
										* Using MPPT Controller		*

Semi-flexible

Semi-rigid



Rigid Polycrystalline

Rigid Monocrystalline

Below is contact information should you have questions or comments.

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