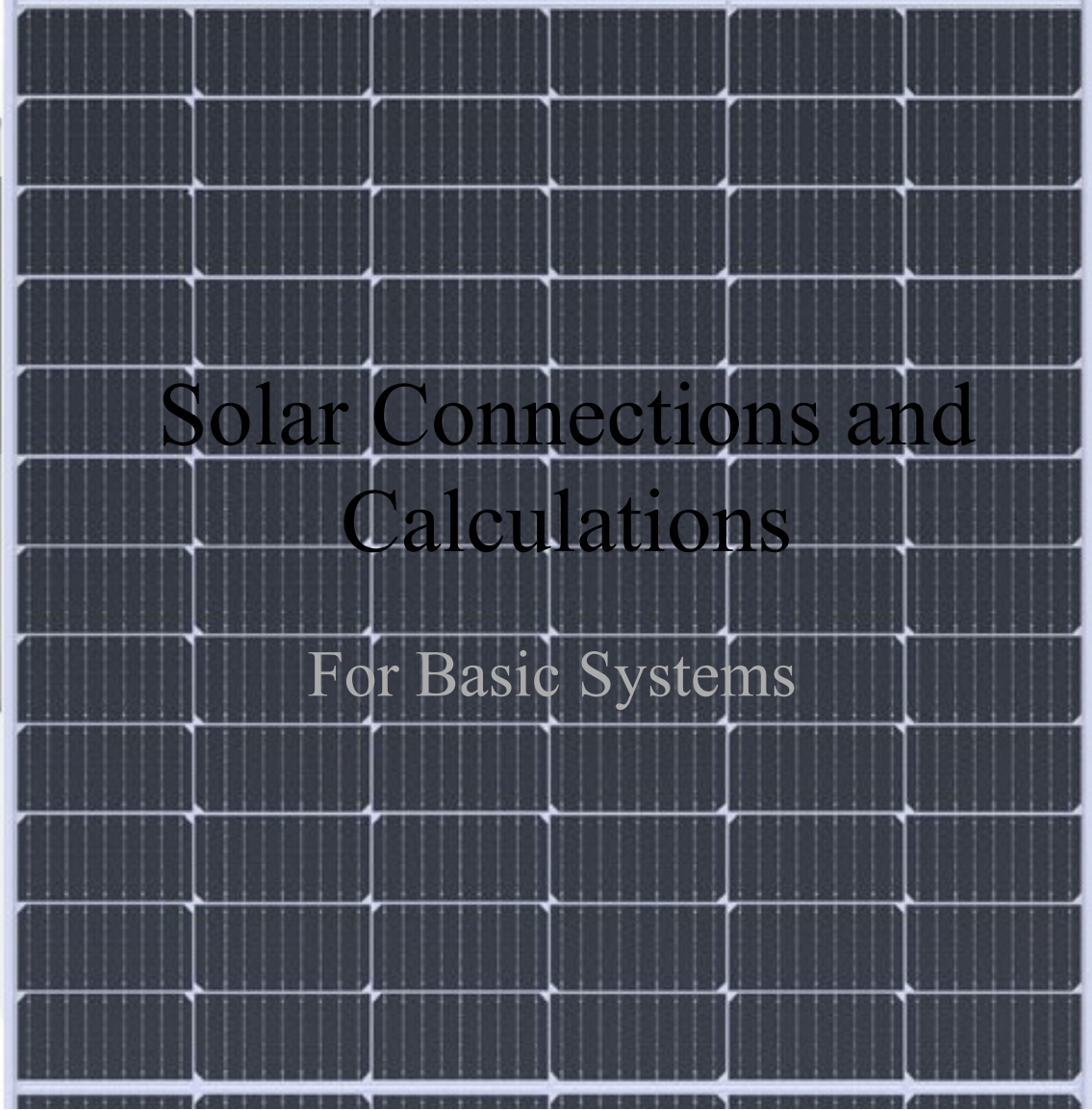




Solar Connections and Calculations

For Basic Systems

Why is this topic important?

- Determine how much power your home needs to run
- Protect your equipment
- Determine your equipment size
- Determine your equipment quantity
- To prevent fire or accidents
- To keep you safe

How much does your home use?

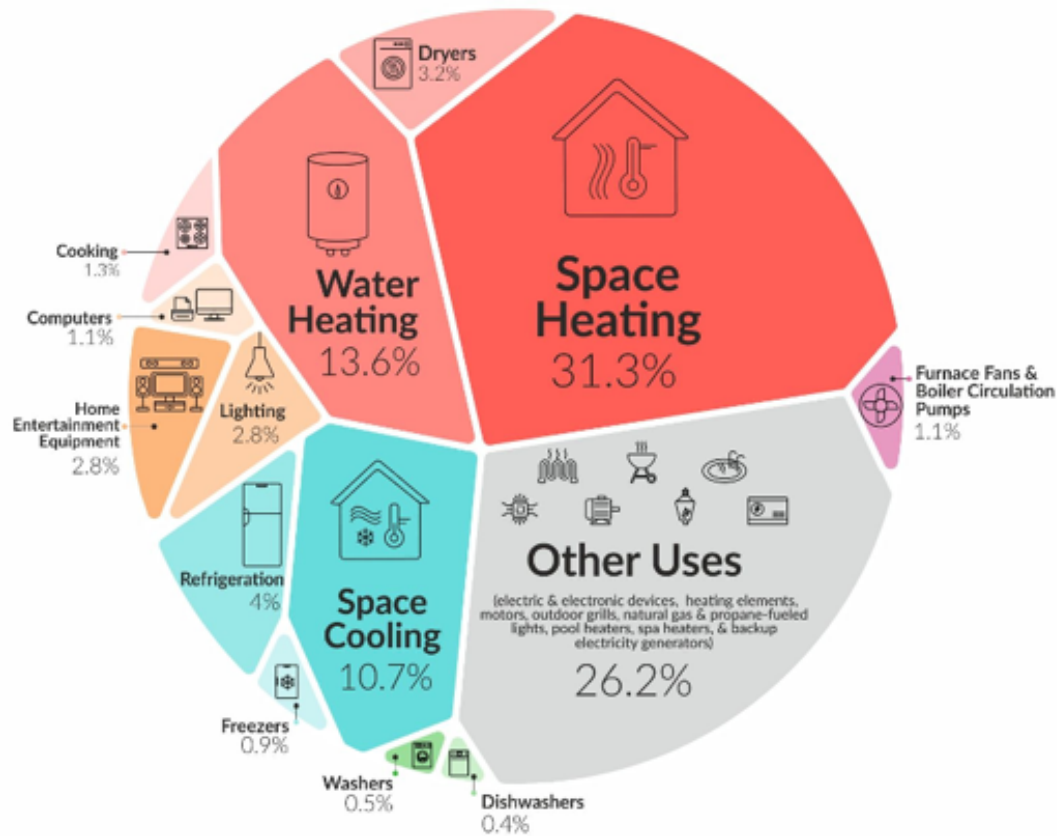
- Can look at your power bill and use an average
- Can use individual energy monitors for each appliance or load (or calculate them from the specs on the label)
- Can use an whole home energy monitor system (which I like and we use)
- Can estimate based on average usage in the US or other country



Examples

Residential Energy Use by Appliance

Percentage of Total Gross End-Use Energy Consumption in Single-Family Households



www.fixr.com/blog | Source: U.S. Energy Information Administration (EIA) - Annual Energy Outlook 2021

FIXR



STATEMENT OF ELECTRIC SERVICE

JANUARY 2016

ACCOUNT NUMBER
99999 99999

FOR CUSTOMER SERVICE OR
PAYMENT LOCATIONS CALL:
1-727-443-2641

WEB SITE: www.duke-energy.com

TO REPORT A POWER OUTAGE:
1-800-228-8485

JANE SMITH
2000 PARK PL
ST PETERSBURG FL 33709

SERVICE ADDRESS
2000 PARK PL
ST PETERSBURG FL 33709

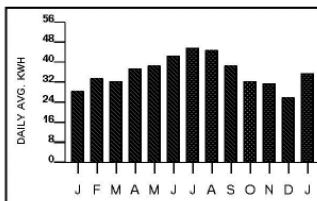
DUE DATE FEB 16 2016	TOTAL AMOUNT DUE 142.54
NEXT READ DATE ON OR ABOUT FEB 24 2016	DEPOSIT AMOUNT ON ACCOUNT NONE

PIN: 425946528

METER READINGS

METER NO.	002111329
PRESENT (ACTUAL)	048951
PREVIOUS (ACTUAL)	047871
DIFFERENCE	1080
TOTAL KWH	1080

Question 18



ENERGY USE

DAILY AVG. USE -	36 KWH/DAY
USE ONE YEAR AGO -	29 KWH/DAY
*DAILY AVG. ELECTRIC COST -	\$4.05

PAYMENTS RECEIVED AS OF JAN 05 2016 107.11 THANK YOU

RS-1 001 RESIDENTIAL SERVICE

BILLING PERIOD..12-23-15 TO 01-22-16 30 DAYS

CUSTOMER CHARGE	8.76
ENERGY CHARGE	
FIRST 1000 KWH	1000 KWH @ 6.90100¢ 69.01
ABOVE 1000 KWH	80 KWH @ 8.26300¢ 6.61
FUEL CHARGE	
FIRST 1000 KWH	1000 KWH @ 3.35300¢ 33.53
ABOVE 1000 KWH	80 KWH @ 4.35300¢ 3.48
*TOTAL ELECTRIC COST	121.39
GROSS RECEIPTS TAX	3.11
MUNICIPAL FRANCHISE FEE	7.76
MUNICIPAL UTILITY TAX	10.28
TOTAL CURRENT BILL	142.54
TOTAL DUE THIS STATEMENT	\$142.54

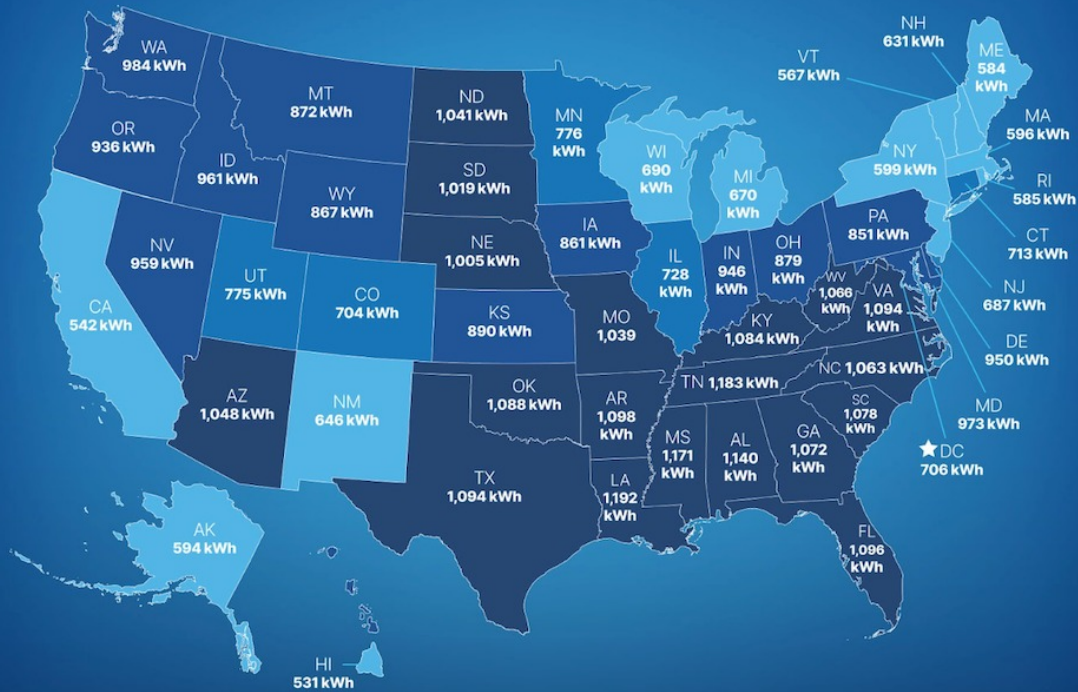
Payment of your bill prior to the above due date will avoid a late payment charge of \$5.00 or 1.5%, whichever is greater. Help those less fortunate stay warm this winter by contributing to our Energy Neighbor Fund program. For more information visit us online at duke-energy.com/ENF.

DETACH AND RETURN THIS SECTION

EB72 0019591



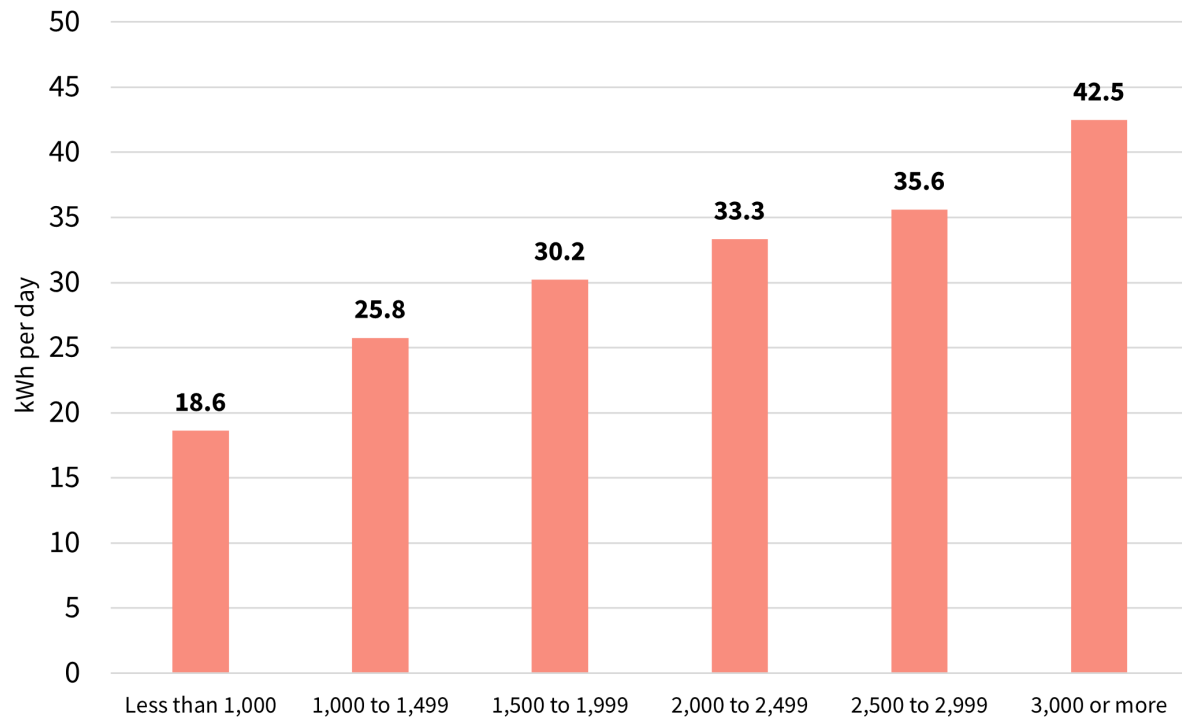
Average monthly kWh usage by state



0 kWh - 700 kWh 701 kWh - 850 kWh 851 kWh - 1,000 kWh 1,000 kWh +

How Many kWh Per Day Is Normal?

Average electricity usage per day by home size



Data: US Energy Information Administration.

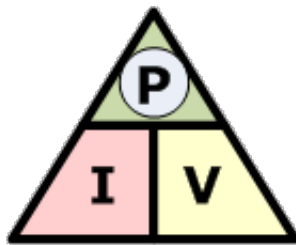
solar.com

Basic calculations are needed for:

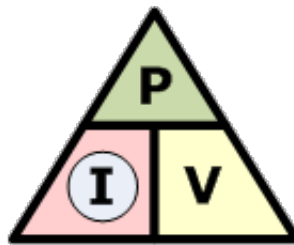
- How many inverters will you need?
- How many panels you can pair with an inverter?
- How to configure your panels?
- How many batteries will I need?

Most useful formula is Watts Law

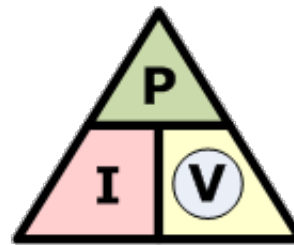
or $P=IV$ which is Watts = Amps x Volts



$$\textcircled{P} = I \times V$$



$$\textcircled{I} = \frac{P}{V}$$



$$\textcircled{V} = \frac{P}{I}$$

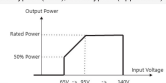
Inverter Parameters

EG4 ELECTRONICS

TECHNICAL SPECIFICATIONS

LINE MODE SPECIFICATIONS	
INPUT VOLTAGE WAVEFORM	Sinusoidal (utility or generator)
NOMINAL INPUT VOLTAGE	120VAC
LOW LOSS VOLTAGE	95VAC± 7V (UPS); 65VAC± 7V (Appliances)
LOW LOSS RETURN VOLTAGE	100VAC± 7V (UPS); 70VAC± 7V (Appliances)
HIGH LOSS VOLTAGE	140VAC ±7V
HIGH LOSS RETURN VOLTAGE	135VAC ±7V
MAX AC INPUT VOLTAGE	150VAC
MIN AC INPUT VOLTAGE	Electronics: 65 - 140VAC Home Appliances: 65 - 140VAC
NOMINAL INPUT FREQUENCY	50Hz / 60Hz (Auto detection)
LOW LOSS FREQUENCY	40 ±1Hz
LOW LOSS RETURN FREQUENCY	42 ±1Hz
HIGH LOSS FREQUENCY	65 ±1Hz
HIGH LOSS RETURN FREQUENCY	63 ±1Hz
OUTPUT SHORT CIRCUIT PROTECTION	Line mode: Circuit Breaker 30A Battery mode: Solid State FETs 400A
EFFICIENCY (LINE MODE)	[8 95% (Rated R load, battery full charged)
TRANSFER TIME	10ms typical (UPS); 20ms typical (Appliances)

OUTPUT POWER DERATING:
WHEN AC INPUT VOLTAGE DROPS TO 95V, THE OUTPUT
POWER WILL BE DERATED.



INVERTER MODE SPECIFICATIONS	
RATED OUTPUT POWER	3kVA/2kW
OUTPUT VOLTAGE WAVEFORM	Pure Sine Wave
OUTPUT VOLTAGE REGULATION	110/120VAC ±5%
OUTPUT FREQUENCY	60Hz or 50Hz
BATTERY TO INVERTER EFFICIENCY	94%
PV TO INVERTER EFFICIENCY	97%
OVERLOAD PROTECTION	5s@ ~150% load; 10s@110% ~150% load
SURGE CAPACITY	2 X rated power for 5 seconds
NOMINAL DC INPUT VOLTAGE	48 VDC
MPPT STARTUP VOLTAGE	120 VDC
LOW DC WARNING VOLTAGE, @LOAD< 20%	44.0 VDC
LOW DC WARNING VOLTAGE, @ 20% ≤ LOAD < 50%	42.8 VDC
LOW DC WARNING VOLTAGE, @LOAD ≥ 50%	40.4 VDC
LOW DC WARNING RETURN VOLTAGE, @LOAD< 20%	46.0 VDC
LOW DC WARNING RETURN VOLTAGE, @ 20% ≤ LOAD < 50%	44.8 VDC
LOW DC WARNING RETURN VOLTAGE, @LOAD ≥ 50%	42.4 VDC
LOW DC CUT-OFF VOLTAGE, @LOAD< 20%	42.0 VDC
LOW DC CUT-OFF VOLTAGE, @ 20% ≤ LOAD < 50%	40.8 VDC
LOW DC CUT-OFF VOLTAGE, @LOAD ≥ 50%	38.4 VDC

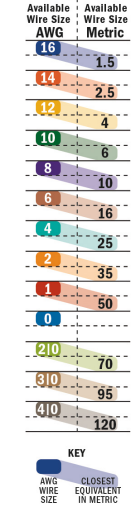


Inverter Parameters: Spec Sheet

- Will tell you min operating volts which in turn will tell you the min amount of panels you will need to “wake up” the inverter
- Will show max VOC (or volts open circuit) which will tell you total max number of panels (and voltage) the inverter can handle. Important to pay close attention to this one. **Over voltage can cause damage to an inverter.**
- Will show amperage input and output which will help you calculate wire size as well as proper amperage for inverter function from the panels
- Will tell you voltage output. Either 120v or 240v
- Will tell you nominal voltage of inverter so that you can match panels and batteries to it. i.e. 12 volt, 24 volt, or 48 volt
- Inverter/Charge Controller will tell you recommended wire size for AC Output, Battery cable, etc.

Wire and breaker sizing

Standard and Metric Wire Comparison Table



CIRCUIT TYPE				CURRENT FLOW IN AMPS																	
10% VOLTAGE DROP Non Critical		3% VOLTAGE DROP Critical																			
0 to 20 ft. 0 to 6.1 M		0 to 6 ft. 0 to 1.8 M		5A	10A	15A	20A	25A	30A	40A	50A	60A	70A	80A	90A	100A	120A	150A	200A		
CIRCUIT LENGTH	30 ft. 9.1 M	10 ft. 3.0 M	16 AWG	14 AWG	12 AWG	10 AWG	8 AWG	6 AWG	4 AWG	2 AWG	1 AWG	0 AWG	2/0 AWG	3/0 AWG	4/0 AWG						
	50 ft. 15.2 M	15 ft. 4.6 M	16 AWG	14 AWG	12 AWG	10 AWG	8 AWG	6 AWG	4 AWG	2 AWG	1 AWG	0 AWG	2/0 AWG	3/0 AWG	4/0 AWG						
	65 ft. 19.8 M	20 ft. 6.1 M	14 AWG	10 AWG	8 AWG	6 AWG	4 AWG	2 AWG	1 AWG	0 AWG	2/0 AWG	3/0 AWG	4/0 AWG								
	80 ft. 24.4 M	25 ft. 7.6 M	12 AWG	10 AWG	8 AWG	6 AWG	4 AWG	2 AWG	1 AWG	0 AWG	2/0 AWG	3/0 AWG	4/0 AWG								
	100 ft. 30.5 M	30 ft. 9.1 M	10 AWG	8 AWG	6 AWG	4 AWG	2 AWG	1 AWG	0 AWG	2/0 AWG	3/0 AWG	4/0 AWG									
	130 ft. 39.6 M	40 ft. 12.2 M	8 AWG	6 AWG	4 AWG	2 AWG	1 AWG	0 AWG	2/0 AWG	3/0 AWG	4/0 AWG										
	165 ft. 50.3 M	50 ft. 15.2 M	6 AWG	4 AWG	2 AWG	1 AWG	0 AWG	2/0 AWG	3/0 AWG	4/0 AWG											
	200 ft. 61.0 M	60 ft. 18.3 M	4 AWG	2 AWG	1 AWG	0 AWG	2/0 AWG	3/0 AWG	4/0 AWG												
		70 ft. 21.3 M	6 AWG	4 AWG	2 AWG	1 AWG	0 AWG	2/0 AWG	3/0 AWG	4/0 AWG											
		80 ft. 24.4 M	4 AWG	2 AWG	1 AWG	0 AWG	2/0 AWG	3/0 AWG	4/0 AWG												
		90 ft. 27.4 M	2 AWG	1 AWG	0 AWG	2/0 AWG	3/0 AWG	4/0 AWG													
		100 ft. 30.5 M	1 AWG	0 AWG	2/0 AWG	3/0 AWG	4/0 AWG														
	110 ft. 33.5 M	0 AWG	2/0 AWG	3/0 AWG	4/0 AWG																
	120 ft. 36.6 M	2/0 AWG	3/0 AWG	4/0 AWG																	
	130 ft. 39.6 M	3/0 AWG	4/0 AWG																		

Although this process uses information from ABYC E-11 to recommend wire size and circuit protection, it may not cover all of the unique characteristics that may exist on a boat. If you have specific questions about your installation please consult an ABYC certified installer.

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Batteries

- Battery chemistry is important. Most are choosing LiFePo₄ (lithium) batteries for modern systems
- Typical 48v batteries have 5120 Wh or 5.12 kWh of capacity within them. This simply means that you can run a 5120 watt load for 1 hour or a 512 watt load for 10 hours until the battery state of charge would be at 0%.
- How many batteries? Depends on your loads which are affected by usage, temperature, etc. I always say, the more the better!



Examples

Most electric water heaters use about 4500 watts to heat the water and will have a recovery rate of between 25 and 40 gallons per hour for a high efficiency model.

If you have a 40 gallon model and use all of the hot water. You will need 4500w for 1 hour to recover the hot water.

That means you will use up almost 1 entire battery just for the water heater

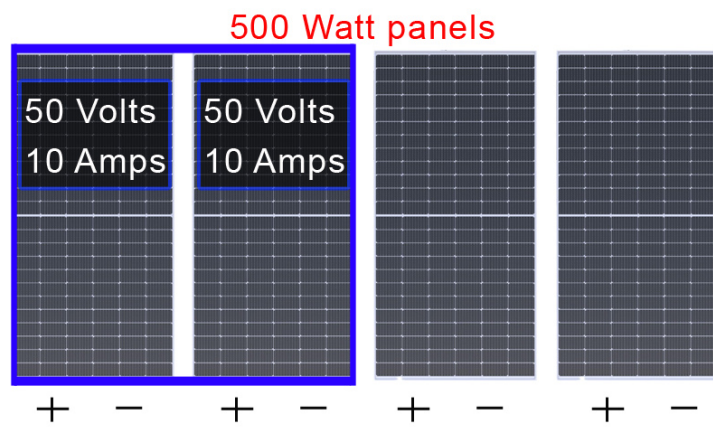


Panels

- Most calculations have to do with the solar panels themselves
- Calculating correctly will ensure other equipment, like the inverter/charge controller, is not damaged
- Each panel has a specific wattage, voltage, and amperage
- Panels are affected by ambient temperature. Counter intuitively panel voltage increases in the cold and decreases in the heat. So when whole panel arrays are calculated for a system, cold temps have to be considered. Usually a 10% increase is safe to assume.
- Panels can be wired in Series or Parallel or Series Parallel to help attain the correct voltage and amperage for your inverter/charge controller

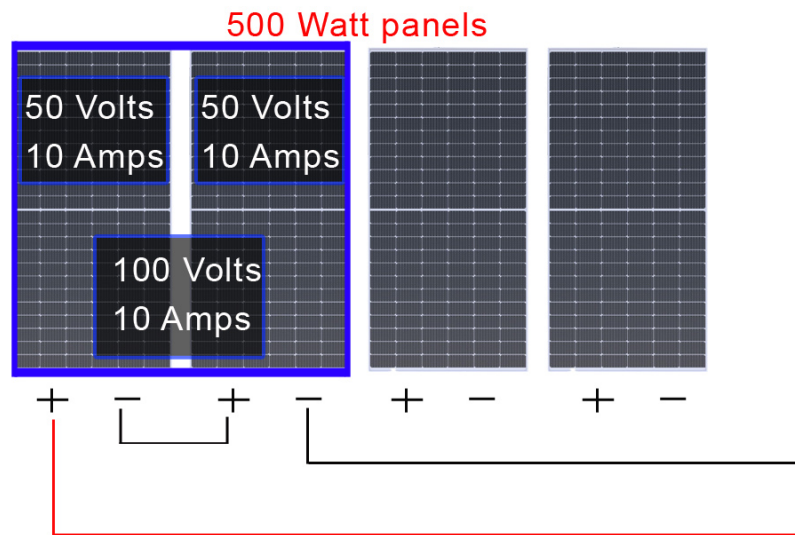


Examples



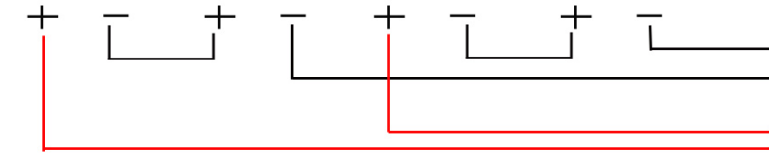
WIRED IN SERIES

- Amps stay the same and Volts add together

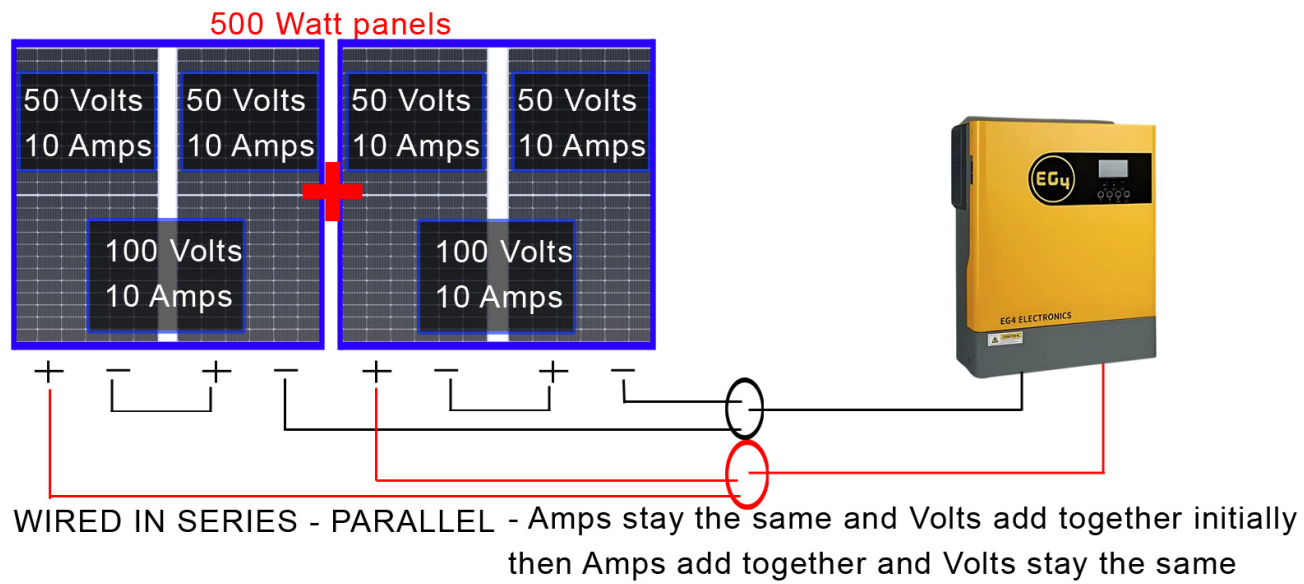


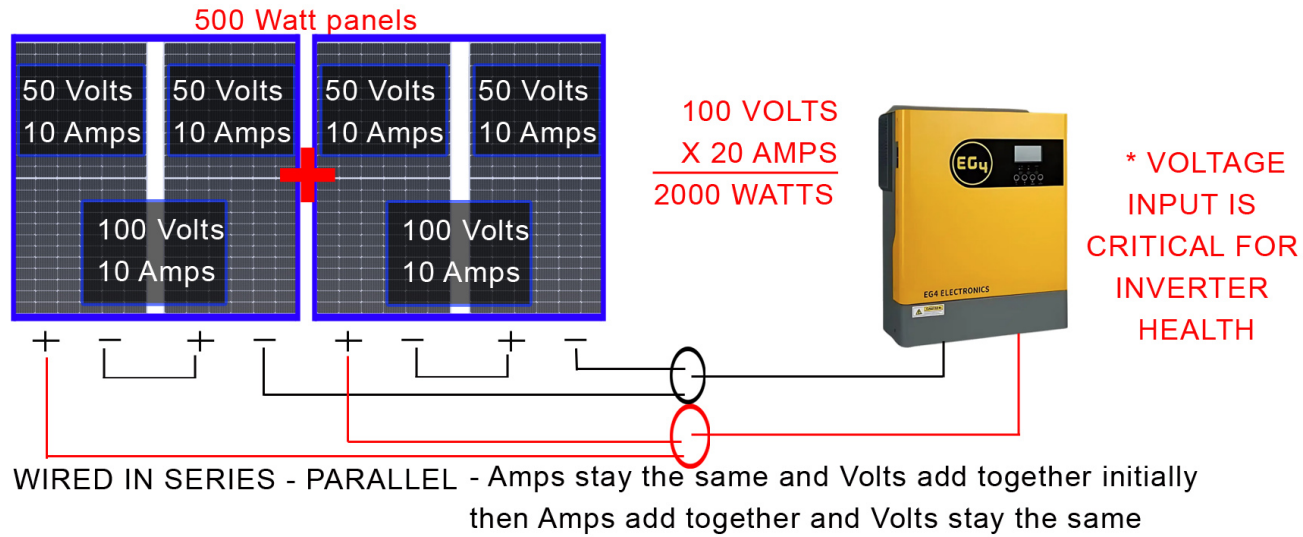
WIRED IN SERIES

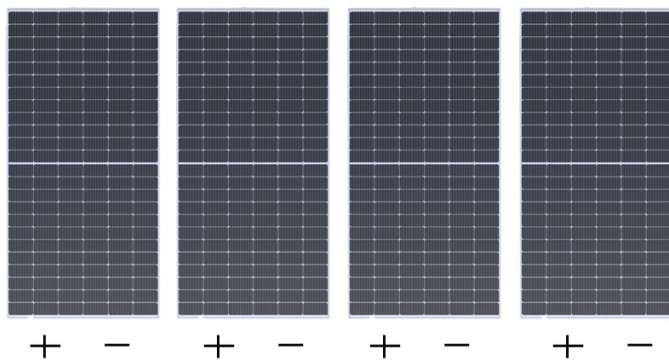
- Amps stay the same and Volts add together



- Amps stay the same and Volts add together

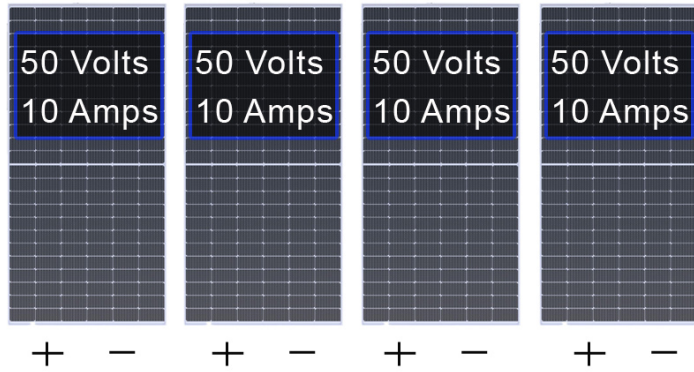






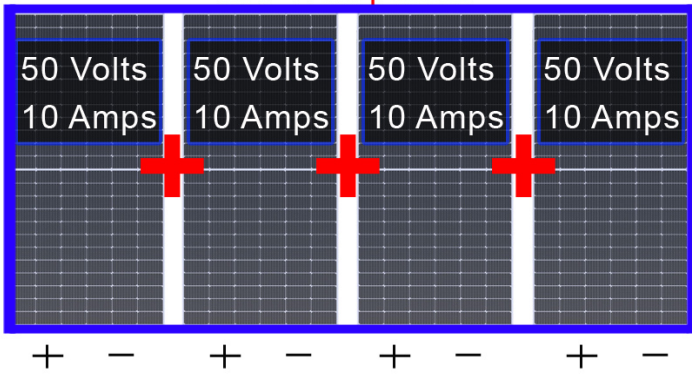
WIRED IN PARALLEL

500 Watt panels



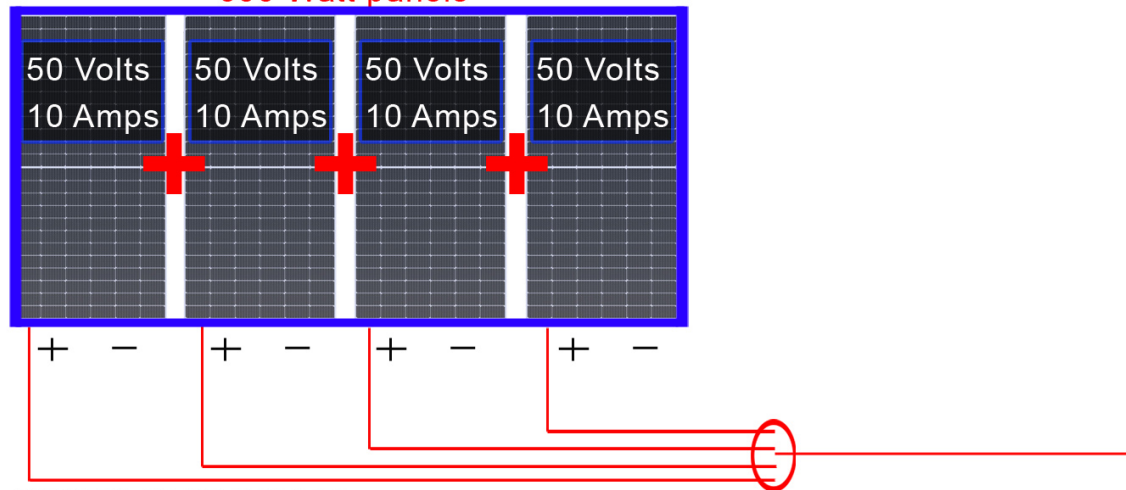
WIRED IN PARALLEL

500 Watt panels



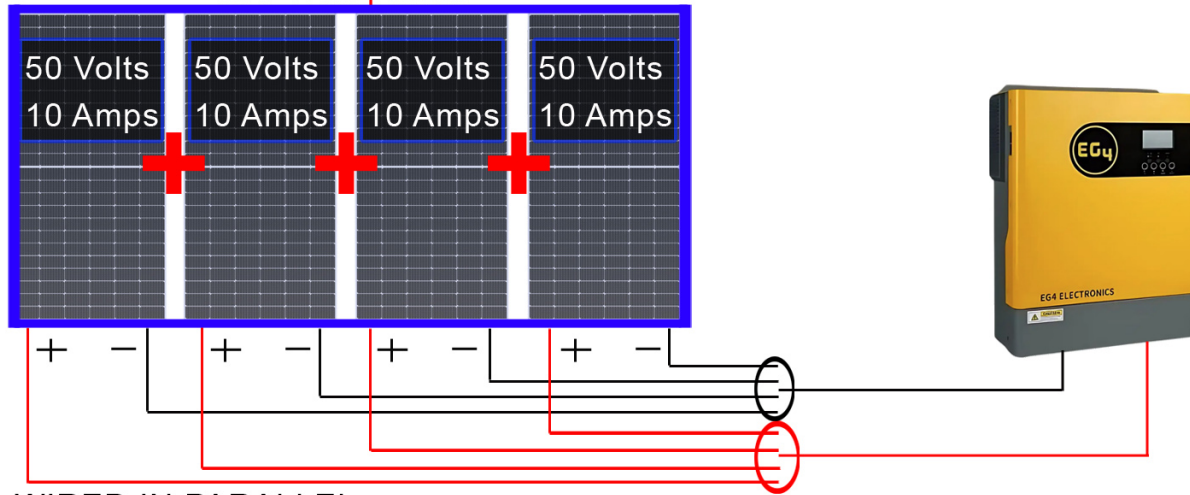
WIRED IN PARALLEL

500 Watt panels



WIRED IN PARALLEL

500 Watt panels



WIRED IN PARALLEL

