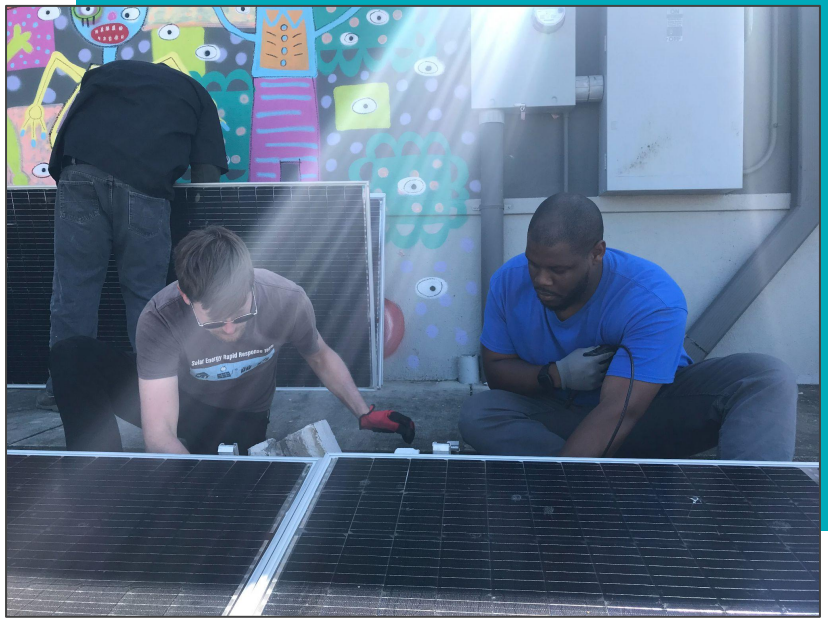
Electricity Basics

FP 3.1



footprintproject.org

Understanding Voltage

Voltage = Pressure in an Electrical System

The water in the tank on the right represents voltage in the system. When the tank is full, it creates more pressure (higher voltage) in the system. When the tank is almost empty, there is a lot less pressure to move the water.

In an electrical circuit, more voltage means that there is more pressure available to move electrons.

The electrical definition of voltage is: the potential difference in charge between two points in an electrical field.

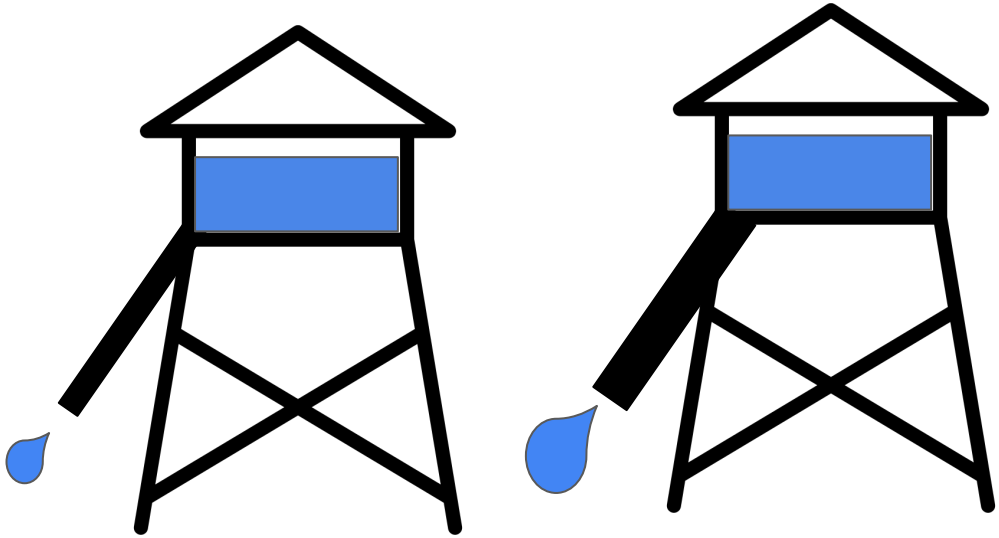
Understanding Current

Current = Flow of Electrons in an Electrical System

The flow of the water out of the tanks on the right represents the current in the system. When the tank is full and there is pressure, the flow will be greater than if there was little pressure there.

If the tanks had the same amount of water in them, but different diameters of pipes coming out, the one with the larger diameter pipe would have higher flow (current).

In an electrical circuit, current is the volume of electrons moving past a point in the circuit at a particular moment.

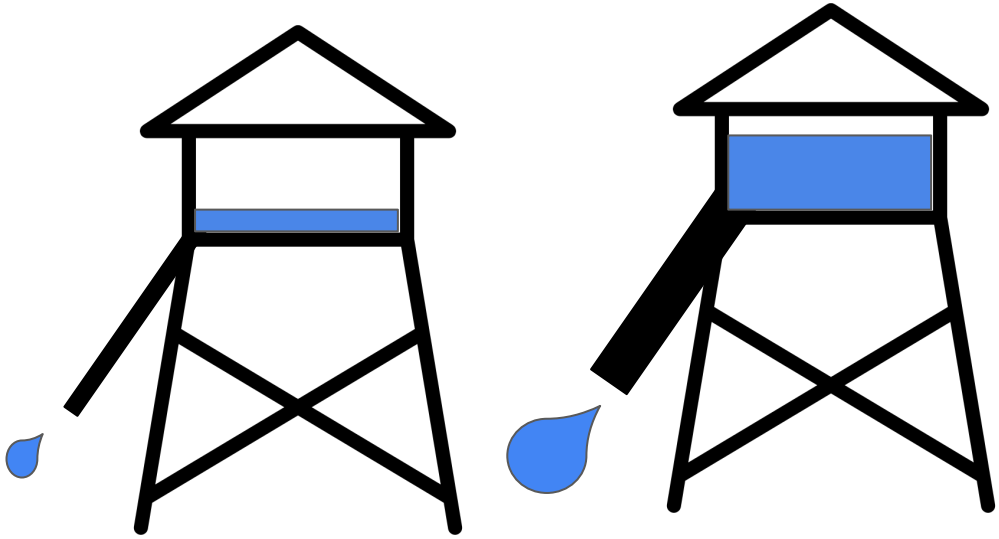


Understanding Power

Power = Voltage X Current

Power is what you get when you multiply the voltage (volts) times the current (amps). It describes the amount of work that can be done. The unit for power is watts.

In the water tank metaphor if you have a tank with a large pipe and a lot of water, you will have a lot of water flow and pressure, so you will have more power. If the tank is nearly empty and you have a very small pipe, it's only a little bit of water flowing slowly, which means it's a small amount of power. Without either voltage or current, you won't have power.



Calculating Power

Example: Lightbulb

We learned this equation in the last slide:
Voltage (volts) x Current (amps) = Power (watts)

Volts * Amps = Watts

Here is an example using a lightbulb:

1 Incandescent Bulb requires 0.5 Amps of Current and runs in a typical home with 120 Volts.

Therefore 120 * 0.5 = 60 Watts of Power

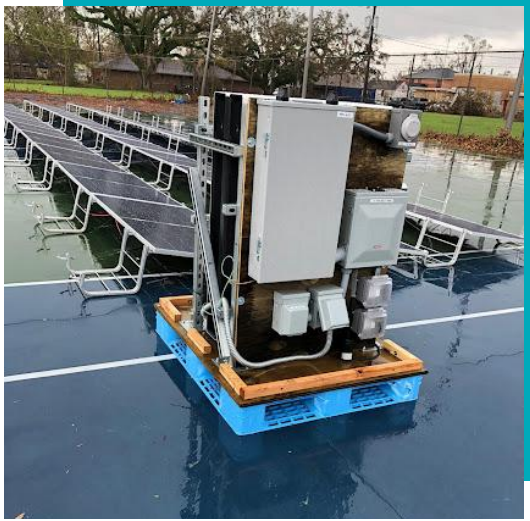
Understanding Energy

Energy = Amount of Power Used / Available Over Time

While power is more of an instantaneous value to describe the amount of work that can be done in an electrical circuit, energy captures the power that is used or available over time.

The unit for energy aligns with this concept because instead of using watts (which is for power), you use watt-hours.

To get energy, you simply multiply the power by the amount of time the load is used.



Calculating Energy

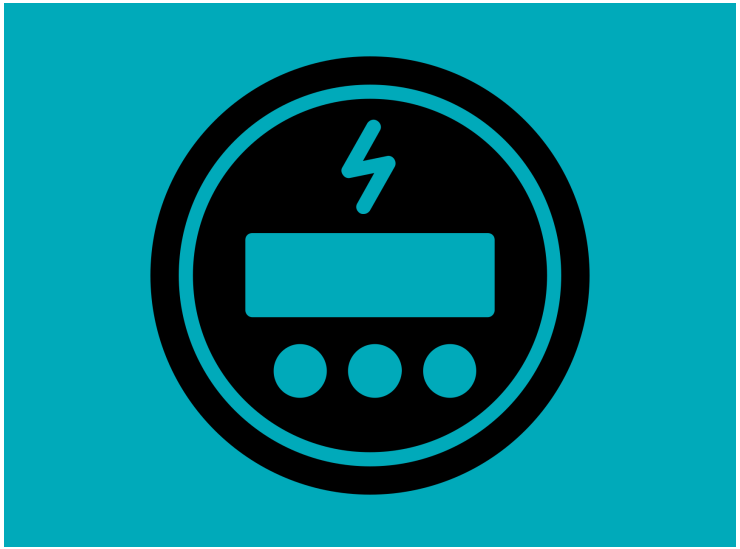
Example: Lightbulb

Given the power calculation we did previously for the 60 watt incandescent lightbulb, we can now apply the formula for energy to determine the watt-hours.

As a reminder, to get power in watts:
Volts * Amps = Watts

1 Incandescent Bulb has 0.5 Amps of Current and runs in a typical home with 120 Volts.
120 Volts * 0.5 Amps = 60 Watts of Power.

To determine energy, let's say you are using that lightbulb for 4 hours one evening. So you now take 60 watts and multiply it by 4 hours = 240 Watt-Hours.



Kilowatt-Hours

Example: Utility Bills

Utility bills are often calculated using kWh or kilowatt-hours. This is just another unit for energy.

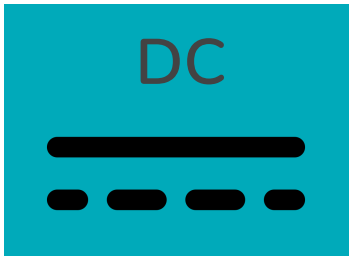
The way that you come up with kilowatt-hours is by taking watt-hours and dividing by 1000.

So, if you utilized 700,000 watt-hours in a month, that would mean 700,000/1000 = 700 kWh. The utility would then charge you for that amount of use based on their rate per kWh.

Summary of Terms/Units

Term	Definition	Unit
Voltage	Voltage is the potential difference in charge between two points in an electrical field.	Volts
Current	Current is the volume of electrons moving past a point in the circuit at a particular moment (the measurement of the flow of electrons).	Amps
Power	Power is the amount of work that can be done in a circuit with the volts and amps available. Power is energy per unit of time.	Watts
Energy	Energy is the ability to do work and is the result of the flow of electric charge. The amount of power that is used or is available over time.	Watt-Hours Kilowatt-Hours

Understanding AC & DC



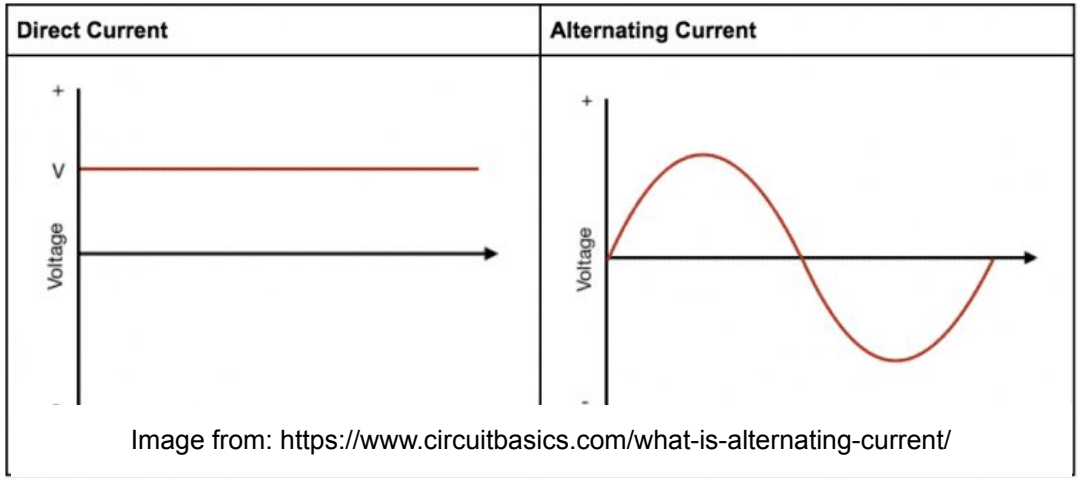
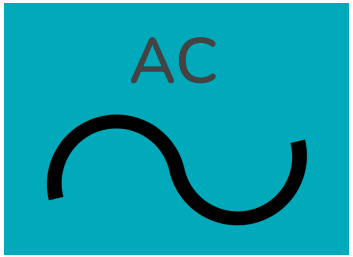


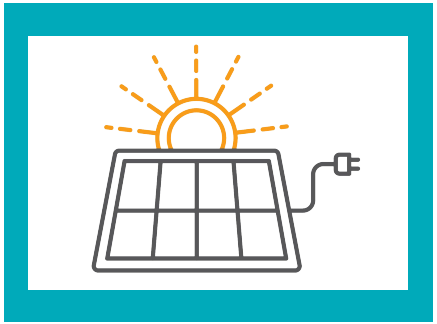
Image from: https://www.circuitbasics.com/what-is-alternating-current/

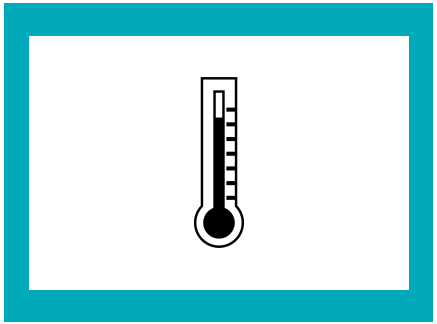


PV Modules generate direct current (DC), which is then changed into alternating current (AC) inside the inverter, which is the type that is used for most of our loads.

Direct current is a flow of electrons going only in one direction, whereas alternating current is reversing direction frequently (60 times per second here in the U.S. where we operate with 60 Hertz).

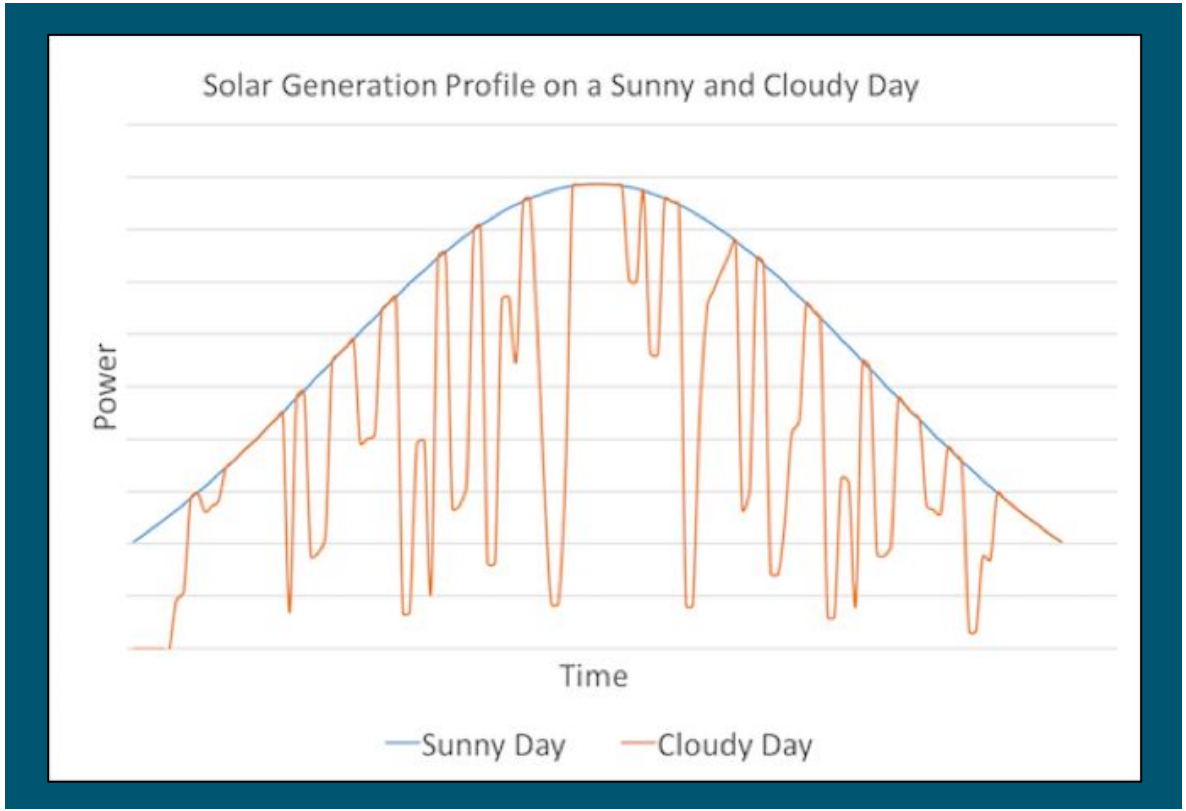
Solar Modules: Variable Power





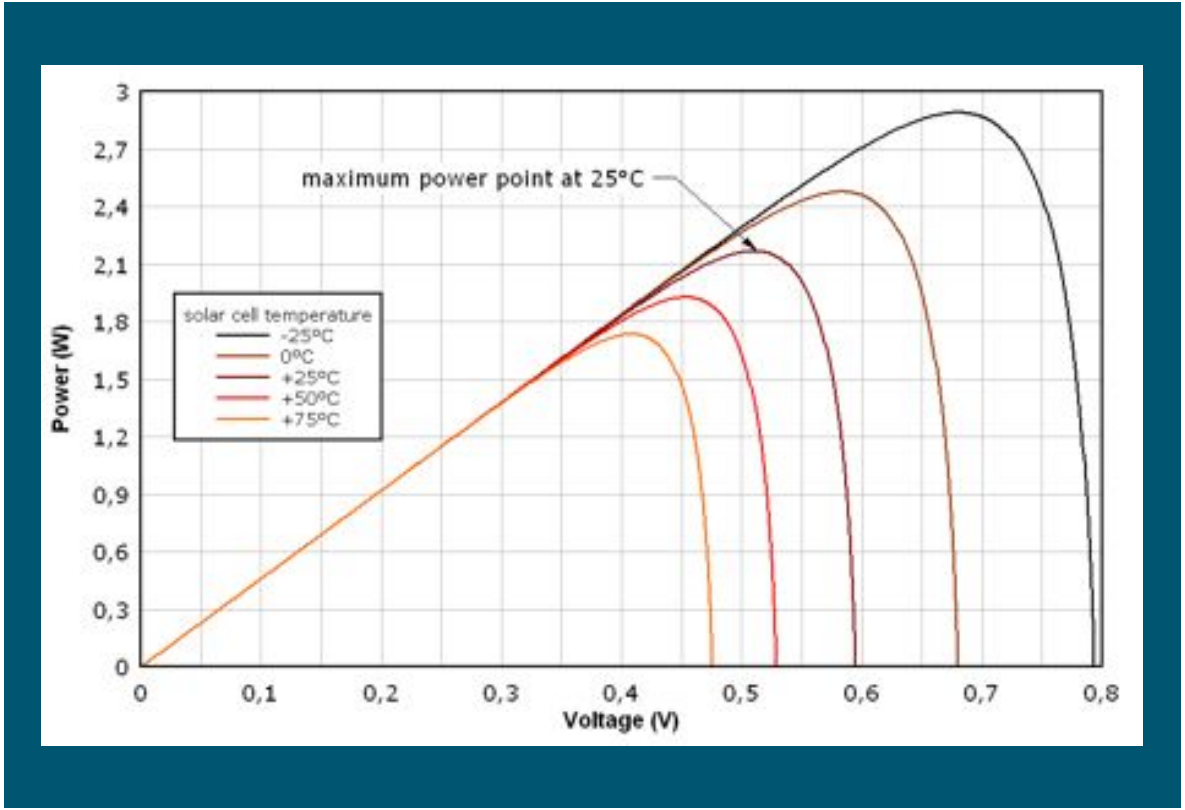
The power output from PV modules is impacted by a variety of factors. The two that can have the biggest impact are the amount of sun hitting the solar cells, and the temperature of the cells. Other factors, such as dust or other soiling of the modules, can also have a great impact on power output.

Solar Modules: Sunny Versus Cloudy Days



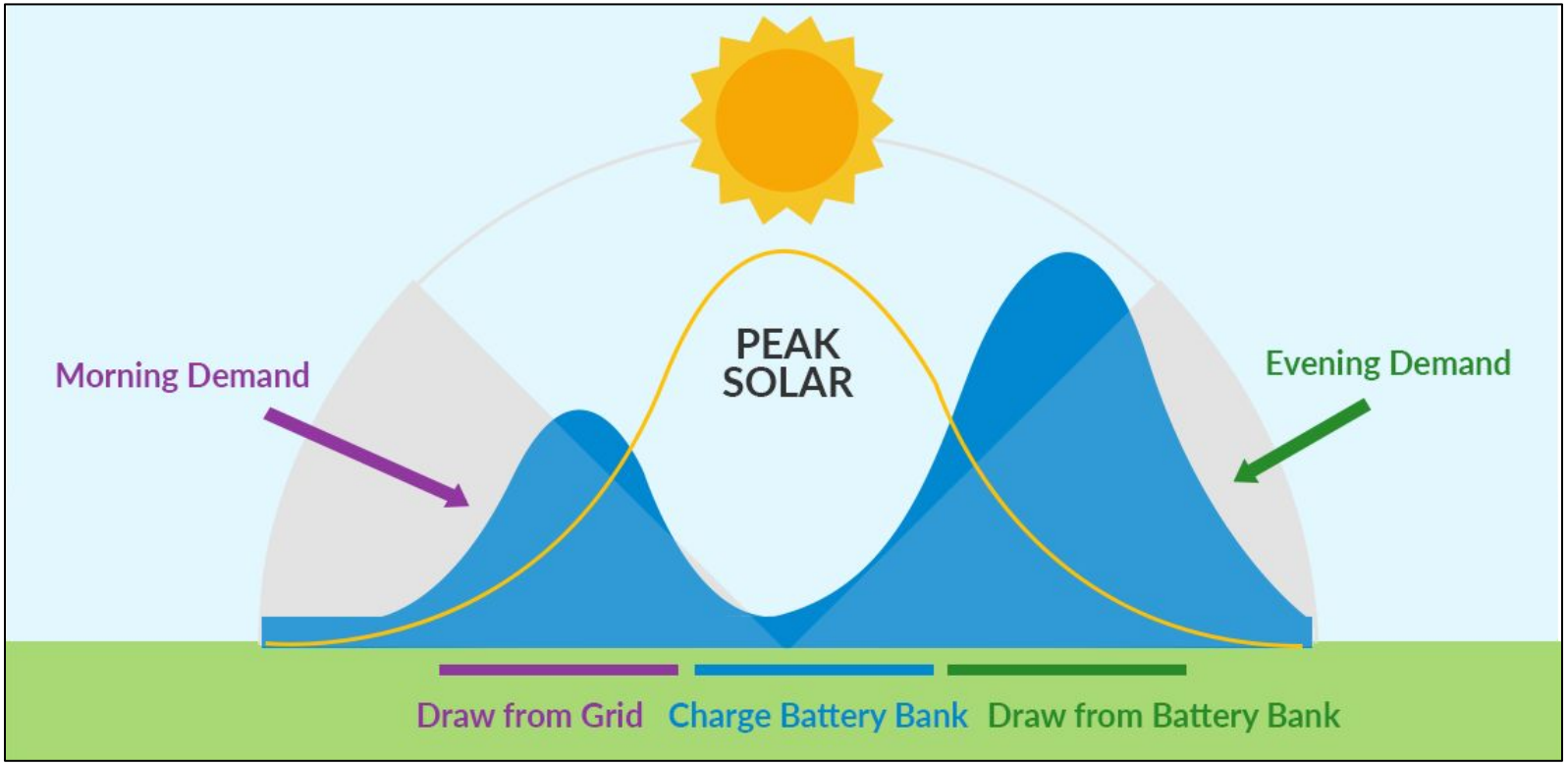
Graph from: https://www.renewableenergyworld.com/solar/finding-solar-energy-s-sweet-spot/#gref

Solar Modules: Temperature Effects



Graph from: https://www.pvresources.com/en/solarcells/solarcells.php

Solar Modules: Batteries Offering Storage



Graphic from: https://www.letsgosolar.com/faq/what-is-a-solar-battery/

Summary

Electricity Basics

- **Voltage** is the pressure in the system. The unit of measurement is volts. The definition is the potential difference in charge between two points in an electrical field.
- **Current** is the flow in the system. The unit of measurement is amps. The definition is the volume of electrons moving past a point in the circuit at a particular moment.
- **Power** is what you get when you multiply the voltage times the current. The unit of measurement for power is watts. The definition is the amount of work that can be done with the available voltage and current.
- **Energy** is the amount of power used/available over a period of time. The unit of measurement is watt-hours.

Summary

Electricity Basics, Continued

- **Direct Current (DC)** goes from one point to another in one direction (from positive to negative), whereas **Alternating Current (AC)** changes direction constantly and very quickly. PV modules and batteries produce DC, and are changed into AC by way of the inverter. Most of our loads rely on AC.
- PV Modules have variable power output. Unlike many sources of power, PV power by itself isn't consistent from minute to minute/hour to hour, and varies based on things like solar irradiance, temperature (and also doesn't work at night of course). Therefore, combining PV modules with inverters, charge controllers, and batteries, or the grid, helps make it work with the loads and systems we are used to by regulating, converting, managing, and sometimes storing the power to use when it's needed.

Thank You!