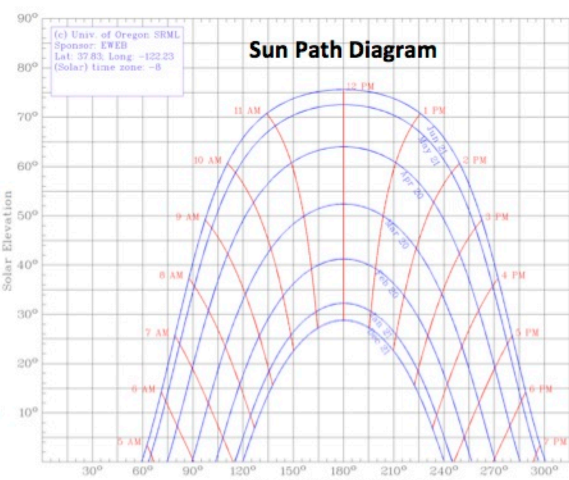
PVSTUDENT.COM
by SEAN WHITE

NABCEP Entry Level
Mobile Study Guide

Sean White
sean@pvstudent.com

Energy=Power x Time
V=Volts=E
I=Amps=Current=Amperes
R=Resistance=Ohms=Ω
W=Watts=Power=P
Energy=kWh or Wh
Amp hrs x V=Wh
milli=thousandth
kilo=thousand
mega=million
giga=billion
V=IR
W=VI
Isc=Short Circuit Current
Isc is when you have all current and no voltage (wires crossed/shorted)
Voc=Voltage Open Circuit
Voc is when you have all voltage and no current (wires not touching/open circuit)
Imp=Current Maximum Power
Vmp=Voltage Maximum Power
Imp x Vmp=STC watts
Standard Test Conditions is what you pay for when you buy PV. STC does not take into consideration the heat from the irradiance. Irradiance is watts/m^2 Irradiance at STC is 1000 watts/m^2. A 175 Watt module would make 175 W of power under Standard Test Conditions. If this module was 1.2 m^2, then it would be (175/1.2)x100%= 14.6% efficient. (1000m^2 would theoretically be 100% efficient).
STC is: 1000 W/Sq. meter, 25C Cell Temp. (not ambient), 1.5 Atmosphere Spectrum of light.
MPPT is maximum power point tracking. Since heat decreases voltage and irradiance increases current, the voltage and current characteristics of the PV are constantly changing. MPPT adapts by changing the resistance, hence the voltage and current of the inverter or charge controller on a battery system. There is a sweet spot where the most power can be made, which at STC would be Vmp & Imp.
When you wire PV in series (positive to negative like batteries in a flashlight) the voltage increases. Once you reach your desired voltage, to get more power you have to wire the strings in parallel. Parallel wiring is combining all of the negatives together and all the positives together. Parallel wiring increases current by the factor of the number of series strings that are wired in parallel.
If you had 40 Vmp 5 Imp modules & wired 2 strings of 4 to an inverter, you would have 160 Vmp & 10 Imp.
120% rule is the Busbar x 1.2 must be greater than or equal to the main breaker + the backfeeed (solar) breaker.
So, if you had a 100A busbar and a 100A main breaker, then you could have a maximum size backfeed breaker of 20A.
Maximum current on the PV source circuit or output circuit is Isc x 1.25. This is because sometimes we get 1250 watts per square of irradiance. For dc PV conductor sizing: Isc x 1.56 and compare Isc x 1.25 & conditions of use, then use the biggest conductor of the 2. AC you multiply by 1.25 once & conditions of use.
Wire colors:
White=Grounded current carrying conductor. White is usually negative.
Green or Bare wire=Grounding & non-current carrying for grounding equipment for safety.
Black or other color=hot-ungrounded current carrying conductor.
Wire sizes:
Bigger wires have smaller numbers until you get to zero and then the more zeros, the bigger the wire. Small wire is AWG 16 and large fat wire is 000
600V is maximum DC voltage to code, but inverter/charge controller manufacturer can have less.
Temperature correction factors for cold temperatures. There are 2 ways of correction. First the PV mfg will give you a temp coefficient of Voc such as -.33%/deg C. Multiply by delta deg C from 25C for increase in Voc for cold temp. If no coef. from mfg, use table 690.7 and multiply Voc by temp factor.
If you had a record low temperature of -40 C, then you correction factor would be 1.25, therefore if you had a 40 Voc module, at zero C, you would have 40 V x 1.25 = 50 Voc.
If you wanted to see how many you could put in series and not go over 600V then:
600V/50V = 12 modules in series max.
Inverter output max current x 1.25 = circuit breaker size (round up to next standard size).
16A max output x 1.25=20A breaker
240Vac x 16A output = 3840 Watts
System Sizing:
To make 10,000kWh/yr determine how much 1kW will make in a year and divide 10,000 by that number.
1kWx5 sun hrs x .77 dc to ac x 365 = 1405 kWh/kW/yr; 10,000/1405=7kW
Derating tips: If you want you number to get bigger divide by numbers smaller than 1 and multiply by numbers greater than 1. Do the opposite if you want numbers to get smaller.

Battery sizing:
Days of Autonomy is how many days of energy you want stored in a full battery bank that you can use before the charge controller stops discharging batteries.
Depth of discharge is how much you want to discharge your batteries before you stop using them, which is typically around 50%. If you used 10 kWh/day & you wanted 3 days of autonomy with a 50% depth of discharge:
10kWh x 3days=30kWh
30kWh/.5 depth of discharge = 60kWh in battery bank. Then you will derate for other things, such as converting electrical to chemical and back.
Big tip=get sleep



Custom PV training all levels anywhere in the world, PV consulting, solar company systems setup, curriculum development, design, industry connections, contact Sean White at sean@pvstudent.com