CALCULATING ARRAY POWER FOR BATTERY CHARGING

Charging the battery using solar generated power is one of the most important aspects of a solar powered car. The solar radiation striking the array is converted to a relatively high voltage depending on the modules configuration. In order to properly charge the batteries that power, often over 200 VDC, must be reduced to the same Voltage as the Battery bank. This is the job of the Charge Controller [CC] which has presumably been programmed to output the correct battery Voltage as well as the upper limit of output Amperage.

At the same time, the CC is charging the batteries at a variable rate based on the State Of Charge [SOC] of the entire battery bank. A heavily discharged battery will absorb a heavy charge rate while a nearly full battery may only accept a trickle charge. The charge will always be at the programmed Voltage and only the Amperage will drop as the SOC approaches 100%.

The relationship of Volts, Amps and power is simple.

Power = Volts x Amps

P = Power (Watts)
V = voltage (Volts)
A = current (Amps)

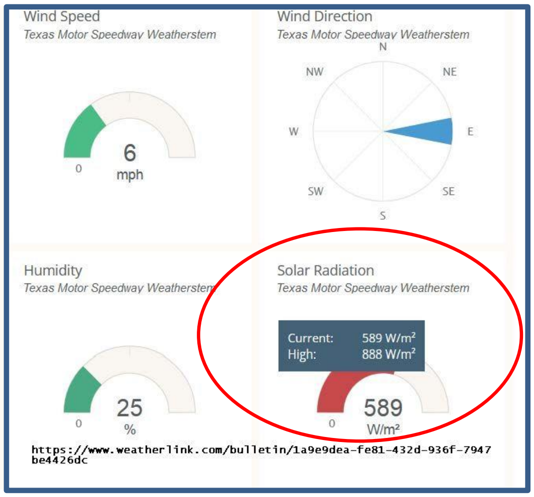
Amps and Volts can be measured, Power can only be calculated.

The intensity of the sun, the IRRADIENCE, determines the maximum amount of Power the solar array sends to the CC and so determines the allowable charge to the battery. A cloud in front of the sun will reduce the charge rate regardless of the battery SOC. Power will drop but Voltage will remain constant. Only Amperage will change. That's why it's critical to know the level of irradiance available. Knowing whether the battery is being discharged faster than it's being charged is the key.

To calculate the solar irradiance striking the horizontal plane of the cars array it will be necessary to obtain a Solar Irradiance Meter. Or you can check the Texas Motor Speedway Weather Station. That reading can be found at:

https://www.weatherlink.com/bulletin/1a9e9dea-fe81-432d-936f-7947be4426dc. [A]

An example of the Watts Per Meter^2 reading from the TMS Weather Station:



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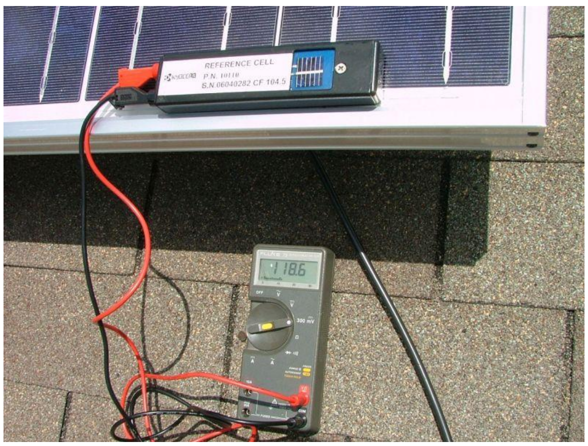
EXAMPLE 1 REFERENCE CELL



EXAMPLE 2 REFERENCE CELL

Another critical factor in calculating the CC Power charging the battery is knowing the temperature of the solar array. Using an infra-red [IR] thermometer or other device to accurately measure the temperature of the rear surface of the cell.

The modules rated nominal Power at Standard Test Conditions [STC] will be listed on the rear label as well as the MODULE manufacturer spec sheet and is calculated assuming a module temperature of 25°C & 1000 W/M² irradience. And based on the number and configuration of series and parallel modules, your power may vary.

But with any temperature increase above 25°C you must take into account power loss percentage for every 1°C above 25°C. Inversely any temperature lower than 25°C will increase the output by the same % for every 1°C.

Using a 260W 60 cell, polycrystalline module as an example: note the temperature coefficient ratings shown for Power, Volts and Amps. [B]

The temperature coefficient of the Open Circuit Voltage [Voc] is -0.32%/°C, a significant amount. Reduced Voltage will reduce the Power charging the battery. So with a drop in Power with the Voltage remaining constant, the effect is reduced Amperage. Any way you measure it, heat reduces power. The formula for calculating that loss using the temperature coefficient is simple.

1. **Actual Cell Temperature - 25°C = Delta T [ΔT]**
2. **ΔT x Temp Coefficient = Percent Loss**

Voltage to CC Loss Example:
65°C – 25°C = 40°C
40°C x -0.32% = -12.8%

So simply assuming that your power into the CC is constant based on the array rated output without compensating for high module temperature and real-time irradience, it will be easy to deplete the battery bank sooner than expected. And this is only the Power feeding the Charge Controller it doesn't necessarily parallel the Power charging the battery bank.

The battery manufacturer data will include the effect of battery temperature as it affects the ability to absorb power. Finally your charge controller should include a Battery Temperature Sensor that will allow the CC to correct the charge rate to the battery based on battery bank temperature. Be sure to install that sensor exactly as instructed.

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