

# How can I find the maximum I am likely to get out of my panels?

Most people want to know this either to check their installation or to plan the size and number of panels to install. These days there are a number of web-based calculators available to help, one of these is provided by the European Commission Joint Research Centre (JRC) here: <http://re.jrc.ec.europa.eu/pvgis/apps4/pvest.php#>.

I was interested in finding out how much my nominal 200 Watt installation of crystalline panels should deliver in my chosen cruising area of Corfu in the summer months and then see if I could work back to estimate the efficiency of the installation taking in to account the panels, regulator, wiring and general losses, in other words 'from sunshine to battery'. The first thing I did on the webpage was choose the location, so using the map, zoom controls and mouse I navigated into the middle of the Corfu channel. I chose a sea area because the system has data on horizons and if I had selected, say, Gouvia Marina it would have shut off the virtual sun as it sank below the virtual mountains.

Next I selected the Daily Radiation tab and filled in some data. The database is the best around so I left it at SAF PVGIS, this is where all the accumulated data for recent years is stored. I wanted data for August and I wanted average and clear sky irradiance (or insolation) so I clicked those boxes. Average takes account of any cloudy days using the accumulated data. Clear sky is blue sky every day from dawn to dusk. I also wanted to compare horizontally mounted and fixed panels with those on a tilting mount so I entered zero degrees

for inclination to produce horizontal panel results. On a boat azimuth is difficult to control so I let orientation stay at zero; due south. I selected graphical output, and asked for a pdf file so that I could keep the results, then hit Calculate and this is what I got:

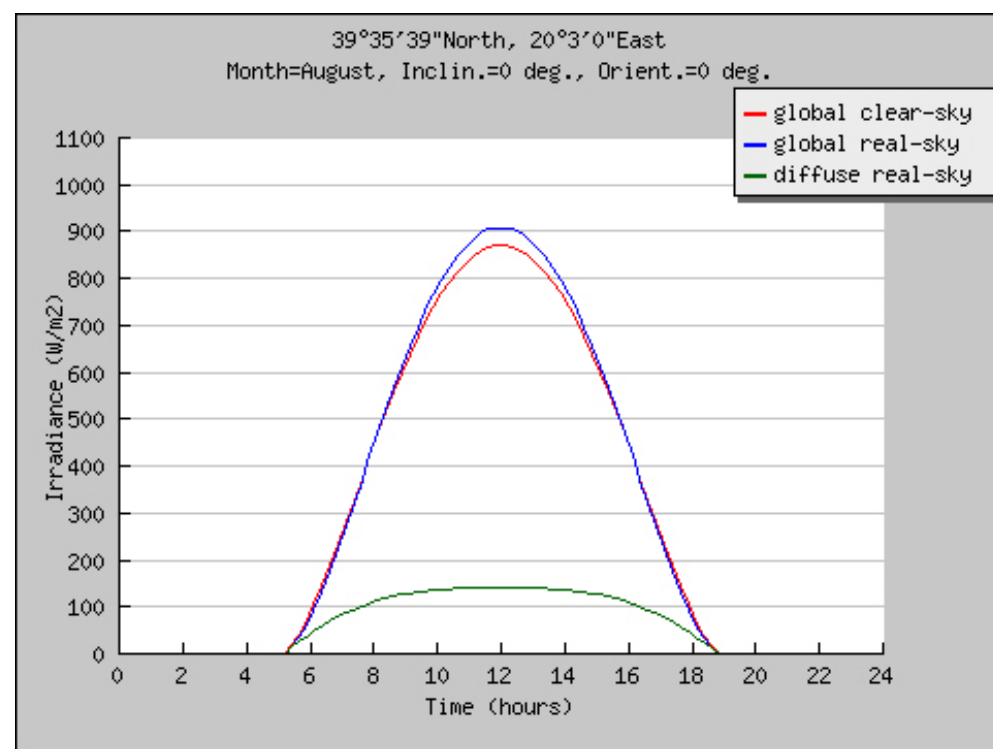
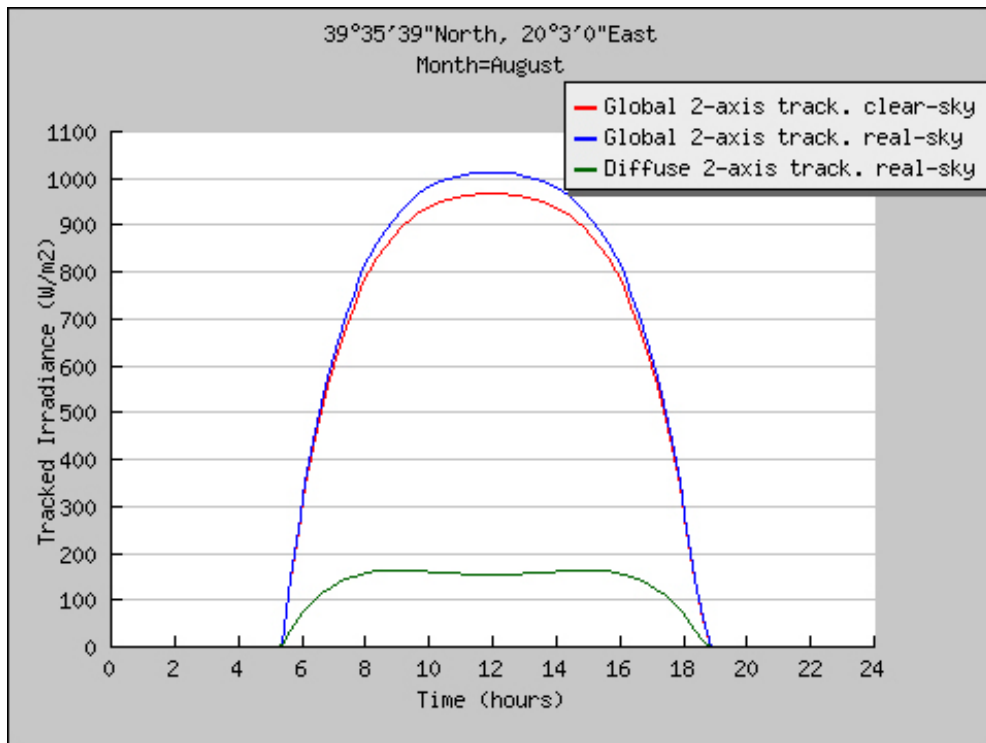


Figure 1 - Irradiation (insolation) on a horizontal panel in Corfu in August [European Commission JRC]



**Figure 2 - Irradiation (insolation) on a two axis tracking panel in Corfu in August [European Commission JRC]**

The first obvious difference between horizontal and tracking installations is the peak power output is less if you can't tilt the panel. This is because the sun is never exactly overhead in Corfu so they can't be equal. Secondly the shapes of the curves are different with the tracking installation being much fatter. This is the result of being able to capture energy when the sun is low, try comparing the values at the edges of the curves, say, 7 a.m.

## Compare theory with reality

I wanted to extract something measurable from this result, not as part of the regulator tests (see later), but just to get an idea of how efficient my installation is. One obvious thing was electrical power. If I could measure voltage and current delivered to the battery at the same point and time then multiply the two I would get power. So this would be something I could use my multimeter to check. I was aware from the start that there would be a number of assumptions and guesses in this calculation, some made by JRC (they explain these in their Help sections) and some by me. Nevertheless I should be able to get into the right ballpark. If I calculated the theoretical power then took my highest ever measured current and voltage readings for August dividing one by the other would give me the efficiency value I wanted.

I have a tilting mount so I could use the tracking results. My panels are nominal 200 Watts which means if they are insolated at 1000 W/m<sup>2</sup> they would output 200W of electrical power at their maximum power point. The peak value of the tracking curve (Figure 2) was 1010 W/m<sup>2</sup> so the peak output was:

$$200 \text{ W} * 1010 \text{ W/m}^2 / 1000 \text{ W/m}^2 = 202 \text{ Watt}$$

The similar result for a horizontal panel was 181 Watt.

Unfortunately for my master plan catching the greatest current going into the batteries is like trying to photograph a dolphin; by the time you've seen it, it's gone. I did, however, have a record of the best I'd seen in the past which was 13.1 Amps at 13.4 Volts giving me 170 Watts (at the controller input) and an overall system performance of

$$170 / 200 * 100\% = 85\%$$

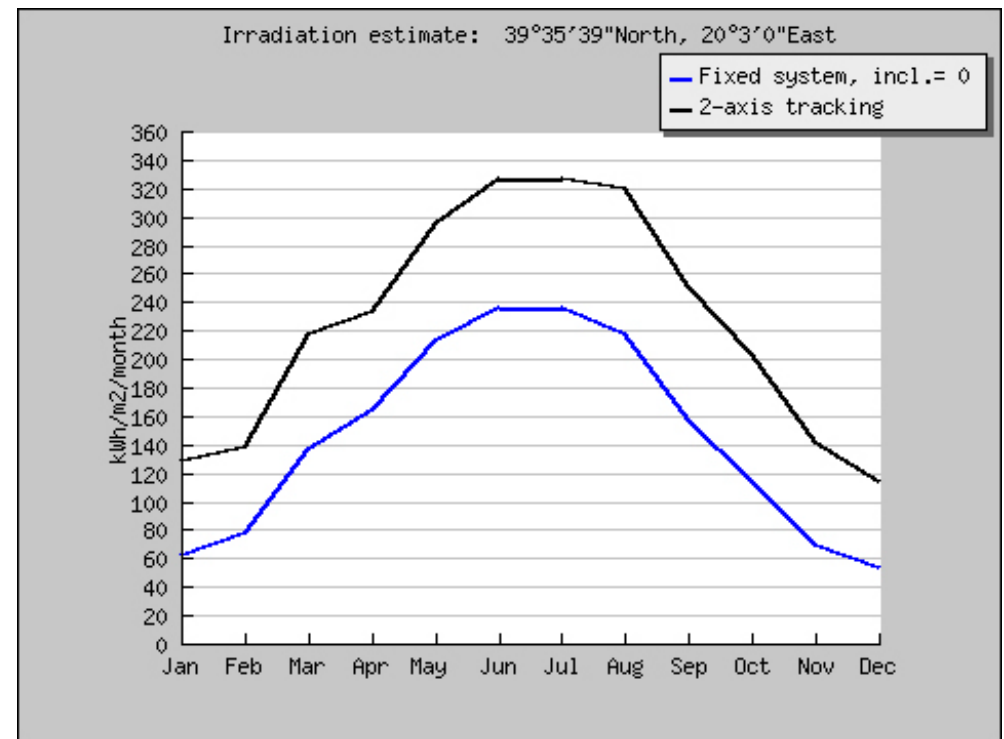
which represents a system loss of 15%. In other words 85% of the theoretical electrical output from the panel reaches my regulator and since the regulator would be fully conducting at this current virtually all of that power would reach the battery. This is actually quite a high value, that 15% loss includes reductions in panel performance due to age and temperature effects as well as the cabling losses and is close to the figure JRC take as a default in their calculations.

Looking back over my records for the last three years though a more typical measured peak efficiency is 70% - 140 Watt from my 200 Watt panels. Since we ought to be pessimistic in our sizing we should assume only 60% or 70% of the nominal panel power reaches the battery at noon.

## Energy

The total area under the curve represents the energy collected in a typical day and I wanted to quantify the difference between a fixed horizontal panel and a tilting one. This was fairly simple. I went to the PV estimation tab and filled in the blanks leaving the JRC estimate of system losses at 14% and entering my 0.2 kW solar panels. I entered zero for the elevation to generate a horizontal panel output and also selected two-axis tracking since this was the comparison I wanted to make.

The result is pretty graphic (Figure 3): you gain a minimum of 33% more energy if you can follow the sun; much more in winter.



**Figure 3 - Irradiation estimates by month for a horizontal panel and a two-axis tracking panel [European Commission JRC]**

# Will my installation keep the batteries charged?

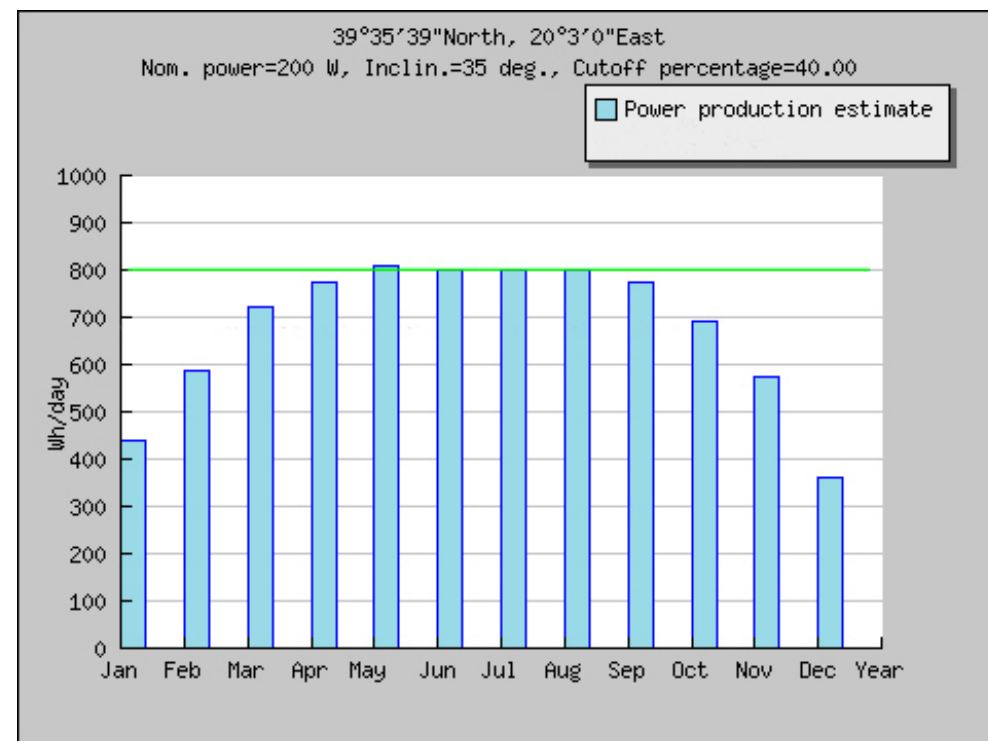
One last useful tab on the JRC website is the Stand Alone PV one. This assumes a system that is the type we have on board where a set of panels feeds into a battery bank. The input parameters are obvious with the exception of the Daily Consumption one. Here you have to do some assessment of your personal energy usage.

Mine is like this:

Voltage 12				
	Device	Current	Duty	Wh/day
	Fridge	4	0.5	576
	Computer	3	0.1	86.4
	Lights	2	0.1	57.6
	Fan	0.5	0.5	72
	Losses	0.1	0.1	2.88
			Total	794.88

**Table 1 - Energy use per day. Current in Amps, duty is a proportion of 24 hrs, the losses are a notional 10% and the total comes to a little shy of 800 Wh/day**

I determined the current of each major device (usually given on a placard somewhere) then estimated the maximum duty cycle, which is the amount of time the device is actually running. Multiplying current by the battery voltage gives Watts, then multiplying by 24 hours and the duty gives the daily energy use for each device in Watt-hrs / day. I summed all the values and fed the result into the box on the website. For me this came to 800 Wh/day so would my 200W panels keep up?



**Figure 4 - Power produced from my 200W tracking array compared to my 800 Wh / day requirement [European Commission JRC]**

The blue bars show the energy produced and these reach the target value of 800 Wh/day throughout the cruising months of the summer. But the panels will need a bit of help from September onwards and before May. The graph cuts off when the target is reached so the panels may well be capable of generating more than the requirement.