Appropriate PV module over ratio can increase in power generation

Preface – What is PV module/inverter DC-AC over ratio?

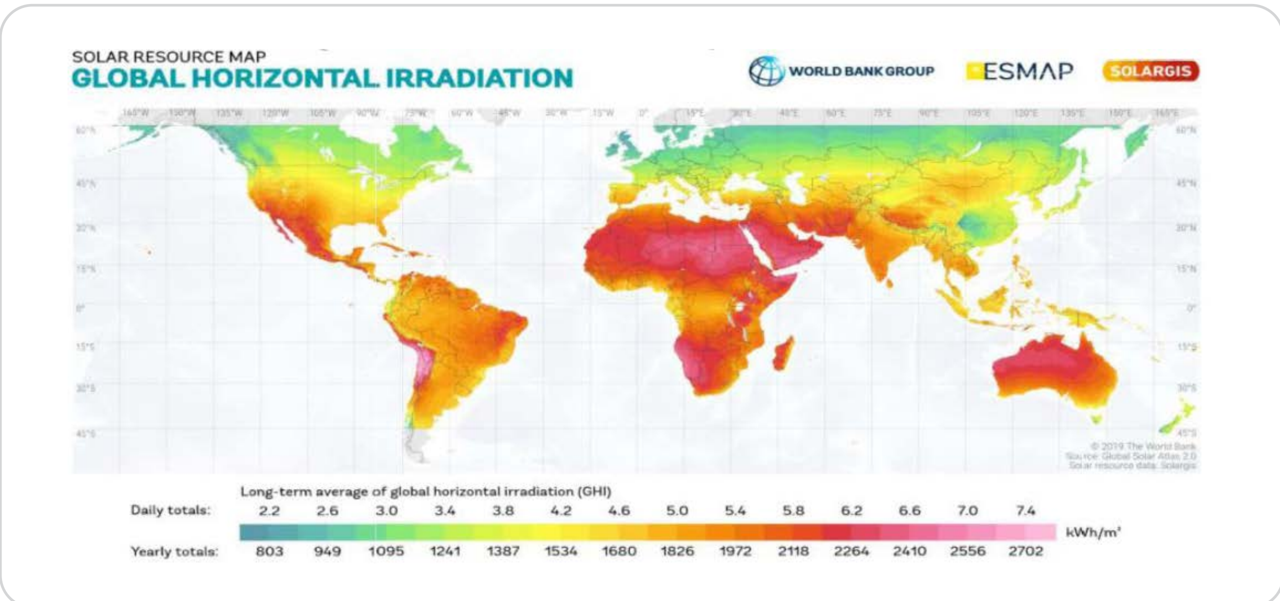
In a typical design of a photovoltaic system, the capacity of the PV modules (total DC power) exceeds the capacity of the inverter (AC power): this is called the DC-AC over ratio. This approach of over ratio is increasingly widely used. Reasonable over ratio design can indeed optimize the utilization of inverters, reduce the cost of equipment on the AC side, and maximize overall benefits.

Why do we need the DC-AC over ratio?

The STC power of the PV module is the maximum output power under test lab conditions (solar radiation intensity at 1000W/M2, temperature at 25°C, spectrum AM1.5). However, the actual environment is complex and changeable, and the output power of modules is always affected. Due to many factors (see details further below), some losses will inevitably occur, so that the output power of the module is always less than its rated STC power. The factors likely to affect the output power of modules are as follows:

1. Solar Resource

Sunlight is the basis of photovoltaic power generation. The sunlight conditions vary greatly in different regions. The rated STC power output of the module will only be realized under specific conditions of an irradiance intensity of 1000W/M2, temperature of 25°C, and a spectrum of AM1.5.

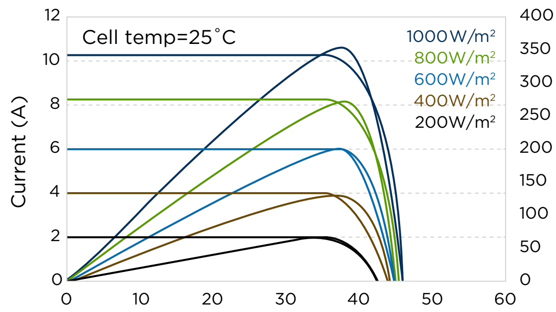


APsystems China
Rm. B305 No.188, Tomson Center, Zhangyang Road, Pudong, Shanghai , China
Phone: +86 21 33928205 - APsystems.com

Once the irradiance is below 1000W M2, the output power of the PV module will be less than its rated STC power *(Figure 1)*. Even in areas with abundant solar energy resources, it is not always under sufficient light conditions throughout the day, and the irradiance varies greatly from morning to night *(Figure 2)*.
Moreover, when the temperature of the module increases, the voltage drop of module decreases, while the current change is minimal; therefore, the power of the module will decrease when the temperature rises *(Figure 3 - Figure 4)*.

Figure 1: Under different irradiance I-V (Power) curve

Current and voltage curve / Power and voltage curve under different irradiance 350W



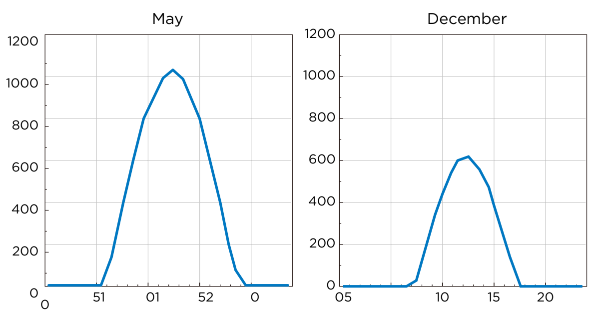


Figure 2: hourly Irradiation

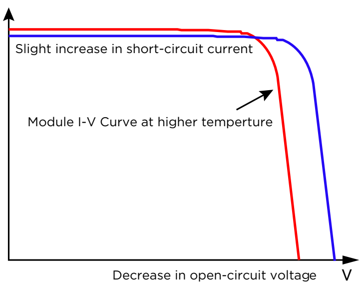


Figure 3: I-V curve

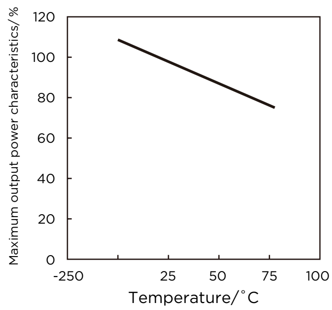


Figure4: temperature-power

2. PV module attenuation

Based on NREL-SAM's outdoor attenuation analysis of more than 2000 PV modules worldwide, the attenuation rate of the module after the second year will change linearly. The 25 year attenuation rate is between 8% and 14% *(Figure 5)*. In fact, the power generation capacity of the modules keeps declining every year as it degrade, and the rated power output cannot be maintained.

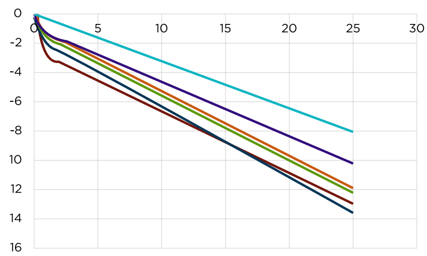


Figure5: PV module attenuation

3. The azimuth of the PV module

The irradiance received by different azimuth angles can vary your production. When the azimuth is 0° due south (facing the equator - the best orientation), the irradiance received by the surface of the photovoltaic module is optimal. As the azimuth becomes larger (in degrees).The actual output power of modules will also drop significantly *(Figure 6)*.

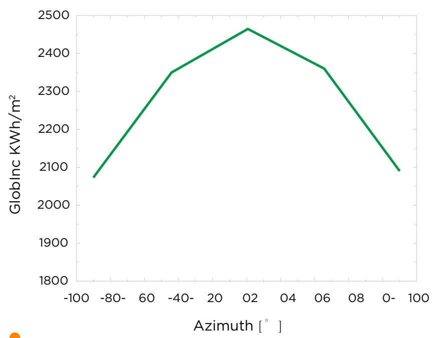


Figure6: azimuth - PV module power

4. Other factors

Soil, salt residue (e.g. oceans), foreign objects, shadows on the surface of photovoltaic modules cause an internal mismatch of modules. Along with degradation of the PV modules, there can be wear and tear in DC cables,

connectors, and a reduction of inverter power consumption, which will reduce the output power of modules.
From the analysis of the above influencing factors, under the traditional 1:1 capacity ratio design, the maximum power generation of the photovoltaic system is lower than its installed capacity, and a certain ratio of component over-configuration can make up for the capacity loss of the inverter and improve the utilization rate of the converter. *Figure 7* illustrates the capacity factor of the inverter, *[Note 1]* and how to increase with higher DC: AC ratio.

Note 1: *The inverter utilization rate is called the capacity factor, which is defined as the ratio between actual and maximum power generation (when the inverter has been running at full output, its capacity factor is 1.0).*

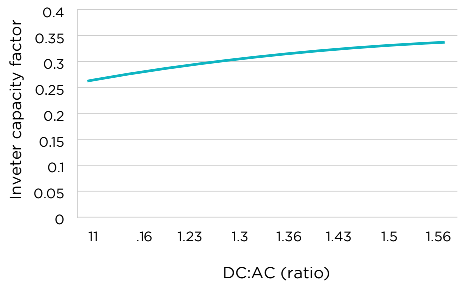


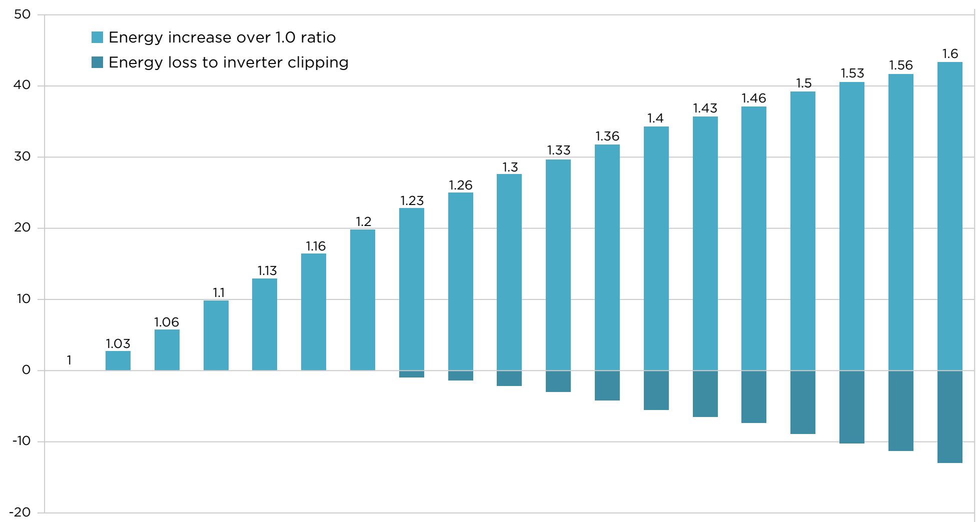
Figure 7 DC: AC Inverter capacity factor

PV module over ratio's power generation simulation

In order to more intuitively prove that the over ratio of modules can bring higher power generation, we choose Mexico Hermosillo (29.09°, -110.98°) region, use NREL-SAM software to simulate the clipping and total power generation in the first year under various DC: AC ratios.

Model setting: Module selection Efficiency Module Model (Temperature Coefficient: -0.4%/°C Pmp) Meteorological data use TMY3; system loss L_{total} loss is 1.5% (assumed); this model uses APsystems' QS1; this model is suitable for any regions.
Figure 8 shows the simulation results of different DC: AC ratios in the Hermosillo area of Mexico. It can be seen from the figure that as the DC: AC ratio increases, the system power generation increases continuously, and the increased power generation is always greater than the power loss due to clipping. This figure is a simulation under the conditions of the optimal inclination of the module and the true south direction and does not consider the attenuation of the module. In fact, the clipping loss rate will be lower.

Figure 8: Hermosillo 20° tilt 180° azimuth



Summary

The main purpose of this article is to demonstrate the value of the module over ratio. By analyzing the relationship between the following factors, it is clear that the actual output power of modules is less than its rated power. In order to improve the utilization rate of the inverter, using over-ratio is considered as a best practice. By using the NREL-SAM example simulation, the data proves that increasing the DC to AC ratio will bring higher power generation. Although there might be a clipping loss, the increased power generation of the system is still higher than the loss caused by clipping.

The optimal DC to AC ratio requires comprehensive consideration of system power generation benefits, system construction costs, operation and maintenance costs, and asset conversion (Including module attenuation, etc.), etc., to find a balance between increased input costs and system power generation revenue. A reasonable DC to AC ratio can increase system revenue, reduce system cost per kilowatt-hour, and maximize overall revenue.

APsystems China
Rm. B305 No.188, Tomson Center, Zhangyang Road, Pudong, Shanghai , China
Phone: +86 21 33928205 - APsystems.com