Capacity rating for solar generating stations

What is a megawatt[1]?

The capacity of solar photovoltaic generation stations can be expressed in more than one way. Because there has historically been some inconsistency in the norms that have been used to specify a capacity rating, this paper assesses the different approaches, considers the alternatives and recommends nomenclature that should be preferred. Wiki-Solar will seek to apply this standard across its website and publications.

The two main alternatives that have been used in the past have been MW_P, the rated DC capacity of the solar array under solar Standard Test Conditions, and MW_{AC}, the output it is designed to deliver to the grid under these conditions. Often the suffixes have been excluded and the designation MW has been used for either measure.

Primary recommendations:

1. The megawatt capacity of a solar generating station, unless expressly stated otherwise, should be the AC output capacity.
2. Ideally this should be referred to as MW_{AC}. Where those following this norm express capacity as MW, it will be assumed to mean MW_{AC}.
3. Where the DC capacity is quoted it should always be expressed as MW_P.

The following paper considers how these recommendations have been derived.

The main alternatives

The two main approaches that have been adopted in the past are:

a) The peak capacity of the solar arrays

The subsystem responsible for converting the primary energy source, in the form of light, into electrical energy is the array of photovoltaic cells. The combined output capability of the solar modules is therefore the first determining factor for the capacity of the system.

Solar cells, modules and arrays are rated according to international standards[2] in terms of peak watts (W_P). This is the DC output produced by the device under standard test conditions (STC)[3] specified to be broadly equivalent to full direct sunshine.

The DC capacity of any solar power station in megawatts peak (MW_P) is the accumulated peak capacity of all the solar modules which it contains. Solar modules are typically individually tested at the end of the production line so that the peak capacity of a system can be determined very accurately. In practice this may vary slightly from the design capacity of the system depending on the grading of the modules actually supplied.

b) The capacity deliverable to the grid

The second alternative capacity rating is the AC output which it is capable of delivering to the grid. In broad terms this is the lowest of:

- the converted array capacity after inverter and transformer losses – roughly equal to the MW_P rating x the performance ratio;
- the combined rated output of the inverters – some system designers consider the optimum system configuration uses inverters whose maximum capacity is somewhat less than the peak DC capacity, such that the inverters would 'clip' at times of peak array output[4]; or
- the rated capacity of the grid connection or the output transformers.

Comparison of the alternatives

Because there are some losses between the solar array and the output to the grid, the AC capacity will be somewhat lower than the peak DC capacity. As a rule of thumb, the ratio between the two will approximate to the performance ratio[5] of the system.

While some sources helpfully quote both measures, the prevailing norm[6] has been for North American developers to express system capacity in MW_{AC} with Europeans preferring MW_P.

Recommended nomenclature

The use of a megawatt peak rating is unique to photovoltaics. Indeed most forms of power generation produce AC directly and therefore have no DC rating. The use of MW_{AC} is therefore the only form readily comparable with other electricity generation technologies.

We therefore recommend that this is AC output, ideally expressed as MW_{AC}, which is applied for utility scale PV systems, unless specifically annotated otherwise.

A second reason for preferring this form of capacity rating is that it is the basis of energy delivery figures, such as the annual megawatt hours output of the system.

It is recognised that there will be many occasions when the DC capacity will be quoted within the photovoltaics industry. For the sake of clarity it is recommended that in such cases the rating is always expressed as MW_P and not simply as MW. For example, the threshold for utility scale photovoltaic systems adopted by Wiki-Solar[7] is set at a MW_P figure. Self-evidently, systems which deliver purely DC output will always be rated in megawatts peak.

It is recommended that when the expression MW is used without either suffix P(eak) or AC, this should be deemed to apply to the AC capacity.

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1 This paper refers to the measure megawatts (MW) because this is the most commonly used in the capacity rating of utility scale PV systems; but the nomenclature and recommendations would also be expected to apply at other orders of magnitude, e.g. gigawatts (GW, GW_P and GW_{AC}).

2 Main standards are published by the International Electrotechnical Commission; Ref IEC 61215 for crystalline modules and IEC 61646 for thin film modules

[3] STC is defined in International Electrotechnical Commission standard IEC 60904-3

[4] See for example p.137, Chapter 13 of *Solar Photovoltaic Projects in the mainstream power market*, Philip Wolfe (url)

[5] Refer for example to *Performance Parameters for Grid-Connected PV Systems*, NREL, B Marion et al (url)

[6] but there are many exceptions

[7] See for example http://wiki-solar.org/data/criteria.html