Solar energy—quantities, and units

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ABSTRACT

It is today increasingly common for both businesses and residences to install solar electrical energy systems.

This article introduces various quantities involved in the basic physics of solar energy systems, and their units.

1 SOLAR FLUX DENSITY

Solar flux is the "stuff" of sunlight, not as it affects what is seen by the eye but rather in terms or power or energy (regardless of wavelength).[1]

At some point where sunlight arrives, its "power potency" is described by the metric *[solar] flux density* (often with the symbol G). This is the amount of power per unit area that crosses a plane perpendicular to the line of travel of the solar rays at that point. The SI unit of solar flux density is the *watt per square meter* (W/m^2).

At the top of the earth's atmosphere, the solar flux density is approximately 1.367 kW/m^2 (the exact value varying slightly over the year due to a small variation of the distance to the sun as a consequence of the eccentricity of the Earth's orbit).

At the Earth's surface, the flux density is less, in part due to scattering by the Earth's atmosphere, and beyond that, at any instant, due to any obscuration of the sky by clouds.

The ratio of the flux density at the Earth's surface and that at the top of the atmosphere is called the *clearness index*. For use in the calculation of the potential for solar power generation at It is often cited as the monthly average (for a given month) over the "daytime" hours.

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[1] The quantities used in solar radiometry correspond to those of photometry. However, in the latter field, everything is based on the response of the human eye, and thus the various components of the light, at different wavelengths, are "scaled" by different amount before being summed to recognize that response of the human eye.

Of the major US cities, Las Vegas Nevada has the highest annual average value, with a value of about 0.72 at the "best" month. For such a month would lead to a daytime average flux density at the Earth's surface of about 984 W/m^2.

Note that, over the daytime hours, the *flux density* at the earth's surface changes little.

2 SOLAR IRRADIANCE

2.1 Definition

The "power potency" of the solar radiation on a specific surface (not necessarily perpendicular to the direction of arrival of the sun's rays) is given by the metric *solar irradiance* (often with the symbol H), usually just called the *irradiance* when the context is understood. It is also denominated in the unit *watt per square meter* (W/m^2).

The irradiance on a surface is the incident flux density times the cosine of the angle between the *normal to the surface* (the line perpendicular to the surface) and the direction of arrival of the sun's rays.

We can see that in the best situation (when the surface is in fact perpendicular to the direction of arrival of the sun's rays), the *irradiance* will be the same as the *flux density*.

Because over the daylight hours the direction of the sun's ways as they arrive at the earth's surface varies, then if we had some fixed surface, the *irradiance* on it would change significantly over those hours.

2.2 The reference irradiance

An irradiance of 1000 W/m^2 is used as the *reference irradiance* at which the fundamental performance parameters of a solar panel are often measured or described[2].

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[2] This is much like the one milliwatt power often used as a reference in telephone and audio system work,