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The Incoming Solar Radiation

On top of the earth's atmosphere, at the average distance between the earth and the sun, the mean energy density of the sun's radiation ("irradiance"), referred to a surface of 1 m^2, normal to the incoming radiation, is 1.367 kW/m^2. This value is called the solar constant, although it is not particularly constant; it changes with the sun's activity ("sun spots," see Figure 1). This change is so slight, in the order of 0.1%, that it needed satellite spectrometric data to find it. A more substantial change, in the order of 3%, is caused by the geometric changes of the reference, the deviation of the earth's orbit from the ideal circular form.

However, the influence of these variations is minimal compared to the 20 to 40% reduction in irradiance during the passage through the earth's atmosphere, due to the mixture of gases called air, suspended matter (as free radicals, aerosols, and aviation contrails), plus the complicated interaction between these elements, shifting concentration, their stability over time, the presence of different greenhouse

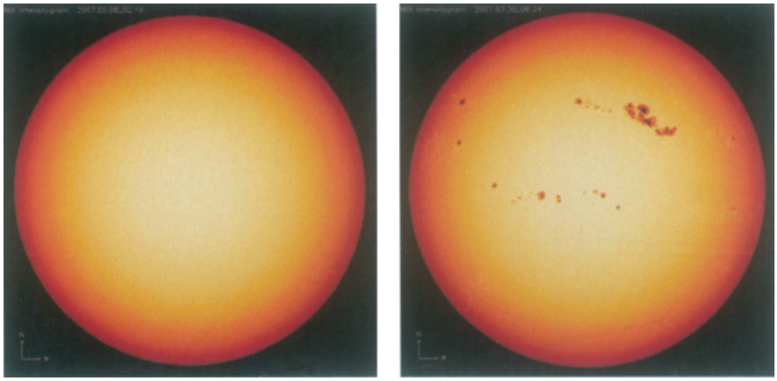

Figure 1 The sun in a calm sun spot period (left) and in an active period (right). (http://lasp.colorado.edu/sorce/newsother/SORCEwebsite_News_Solar_Cycle.pdf).

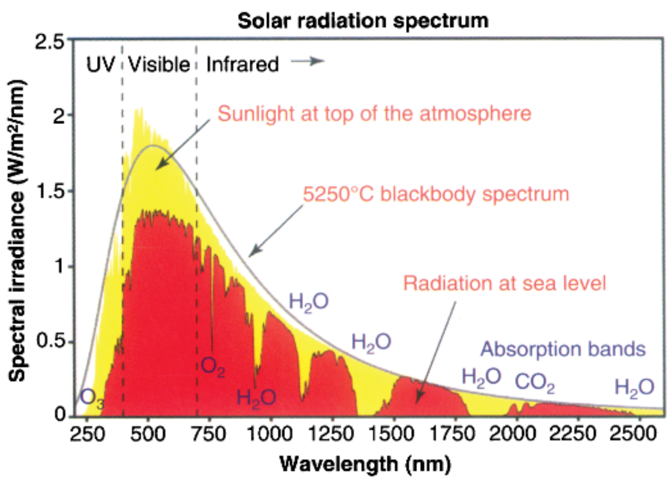

Figure 2 Irradiance spectrum on different levels in the atmosphere (Source Wikipedia).

gases, and solar UV light (photo-smog), all of this whipped by wind and jet stream, sifted through different pressures, temperatures, the effects of human activity and, finally, the eruption of the odd volcano. Figure 2 shows the spectral irradiance (the wavelength distribution of the irradiance). The red spectrum is received at sea level by burned tourists or is available for solar energy applications in two fractions:

- Diffuse radiation having been scattered, but not absorbed on its way. This part is not adapted to concentration, but can be used for low-temperature applications.
- Direct incoming radiation having maintained its original direction on its way through the atmosphere. This part can be used for all applications, concentrating or not.

The difference between the yellow and red spectra is reflected and/or absorbed by the atmosphere. In general, the spectrum marked in red may be available for solar energy applications, provided the sun is shining.

The Availability and Power Density Issue – Fossil vs. Solar Energy

There has been some confusion in the debate on availability and power density, and hence, usefulness, of fossil vs. solar energy. Solar (and particularly solar thermal) energy was often described as a highly diluted, unreliable energy source with limited potential for storage and high-temperature applications, whereas, at present, most experts would agree that:

- Solar energy (and its source, the sun) is a highly reliable, non-depletable energy source… but it is plagued by frequent "meteorological power cuts" (clouds) and limited storage potential; its high and intermediate temperature potential depends on the availability of direct radiation and sufficient concentration ratios; and its potential for low-temperature applications depends on available irradiance and adapted technology, good for tailor-made solutions for specific tasks. It is not particularly diluted: the power of the sun shining on the safety area of a nuclear power plant is in the order of the plant's power, but only during the day... Also, solar energy is prone to heat loss: in order to catch radiant energy, the absorbing element has to be open to incoming radiation, which means also open to potential heat loss, for example, at night.

- The reliability of solar energy can be improved by a number of measures, such as adaptation of supply and demand (e.g., solar air conditioning), storage (heat, dried products), transport (PV super grids), and transformation (synfuels).
- In some respects, fossil energy is the inverse of solar: depletable, but easy to store and uncritical to use at all temperatures. It is practical and versatile, just how much so we realize now that we are running out.

Luckily, many advantages of fossil fuels are also advantages of all fuels (shared by non-fossil fuels); sustainable fuels will remain part of the future energy supply system, as they have been since prehistoric times.

The Need for Tracking

To complicate the solar energy issue further, the sun does not have a constant position in the sky, which is rather good for us (otherwise we would not be here), but bad for solar energy devices. They must be tracked in order to function at optimum efficiency. Also, tracking must be more precise with increasing concentration ratio (and temperature).

The quantitative implications can be found in tables (Solar Energy Pocket Reference, Christopher L. Martin, D. Yogi Goswani, ISES 2005) and websites (www.nasa.org).

To summarize, it can be concluded that the sun's position in the sky is surprisingly different for different places on the globe, and it is standard practice to fool seasoned overseas solar visitors by asking them to indicate due north without a compass.

Of course, this would NEVER happen to our alert reader who, in the meantime, will have realized that the solar vs. fossil issue is getting more complex with every line, and that the voice level is increasing. This is the point where cool information, based on the necessary understanding of details, can help the reader to arrive at his or her own conclusions.

You are welcome.