Q&As

Week 6: Solar Energy

What is the difference between the Sun's radiation outside the atmosphere and what actually reaches the ground?

Answer : The Sun emits energy at a rate known as the solar constant about 1370 W/m2 at the top of Earth's atmosphere. However, not all of this energy reaches the surface, part of the sunlight is dispersed by air molecules and dust, while gases such as carbon dioxide, ozone, and water vapor absorb some of it. On top of that, clouds reflect a significant portion of the incoming radiation back into space.

Why the solar constant is not really constant?

Answer : Even though it's called a constant, the amount of solar energy Earth receives actually changes throughout the year because our planet's orbit is not a perfect circle, therefore the distance between Earth and the Sun varies over time. When Earth is closer to the Sun, it receives a bit more energy, when it's farther, it gets less.

How does the greenhouse effect change Earth's temperature?

Answer : Without the greenhouse effect, Earth would be a very cold, with an average temperature around -19°C, but thanks to gases such as CO2, water vapor, and ozone act like a thermal cover, trapping the heat the planet radiates back toward space, and his natural process keeps the Earth's average temperature around 15°C, making it warm enough to sustain life.

1. Why is assessing local solar radiation important in system design?

Solar energy availability varies significantly by location, season, and weather. Accurate local radiation data ensures that solar systems are sized and designed properly, maximizing efficiency and preventing under- or over-estimation of power output.

2. What happens to solar radiation as it travels through the Earth's atmosphere?

As sunlight passes through the atmosphere, it is scattered and absorbed by air molecules, aerosols, and gases such as water vapor, ozone, and carbon dioxide. This leads to a reduction in the amount of radiation reaching the surface and changes its spectral composition.

3. What role do greenhouse gases play in the Earth's energy balance?

Greenhouse gases absorb and re-emit infrared radiation emitted by the Earth's surface. This traps heat in the lower atmosphere, maintaining a temperature suitable for life. Without them, the planet would be much colder and unable to support most current ecosystems.

4. Why does the variability of atmospheric conditions pose a challenge for solar energy systems?

Cloud cover, pollution, humidity, and aerosols cause unpredictable fluctuations in solar radiation levels. This variability affects energy generation consistency, making it necessary to use storage systems or hybrid designs to ensure reliable energy supply.

5. What is the significance of diffuse and beam radiation for solar panel performance?

Even when sunlight is scattered or reflected, it contributes to the total energy received by solar panels. Diffuse and beam radiation allow solar collectors to generate power even on cloudy days or from surrounding reflected light, improving total energy yield.

What is solar constant?

The intensity of solar radiation emitted from the surface of the sun with a mean value of 1370 w/m^2

What is clearness index (kt)?

The ratio of global radiation on a specific site to extraterrestrial radiation.

Why do we tilt solar panels?

To increase the captured radiation

What is global radiation?

It is the sum of the direct radiation to surface B, reflected from the surface R, and scattered radiation to surface D.

What is diffuse radiation D?

The portion of solar radiation that is scattered by gases and particles in the atmosphere before reaches earth surface.

1. Why greenhouse effect detailed calculation is the starting point for our solar energy course and how it directly relates to the subsequent solar irradiance calculations?

2. The practical application of the Clearness Index (KT). Why we can reliably use this single KT value with an empirical formula to split the total radiation G into its Beam B and Diffuse D components?

3. The exact mathematical relationship between the instantaneous horizontal radiation Ho and the total daily radiation Hot, specifically how the equation Hot is derived from integrating equation Ho from sunrise to sunset?

4. When calculating the beam radiation on an inclined surface B (β), a new sunrise hour angle ω' is introduced, what the physical difference between this ωs' and ω' ?

5. In a real installation, we must fix one angle. Should we simply choose the angle for the "Yearly Mean" (like 40°) or are there other practical considerations?

Q1. What is meant by blackbody radiation and give examples of blackbodies that can be found around us with their applications?

Answer: Blackbody radiation describes the continuous electromagnetic spectrum emitted by an ideal surface that absorbs and re-emits all incident energy according to its temperature.
Solar thermal collectors that harness radiant energy efficiently, radiation pyrometers for temperature measurement, and incandescent lamps whose visible light emission arises from blackbody radiation at high filament temperatures are everyday examples of the application of blackbodies.

Q2. Derive and interpret the relationship between declination angle, hour angle, and solar altitude for daily irradiance estimation.

Answer: Solar altitude (α) is derived from:

$$\sin\alpha = \sin\phi \sin\delta + \cos\phi \cos\delta \cos\omega$$

where φ = latitude, δ = declination, and ω = hour angle. This relationship determines the solar elevation throughout the day and forms the geometric basis for estimating daily insolation, varying angle and tracking system performance.
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Q3. What happens to solar radiation as it passes through the atmosphere, with reference to air mass?

Answer: When solar radiation travels through the atmosphere, some of it is absorbed by ozone, Carbon dioxide gases, while other portion is scattered by air molecules. The extent of this depends on the air mass (AM), which increases as the Sun moves away from the zenith. At higher air masses, the radiation passes through a longer atmospheric path, resulting in greater loss of intensity and a shift in the spectrum toward longer wavelengths.

Q4. Why is understanding solar irradiance at Earth's surface crucial for renewable energy design?

Answer: Accurate irradiance estimation determines the potential energy output and efficiency of solar PV and thermal systems. It affects panel sizing, tilt angle, and site selection. Variations in irradiance due to weather, air mass, and latitude directly influence system reliability and economic viability.

Q5. Differentiate between beam, diffuse, and reflected radiation (with respect to characteristics).

Answer:

Type of Radiation	Characteristics
Beam Radiation	Travels in a straight line from the Sun without scattering; highly directional and strongest under clear skies.
Diffuse Radiation	Scattered in many directions by air molecules, dust, and clouds; non-directional and present even when the Sun is obscured.
Reflected Radiation	Bounces off ground or surrounding surfaces; intensity depends on surface reflectivity (albedo) and contributes to total global radiation.