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Solar energy — Vocabulary

Énergie solaire — Vocabulaire

Sonnenenergie — Vokabular

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 180, *Solar energy*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 312, *Thermal solar systems and components*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This second edition cancels and replaces the first edition (ISO 9488:1999), which has been technically revised.

The main changes compared to the previous edition are as follows:

— update of definitions;

— addition of several new terms, according to the development of new standards for solar thermal technology in the past two decades.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Solar energy — Vocabulary

1 Scope

This document defines basic terms relating to the work of ISO/TC 180. The committee covers standardization in the field of the measurement of solar radiation and solar energy utilization in space and water heating, cooling, industrial process heating and air conditioning. Consequently, the vocabulary within this document is focussed on definitions relating to those measurement and utilisation technologies.

Since the 1999 version of this document there has been considerable development in solar photovoltaic technologies and high temperature solar thermal technologies that use heat to produce electricity or to provide high temperatures for processes that require elevated temperatures. This standard has some definitions that are useful also for those technologies; however, there are other documents that cover vocabulary for these technologies in more detail.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1 Terms for solar geometry

3.1.1
aphelion
<of Earth> point in the Earth's orbit at which it is furthest from the Sun

Note 1 to entry: At the aphelion, the Earth is approximately 152×10^6 km from the Sun.

3.1.2
perihelion
<of Earth> point in the Earth's orbit at which it is closest to the Sun

Note 1 to entry: At the perihelion, the Earth is approximately 147×10^6 km from the Sun.

3.1.3
solar declination
δ
angle subtended between the Earth-sun line and the plane of the equator (north positive)

Note 1 to entry: The solar declination is zero on equinox dates, varying between +23,45° (June 22) and -23,45° (December 22).

3.1.4
solar azimuth angle
solar azimuth
γ_S
angular displacement from the chosen reference direction of the projection of a straight line from the apparent position of the sun to the point of observation, onto the horizontal plane

Note 1 to entry: To avoid errors, the same definition (reference direction and measuring direction) must be used for both solar azimuth and inclined surface azimuth.

Note 2 to entry: The reference direction can be either North or South and the azimuth angular displacement from the reference direction can range from 0° to 360° or -180° to +180°.

Note 3 to entry: The geographic azimuth is measured clockwise from due north 0° to 360°.

Note 4 to entry: The two most common definitions in use for solar energy applications are:

1) Solar azimuth is 0° for a northern hemisphere location (north of the tropics at latitude angles > +23,45º) at *solar noon* (3.1.9). Angular displacements east are negative and west are positive, i.e. $-180° \leq \gamma_S \leq +180°$. This definition results in a simple set of equations; however, it leads to counter intuitive values for southern hemisphere locations (outside of the tropics at latitude angles < -23,45º), the solar azimuth angle being 180° for a north facing inclined *solar collector* (3.6.1) in the southern hemisphere (see Reference [3]).

2) Solar azimuth angle is 0° at *solar noon* (3.1.9) for both Northern & Southern hemispheres (outside the tropics). Angular displacements east are negative and west are positive, i.e. $-180° \leq \gamma_S \leq +180°$. For this definition, the solar azimuth angle of a *solar collector* (3.6.1) tilted towards the equator at *solar noon* (3.1.9) in both north and south hemispheres is 0° (outside the tropics).

3.1.5
zenith
point vertically above the observer

3.1.6
solar zenith angle
θ_z
angular distance of the sun from the vertical

3.1.7
solar altitude angle
solar elevation angle
h
complement of the *solar zenith angle* (3.1.6)

$$h = 90° - \theta_z$$

3.1.8
solar hour angle
ω
angle between the sun projection on the equatorial plane at a given time and the sun projection on the same plane at *solar noon* (3.1.9)

Note 1 to entry: The solar hour angle changes by approximately 360° within 24 h (approximately 15° within 1 h). This angle is negative for morning hours and positive for afternoon hours, i.e. ω (in degrees) ≈ 15 (t_{Hr}-12) where t_{Hr} is the *solar time* (3.1.10) in hours.

3.1.9
solar noon
local time of day at which the sun crosses the observer's meridian

3.1.10
solar time
t_{sol}
hour of the day as determined by the apparent angular motion of the sun across the sky, with *solar noon* (3.1.9) as the reference point for 12:00 h

Note 1 to entry: $t_{sol} = t_{st} + 4\,(L_{st} - L_{loc}) + E$, where t_{st} is the standard time, L_{st} is the longitude of the standard meridian for the local time zone and L_{loc} is the longitude of the location in question with both longitudes specified in degrees west (0° ≤ L° ≤ 360º). E is the equation of time, which takes into account the perturbations in the Earth's rate of rotation around the sun that affect the time at which the sun crosses the observer's meridian.

Note 2 to entry: The correction $4\,(L_{st} - L_{loc}) + E$ is expressed in minutes. An additional correction is needed if the standard time is a daylight saving time.

3.1.11
angle of incidence
incidence angle
θ
angle between the line joining the centre of the solar disc to a point on an irradiated surface and the outward normal to the irradiated surface

3.1.12
solar tracker
sun tracker
power-driven or manually operated movable support which may be employed to keep a device oriented toward a given direction with respect to the sun.

3.1.13
equatorial tracker
sun-following device having an axis of rotation parallel to the Earth's axis

Note 1 to entry: The parameters of motion are the hour angle and the declination of the sun.

3.1.14
altazimuth tracker
sun-following device which uses the *solar elevation angle* (3.1.7) and the *azimuth angle* (3.1.4) of the sun as coordinates of movement

3.1.15
sun-path diagram
graphic representation of *solar altitude* (3.1.7) versus *solar azimuth* (3.1.4), showing the position of the Sun as a function of time for various dates of the year

Note 1 to entry: If *solar time* (3.1.10) is used, the diagram is valid for all locations of the same latitude.

3.1.16
heliodon
solar-angle simulator for conducting shading assessments on buildings or collector arrays, usually having a model table which tilts for the latitude and rotates for the hour of day, and a lamp to represent the sun, mounted at some distance away on a vertical rail, allowing adjustment for declination

3.1.17
solarscope
device similar to a *heliodon* (3.1.16), but having a fixed horizontal model table and a light source movable to any solar altitude and azimuth

3.2 Radiation terms and quantities

3.2.1
radiation
emission and transfer of energy in the form of electromagnetic waves or particles

[SOURCE: WMO R0260[4]]

Note 1 to entry: *Radiation* can also be used to refer to multiple quantities used to describe the process called radiation. For example, *radiation* could mean *energy* or *irradiance* (3.2.5) (see Reference [5]).

3.2.2
radiant energy
quantity of energy transferred by *radiation* (3.2.1)

[SOURCE: WMO R0200[4]]

3.2.3
radiant flux
radiation flux
flux of radiation
Φ
power emitted, transferred or received in the form of *radiation* (3.2.1)

3.2.4
radiance
radiant flux (3.2.3) emitted, transmitted, reflected or received by a given surface, per unit of solid angle per unit of projected area

Note 1 to entry: Unit: $W \cdot m^{-2} \cdot sr^{-1}$.

3.2.5
irradiance
G
quotient of the *radiant flux* (3.2.3) incident on the surface and the area of that surface, or the rate at which *radiant energy* (3.2.2) is incident on a surface, per unit area of that surface

Note 1 to entry: Unit: $W \cdot m^{-2}$.

3.2.6
irradiation
DEPRECATED: insolation
H
incident energy per unit area of a surface, found by integration of solar *irradiance* (3.2.5) over a specified time interval

3.2.7
radiant exitance
M
<at a point on a surface> *radiant flux* (3.2.3) leaving the element of the surface, divided by the area of that element

Note 1 to entry: Formerly called radiant emittance.

Note 2 to entry: The *radiant energy* (3.2.2) may leave the surface by emission, reflection and/or transmission.

3.2.8
ultraviolet radiation
electromagnetic radiation of wavelength in the range of 10 nm to 400 nm

Note 1 to entry: UVA radiation has a wave-length range of 315 nm to 400 nm; UVB radiation has a wavelength range of 280 nm to 315 nm; UVC radiation (wavelength range 280 nm to X-rays) cannot be detected by solar energy technologies.

3.2.9
visible radiation
light
electromagnetic radiation of wavelengths causing visual sensations for humans

Note 1 to entry: Visible radiation is generally accepted to be within the wavelength band of 380 nm to 780 nm

3.2.10
infrared radiation
electromagnetic radiation of wavelengths longer than those of *visible radiation* (3.2.9) and shorter than about 1 mm

3.2.11
shortwave radiation
radiation of wavelength shorter than 3 µm but longer than 280 nm

Note 1 to entry: This definition is linked to radiation typically measured with *pyrheliometers* (3.3.5) and *pyranometers* (3.3.4) that are often considered as measuring *solar irradiance* (3.2.5) even though the wavelength range excludes a small part of the *solar spectrum* (3.2.16).

Note 2 to entry: This term is specific to solar energy applications

3.2.12
longwave radiation
radiation of wavelength greater than 3 µm, typically originating from sources at terrestrial temperatures

Note 1 to entry: Examples of sources of longwave radiation are clouds, atmosphere, ground and terrestrial objects.

Note 2 to entry: Sometimes is called *thermal radiation*.

Note 3 to entry: This definition is linked to radiation typically measured with *pyrgeometers* (3.3.7) that are considered as measuring *irradiance* (3.2.5) from sources at terrestrial temperatures even though the wavelength range includes a small part of the *solar spectrum* (3.2.16).

Note 4 to entry: This term is specific to solar energy applications.

3.2.13
solar radiation
DEPRECATED: *shortwave radiation*
DEPRECATED: insolation
radiation (3.2.1) emitted by the sun

3.2.14
solar energy
energy emitted by the sun in the form of electromagnetic waves

Note 1 to entry: Solar energy is primarily in the wavelength region from 0,3 µm to 3,0 µm.

Note 2 to entry: Solar energy is generally understood to mean any energy made available by the capture and conversion of *solar radiation* (3.2.13).

3.2.15
solar flux
radiant flux (3.2.3) originating from the sun

3.2.16
solar spectrum
distribution by wavelength (or frequency) of electromagnetic radiation emitted from the sun

3.2.17
direct radiation
direct solar radiation
beam radiation
beam solar radiation
solar radiation (3.2.13) incident on a given plane, and originating from a small solid angle centred on the sun's disk

Note 1 to entry: In general, direct solar radiation is measured by instruments with *field-of-view angles* (3.3.6) of up to 6°. Therefore, a part of the scattered radiation around the sun's disk [*circumsolar radiation* (3.2.18)] is included, as the solar disk itself has a *field-of-view angle* (3.3.6) of about 0,5°.

Note 2 to entry: Direct radiation is usually measured at normal incidence.

Note 3 to entry: Approximately from 97 to 99 % of the direct solar radiation received at the ground is contained within the wavelength range from 0,3 µm to 3 µm (see Reference [6]).

Note 4 to entry: Further details on *circumsolar radiation* (3.2.18) and its role for direct radiation are provided in *irradiance* (3.2.5), *circumsolar irradiance* (3.2.19), *circumsolar contribution* (3.2.20), *sunshape* (3.2.21) and *direct solar irradiance* (3.2.28).

3.2.18
circumsolar radiation
radiation (3.2.1) scattered by the atmosphere so that it appears to originate from an area of the sky immediately adjacent to the sun

Note 1 to entry: Circumsolar radiation causes the solar aureole.

Note 2 to entry: Further details on *circumsolar radiation* and its role for *direct radiation* (3.2.17) are provided in *circumsolar irradiance* (3.2.19), *circumsolar contribution* (3.2.20), *sunshape* (3.2.21) and *direct solar irradiance* (3.2.28).

3.2.19
circumsolar irradiance
quotient of the *radiant flux* (3.2.3) of the *circumsolar radiation* (3.2.18) on a given plane *receiver* (3.7.3) surface to the area of that surface

Note 1 to entry: If the *receiver* (3.7.3) plane is perpendicular to the axis of the solid angle, the circumsolar irradiance is called circumsolar normal irradiance. Circumsolar irradiance is usually measured at normal incidence.

3.2.20
circumsolar contribution
contribution of a specific portion of the circumsolar normal irradiance to the direct normal irradiance

Note 1 to entry: The circumsolar contribution refers to a specific ring-shaped angular region described by an inner and the outer angular distance from the centre of the sun.

Note 2 to entry: If the inner angle describing this angular region is the half-angle of the sun disk the circumsolar contribution is also called circumsolar ratio.

Note 3 to entry: Depending on the *circumsolar irradiance* (3.2.19) measurement instrument or the solar technology involved, different wavelength ranges are included. In order to describe *circumsolar irradiance* (3.2.19) correctly, the wavelength range or the spectral response of the instrument or the involved technology has to be specified.

3.2.21
sunshape
azimuthal average radiance profile as a function of the angular distance from the centre of the solar disc, normalized to 1 at the centre of the disc and considering the wavelength range of *shortwave radiation* (3.2.11).

3.2.22
hemispherical radiation
hemispherical solar radiation
solar radiation (3.2.13) received by a plane surface from a solid angle of 2π·sr

Note 1 to entry: The *tilt angle* (3.10.1) and the *azimuth* (3.10.2) of the surface should be specified, e.g. horizontal.

Note 2 to entry: Hemispherical solar radiation is composed of direct solar radiation and diffuse solar radiation (solar energy scattered in the atmosphere as well as solar radiation reflected by the ground).

Note 3 to entry: Solar engineers commonly use the term *global radiation* (3.2.23) in place of *hemispherical radiation*. This use is a source of confusion if the referenced surface is not horizontal.

Note 4 to entry: Approximately 97 % to 99 % of the hemispherical solar radiation incident at the Earth's surface is contained within the wavelength range from 0,3 µm to 3 µm (see Reference [6]).

3.2.23
global radiation
global solar radiation
hemispherical solar radiation received by a horizontal plane on the Earth's surface

Note 1 to entry: Approximately 97 % to 99 % of the global solar radiation incident at the Earth's surface is contained within the wavelength range from 0,3 µm to 3 µm (see Reference [6]).

Note 2 to entry: Solar engineers commonly use the term *global radiation* in place of *hemispherical radiation* (3.2.22). This use is a source of confusion if the referenced surface is not horizontal.

3.2.24
diffuse radiation
diffuse solar radiation
hemispherical solar radiation minus direct solar radiation

Note 1 to entry: For the purposes of solar energy technology, diffuse radiation includes a part of solar radiation scattered in the atmosphere as well as a part of solar radiation reflected by the ground, depending on the *tilt angle* (3.10.1) of the receiver surface.

Note 2 to entry: The *tilt angle* (3.10.1) and the *azimuth* (3.10.2) of the receiver surface should be specified, e.g. horizontal.

3.2.25
atmospheric radiation
DEPRECATED: sky radiation
longwave radiation (3.2.12) emitted by and propagated through the atmosphere

[SOURCE: WMO A2940[4]]

3.2.26
extra-terrestrial solar radiation
solar radiation (3.2.13) received at the limit of the Earth's atmosphere

[SOURCE: WMO E1370[4]]

3.2.27
solar constant

G_{sc}

solar irradiance outside the Earth's atmosphere on a plane normal to the direction of this radiation, when the Earth is at its mean distance from the sun ($149{,}5 \times 10^6$ km)

Note 1 to entry: Historically the solar constant is considered to be 1 367 $W \cdot m^{-2} \pm 7$ $W \cdot m^{-2}$. The new value of 1 361,1 $W \cdot m^{-2}$, from the most recent determination of the solar constant, is currently under consideration, see Reference [7].

3.2.28
direct solar irradiance

G_b

quotient of the *radiant flux* (3.2.3) on a given plane receiver surface received from a small solid angle centred on the sun's disk to the area of that surface

Note 1 to entry: If the plane is perpendicular to the axis of the solid angle, direct normal solar irradiance G_{bn} is received.

Note 2 to entry: Unit: $W \cdot m^{-2}$.

Note 3 to entry: Approximately 97 % to 99 % of the direct solar radiation received at ground level is contained within the wavelength range from 0,3 µm to 3 µm (see Reference [3]). Depending on the direct irradiance measurement instrument or the solar technology involved, different wavelength ranges are included. In order to describe direct irradiance correctly, the wavelength range or the spectral response of the instrument or the involved technology has to be specified.

Note 4 to entry: In general, direct normal solar irradiance is measured by instruments with *field-of-view angles* (3.3.6) of up to 6°. The currently recommended instrument design uses 5° field-of-view (see Reference [5]). A part of the scattered radiation around the Sun's disk (*circumsolar radiation* (3.2.18)) is included, as the solar disk itself has a *field-of-view angles* (3.3.6) of about 0,5°.

Note 5 to entry: In order to describe direct normal solar irradiance accurately, it is necessary to specify how *circumsolar radiation* (3.2.18) is included in it using the following terms. B_n is the experimental direct normal irradiance.

$$B_n = \int_0^{2\pi} \int_0^{\alpha_L} P(\xi,\varphi) L(\xi,\varphi) \cos(\xi) \sin(\xi) \, d\xi \, d\varphi .$$

where

$L(\xi,\varphi)$ is the broadband sky radiance - usually expressed in $W \cdot m^{-2}$ sr^{-1} - for an element of sky whose angular position is defined by the angular distance ξ from the centre of the sun disk and the azimuth angle φ in the sun disk and the circumsolar region;

$P(\xi,\varphi)$ is the penumbra function of the measurement device that is sometimes also called “acceptance function”;

α_L is the greatest angular distance from the sun disk centre for which radiation is measured by the instrument.

In atmospheric radiation transfer models, another parameter is often used: $B^{ideal}{}_n(\alpha_L)$. $B^{ideal}{}_n(\alpha_L)$ is the direct normal irradiance up to the angular limit, α_L, which in this case mostly corresponds to the sun disk half-angle (~0,27°). $B^{ideal}{}_n(\alpha_L)$ is calculated as B_n, the penumbra function being set equal to 1 (see also Reference [6]). In concentrating solar power plant models $B^{ideal}{}_n(\alpha_L)$ or B_n might be used depending on the *sunshape* (3.2.21) data applied in the model. The angular limit, α_L, also has to fit to the applied *sunshape* (3.2.21)

3.2.29
hemispherical irradiance
hemispherical solar irradiance
DEPRECATED: incident solar radiation intensity
DEPRECATED: instantaneous insolation
DEPRECATED: insolation
DEPRECATED: incident *radiant flux* density
G_{hem}
quotient of the *radiant flux* (3.2.3) on a given plane receiver surface received from a solid angle of 2π sr to the area of that surface

Note 1 to entry: The *tilt angle* (3.10.1) and the *azimuth* (3.10.2) of the surface should be specified, e.g. horizontal.

Note 2 to entry: Unit: W·m^{-2}.

Note 3 to entry: Examples for hemispherical irradiance are *global irradiance* and the irradiance received in the plane of *solar collector* (3.6.1) [Plane of Array (POA) irradiance], also called "global tilted irradiance".

3.2.30
global irradiance
global solar irradiance
G_h
hemispherical solar irradiance on a horizontal plane on the Earth's surface

Note 1 to entry: Unit: W·m^{-2}.

Note 2 to entry: Global irradiance always refers to a horizontal plane. Global irradiance should not be confused with global tilted irradiance, see *hemispherical irradiance* (3.2.29), Note 3.

3.2.31
diffuse solar irradiance
G_d
irradiance (3.2.5) of diffuse solar radiation on a given plane receiver surface

Note 1 to entry: The *tilt angle* (3.10.1) and the *azimuth* (3.10.2) of the receiving surface should be specified, e.g. horizontal.

Note 2 to entry: Unit: W·m^{-2}.

3.2.32
spectral solar irradiance
E_λ
solar irradiance per unit wavelength interval at a given wavelength

Note 1 to entry: Unit: W·m^{-2}·μm^{-1}.

3.2.33
clear sky irradiance
G_c
global solar irradiance (3.2.30) during cloudless sky conditions

Note 1 to entry: Clear-sky irradiance is often determined with radiation transfer models using a cloudless atmosphere characterization based on climatological or meteorological reanalysis values. This allows the determination of clear-sky irradiance even for locations and times when the atmosphere is not cloudless.

Note 2 to entry: Unit: W·m^{-2}.