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TECHNICAL SPECIFICATION

colour inside

Solar thermal electric plants –
Part 1-2: General – Creation of annual solar radiation data set for solar thermal electric (STE) plant simulation

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Technical Specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

IEC TS 62862-1-2, which is a Technical Specification, has been prepared by IEC technical committee 117: Solar thermal electric plants.

The text of this Technical Specification is based on the following documents:

Enquiry draft	Report on voting
117/67/DTS	117/77/RVDTS

Full information on the voting for the approval of this Technical Specification can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 62862 series, published under the general title *Solar thermal electric plants*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- transformed into an International standard,
- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

During the various stages of planning, design and start-up of a solar thermal electricity (STE) plant, engineering and economic studies often require the simulation of plant power production, and an analysis of the response of its various components and systems. All these simulation studies use precise, organized and standardized information of the solar resource and other meteorological variables.

As a one-year period includes the most important meteorological cycle, the response of a power plant is simulated for a complete year, and attempts to achieve results that can be extrapolated to the long term. The need therefore arises for a complete year of data for the meteorological variables that influence plant operation and provide a response to solar thermal power plant simulation studies. This standard year of data, which is known as the typical meteorological year (TMY), serves for both annual plant electricity production studies and engineering studies associated with a solar thermal power plant project, except for studies on extreme events.

The meteorological information for a specific place, especially knowledge of the solar resource, is always subject to uncertainty. Furthermore, this information comes from quite different sources and its availability is very irregular. Therefore, in order to generate a typical meteorological year, a standard, characteristic methodology is used which ensures its operability in the framework of solar thermal power plant projects, and offers adequate support for decision-making in this type of project.

This functional typical meteorological year as defined by this document is hereinafter called the annual solar radiation (ASR) data set.

Precise knowledge of the solar resource available is important for the design and development of any system that intends to make use of the energy from the sun. The large non-determining component of solar radiation[1] and the need to simulate the response of a solar system in the long term have led to the development of a methodology for generating a reference year that includes information on diurnal and seasonal variations in the meteorological variables involved as well as their long-term averages.

The typical meteorological year that has made this name best known was developed at Sandia National Laboratories [4], and employed part of the SOLMET/ERSATZ (1951-1976) database [5] made up of 248 stations of which 26 provide solar radiation measurements and the rest estimated data, for the US and adjacent territories. This TMY was built up from the concatenation of typical months to form a year with 8 760 hourly records. Each month was selected by evaluating nine variables: the mean, maximum and minimum temperature and dew point temperature, maximum and mean wind speed and global horizontal radiation. A weighted sum of the Filkenstein-Schafer statistic [5] [6] was used, resulting in the selection of five months. The final choice of the typical month considered the long-term persistence of climate patterns.

Although various authors have proposed slight variations in the Sandia methodology, in essence it remains practically unaltered in the generation known as TMY2 and TMY3 [5] [7].

TMY version 2 employs data from the National Solar Radiation Database (NSRDB) from 1961 to 1990, with 93 % of the data estimated by models and 7 % from data measured for 239 locations. The records include measurements of associated meteorological variables

1 In this document, the term solar radiation is used as a generic reference to the "radiation emitted by the Sun" (as is defined in ISO 9488:1999, 3.13), and irradiance and irradiation are used as the physical magnitudes defined in ISO 9488:1999, 3.4 and 3.5 respectively]. On the other hand, these references notwithstanding, in this document, it has been agreed to express irradiance in W/m^2 and irradiation in Wh/m^2.

such as temperature, humidity, cloud cover and visibility. The solar radiation measurement is present at 52 NSRDB stations, but the measurement period is short.

The TMY version 3 was produced using hourly solar radiation data and meteorological data from 1 454 stations, from NSRDB database time series (1961-1990) and its update, consisting of NSRDB station time series (1 %) and a dataset estimated using the State University of New York (SUNY) model based on geostationary operational environmental satellite (GOES) images for an eight-year recording period (1998-2005).

Finally, it should be mentioned that there are other methodological proposals that differ somewhat more from the National Renewable Energy Laboratory (NREL) TMYs, involving other variables, with a variety of statistics and even proposing the collection of typical meteorological data for only a few days a month instead of a whole year.

As the data necessary for generating the TMYs mentioned above are not available in the locations of most STE plant projects, a procedure is defined for the creation of an annual solar radiation data set for the plant simulation that standardizes the procedures currently used for this.

In this document, a set of procedures are presented. Only the minimal requirements of these procedures are described even when there may be additional considerations that will be more than welcome during the application of the procedures, but there may be times that they will not be available and the inclusion in this document will block the option of following it.

It is important that all the proposed methodologies use a measurement campaign with well-defined quality characteristics during a whole year and at least containing direct solar irradiance (G_b) measurements in the expected location.

Two options are proposed to generate the annual solar radiation data set depending on the data availability. One only uses measurements of G_b but in addition uses high quality G_b estimations during more than 10 years. This methodology is very similar to the classic TMY but with a preliminary assessment of coherence with the local measurements. In this methodology, the ASR could be formed by the estimations selected in the process, by G_b measurements or by simultaneous measurements of GHI and G_b.

The other option uses G_b measurements as well as global horizontal irradiance (GHI); and uses a methodology for GHI long-term estimation based on additional sources of information (aimed low quality GHI estimations). In this second methodology, the ASR will always be formed by simultaneous measurements of GHI and G_b.

Recent works, such as the creation of multiple annual solar radiation (MASR) data sets for the simulation of a STE plant, are out of the scope of this document even when their use could be better than the use of a unique annual data set of data for the prefeasibility assessment of a STE plant project. At the moment of the elaboration of this document, there is not a consensus or a relation of procedures for MASR creation.

MASR creation as well as annual solar radiation data sets referred to an annual percentile (commonly the 10th percentile 10 of the estimated annual values distribution) could be covered in future projects.

This document is related to works developed in the context of the International Energy Agency SolarPACES and Solar Heating and Cooling agreements as a liaison organization of experts in solar radiation for energy applications. Coordination with subcommittee 1 of ISO technical committee 180 is also considered.

SOLAR THERMAL ELECTRIC PLANTS –

Part 1-2: General – Creation of annual solar radiation data set for solar thermal electric (STE) plant simulation

1 Scope

This part of IEC 62862 defines the procedures for the creation of annual solar radiation data sets (ASR) for solar thermal electricity (STE) plant simulation.

In addition to the definition of procedures needed for the ASR construction, its components and parameters will be also described.

The scope of application of this document refers to the needs associated with solar thermal power plant projects and mainly related to the simulation of an annual period with a solar radiation sum close to a normal annual value (from among an estimation of all possible annual values).

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 9488:1999, *Solar energy – Vocabulary*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
annual solar radiation data set
ASR
complete standardized set of solar irradiance data, which may be accompanied by other meteorological variables considered of interest, and which attempts to establish a reference for radiometric evolution in a specific place during the year

Note 1 to entry: This data set shall have a solar radiation sum close to a normal annual value (among an estimation of all possible annual values).

3.2
direct measurement
value of a certain variable found with a measurement instrument on the surface at the specific site

Note 1 to entry: Direct measurement data shall be considered to be any statistic derived from values of the same variable that meet the above definition for a given period of time. For example, those found by the arithmetic mean of values recorded by the corresponding measurement instrument (sensor and data acquisition system) for a given period of time are direct measurements.

3.3
indirect measurement
value of one variable found by combining direct measurements of other variables

EXAMPLE The measurement of direct solar irradiance with a pyrheliometer directed at the sun is a direct measurement process. On the other hand, its determination from the direct measurement of global solar irradiance and diffuse solar irradiance is an indirect measurement involving two previous direct measurements.

Note 1 to entry: Finding direct solar irradiance from a numerical model, for example, a regression equation, may not be considered either direct or indirect measurement.

3.4
derived data
data found from a statistical function that relates to a set of simultaneous data for different variables at the same place

EXAMPLE Data found from regression models, such as some models for calculating direct solar irradiance from global horizontal irradiance, are derived data.

3.5
synthetic data
<synthetic generation of a series> interpolated data of the same variable recorded in another space and/or time frequency

EXAMPLE All data found from spatial or temporal interpolation are synthetic data.

3.6
satellite data
data found from information collected by a measurement instrument on board a satellite

Note 1 to entry: This document distinguishes between high and low quality satellite data. High quality satellite data refers to satellite data with a temporal resolution of one hour or less, and a maximum spatial resolution of 20 km [8]. ASR data sets could be formed by high quality satellite data.

3.7
meteorological model data
NWP
data found from models that include a numerical solution of differential equations defining the behaviour of the atmosphere based on given initial conditions

Note 1 to entry: This document distinguishes between high and low quality data from meteorological models. High quality data from a meteorological model refers to data from a meteorological model with a temporal resolution of one hour or less, and a maximum spatial resolution of 20 km [8]. ASR data sets could be formed by high quality data from meteorological models.

4 Elements forming the ASR data set

4.1 Geographic and time identification

4.1.1 Geographic identification

The WGS 84 world geodetic system standard is taken as the reference ellipsoid to define the geographical location on lambertian coordinates.

The geographic identification of the place to which the data set refers to is determined by:

- the geodetic latitude and longitude coordinates;
- the elevation above mean sea level.

4.1.2 Time reference

For each individual data point in the ASR, two timestamps should be given. One timestamp should indicate the time of the value within the ASR (functional date). The other timestamp corresponds to the time to which the original data value belongs (original date). The time in the ASR cannot be completely defined without stating the year. In order to avoid errors and ambiguities, the year of the ASR data set should be set to 2015. This way, the solar position can be calculated in the same way by all users and it is clear that the ASR is no leap year.

The record date shall follow the time reference established in this document, that is, they shall correspond to the UTC referencing system (see Annex A).

4.1.3 Time frequency

ASR data set frequency has to be hourly or higher (higher frequency corresponds to a shorter time period). The value corresponding to the time period (one hour, ten minutes, five minutes, etc.) may come from a high sampling frequency, which has to be an exact divider of one hour. The corresponding record is assigned an average, maximum, minimum, or instantaneous value for that period, depending on the variable observed. In the case of direct solar irradiance, ASR shall at least be the average.

4.2 Variables

4.2.1 General

The ASR data set shall contain the number of records corresponding to a whole year at the frequency of direct solar irradiance and in all available variables. There shall be records corresponding to twelve different months from January to December, not necessarily consecutive nor do they have to be from the same year.

4.2.2 Mandatory variable

The unit for direct solar irradiance is Wm^{-2}, expressed in integer numbers. In this document, direct solar irradiance is understood as the value of the magnitude as defined in ISO 9488, i.e. direct solar irradiance is the radiant flux received on a flat surface from a small solid angle centered on the solar disk, and the area of this surface, which is perpendicular to the axis of the solid angle.

The detailed definitions of direct solar irradiance given in IEC TS 62862-1-1[2] should be taken into account.

In the framework of this document, we refer to a small solid angle that corresponds to the recommendations for new pyrheliometers from the WMO [20].

The recommended nomenclature for direct solar irradiance is G_b (ISO 9488), although other nomenclatures commonly used for this variable are: DNI (from Direct Normal Irradiance), B (from the term beam radiation) and I_b [9].

4.2.3 Other variables

The direct solar irradiance series may be accompanied by other variables, such as:

- global horizontal irradiance;
- diffuse horizontal irradiance;
- ambient temperature;

2 Under preparation. Stage at the time of publication: IEC BPUB 62862-1-1:2017.