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TECHNICAL SPECIFICATION

Solar thermal electric plants –
Part 1-3: General – Data format for meteorological data sets

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SOLAR THERMAL ELECTRIC PLANTS –

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FOREWORD

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- the required support cannot be obtained for the publication of an International Standard, despite repeated efforts, or
- the subject is still under technical development or where, for any other reason, there is the future but no immediate possibility of an agreement on an International Standard.

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

IEC TS 62862-1-3, 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:

Draft TS	Report on voting
117/68/DTS	117/78/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- withdrawn,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.

SOLAR THERMAL ELECTRIC PLANTS –

Part 1-3: General – Data format for meteorological data sets

1 Scope

The goal of this document on data format is to reduce efforts for data exchange and to avoid errors caused by misunderstandings due to the application of various different and at times unclear formats. To achieve this goal, the proposed format has the following properties:

- suitability for common operation systems;
- suitability for satellite/model-derived data;
- suitability for measured data;
- suitability for combined data sets;
- suitability for typical meteorological years and forecasted data.

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 8601, *Data elements and interchange formats – Information interchange – Representation of dates and times*

ANSI INCITS 4-1986 (R2007), *American National Standard for Information Systems – Coded Character Sets – 7-Bit American National Standard Code for Information Interchange (7-Bit ASCII)*

3 Terms and definitions

No terms and definitions are listed in this document.

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

4 Format description

The data format has been inspired by the thesaurus on solar irradiance proposed at EnvironInfo 2007.

After a header with information about the data, a data section follows with the meteorological data. The data section starts after the "#begindata" header field (see Table 1), where the first line contains the name or acronym of the parameters. The order of the columns is the same as the order defined on the "channel" description (Table 7). After the data section, the last line of the file contains "#enddata".

The thesaurus is usually implemented in an XML-file format. Many applications in solar energy tend to use a simpler ASCII data format with values separated by spaces or semicolons ';', each line standing for one point in time. The proposed data format tries to combine both, as the data is stored in a simple ASCII format line by line. But it includes a header which contains all information of the thesaurus. The data can be very easily converted into an appropriate XML-file to be exchanged via standard web protocols.

Other sources which were used are the depri format which is used in some wind energy environments (http://depri.org) and the climate and forecasting metadata conventions. For the available options for delimiters, see Table 1, "#delimiter".

The fieldnames from Tables 1 to 8 are separated from the value of the parameter by a space.

5 General conventions

5.1 Character set

The format shall be based on the standard ASCII character set as defined in ANSI INCITS 4-1986 (R2007). Using only the first 127 characters will ease exchange of data between different operating systems. The field "#characterset" is mandatory as a second line of the file to ease interpretation of the remaining text fields.

5.2 New line

New lines are set by ASCII character 10 (line feed as in UNIX[1]). Also acceptable is the combination "Carriage return + line feed" with ASCII characters 13 and 10 (DOS/Windows[2] new line). When transferring data between DOS/Windows and UNIX type systems, care should be taken of the different conventions for new lines on each of the systems.

For the available options, see Table 1, "#endofline".

5.3 Time-stamps, integration and averaging

Time stamps follow ISO 8601 YYYY-MM-DDTHH:MM:SS.ssss with leading zeros. Time stamps for temporally averaged data shall refer to the end of the integration period, as it is the convention in meteorology. Instantaneous values can also be described by the data format (see parameter "#time.averaging" in Table 3).

Integration and averaging always refer to the complete time interval. This is especially important at sunrise and sunset, and it should also include the time frame when the sun is still or already below the horizon. Limiting such intervals only to the time when the sun is above the horizon is not allowed.

The only exception is the sun elevation or sun zenith angle. During the sun rise or sunset, these values should be calculated in a way that allows calculating the DNI from direct horizontal irradiance using the averaged angles.

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1 UNIX is the trade name of a product supplied by The Open Group. This information is given for the convenience of users of this document and does not constitute an endorsement by IEC of the product named. Equivalent products may be used if they can be shown to lead to the same results.

2 DOS and Windows are the trade names of products supplied by Microsoft Corporation. This information is given for the convenience of users of this document and does not constitute an endorsement by IEC of the products named. Equivalent products may be used if they can be shown to lead to the same results.

6 Meteorology file format

Table 1 – General header fields

Field name	Data type	Unit	Complexity level	mandatory/ optional	Example(s)	Description
#MET_IEC.v1.0 headerlines: *number_of_headerlines*	String		1	m	#MET_IEC.v1.0 headerlines:57	Indicates that this is a meteorological data file of the IEC document. It gives the version number. The last field is the number of header lines in the field until the data begins (line number of the line "#begindata"). Header name and number of header lines have to be written in one line.
#characterset	String		1	m	#characterset 850	This is a mandatory second line of the file.
					#characterset ISO/IEC-8859-1	Defines which extended character set has been used for ASCII characters above 127. It can be an MS-DOS or Windows code-page indicated by a three- or four-digit number. Or reference is made to ISO/IEC 8859 (all parts). In this case, it should read ISO/IEC-8859-1, for example Latin-1, the western European version.
#delimiter	String		1	m	#delimiter space tab	Delimiter between different columns in the data section. Options are "space", ";", ",", or "tab". A combination of different delimiters is not allowed.
#endofline	String		1	m	#endofline \n	The ASCII character indicates that a new line starts. Options are "\n" or "\n\r".
#title	String		1	o	#title Plataforma Solar	Title of the time series.
#history.*timestamp*	String		1	o	#history.2016-02-09T12:30 initial research	The #history field describes the evolution of the data set, and by whom it has been processed after the original creation. "#history" fields should be numbered to ensure that the order of processing can be evaluated. Each processing step should be documented by additional "#history" fields.
						If a modification is described in several lines, the order of the lines can be kept by marginally increasing the timestamp.
#comment	String		1	o	#comment this is a general comment	General comments

Field name	Data type	Unit	Complexity level	mandatory/ optional	Example(s)	Description
#datasource	String		1	m	#datasource measured	Indicator of which type of data is in the file: "measured", "modelled", "synthetic", "mixed", "satellite", "NWP". "measured" or "modelled" data refer to a real time series. "synthetic" means an artificial data set with no real time reference. Examples are typical meteorological data sets or data from algorithms that generate data sets. "mixed" indicates that the file contains data from several categories, for example measured and modelled data. "forecast" indicates that the data is forecasted data.
#status_update begindateenddate text	String		1	o	#status_update 2015-01-01T12:45 2015-03-02T09:00 Failure of sensor 1.	Describes status updates within the data set, for example sensor failures, cleaning events, external influences, etc. Timestamps follow ISO 8601.
#begindata time "sign of second column" "sign of third column" ...	String		1	m	#begindata time ghi dni dhi noo	Beginning of the data section. The order of the columns is defined by writing the names of the signs contained in the columns after "#begindata" in the next line in the same order as the columns. All signs are separated by the defined delimiter from each other. The first column from the left of the data section shall be "time". If "begin_time" and/or "end_time" and/or "time_orig" are also given, these columns shall appear on the right of "time" and on the left of all other columns.
#enddata			1	m		End of the data section. Last line of the data file.
#user_defined_fields	String		2	o	#user_defined_fields yes	Options are "yes" and "no". No: Only field names from Tables 2 to 8 are used. Yes: Additional user field names are used (e.g. variables defined by the user that are not included in Table 8).
#user_defined_fields_reference	String		2	o	#user_defined_fields_reference www.example.com/mesor_specific_extensions.pdf	Gives a reference of where a description of the extension can be found. Can be on the internet or local environment.

Table 2 – IPR header fields

Field name	Data type	Unit	Complexity level	mandatory/ optional	Example	Description
#IPR. source.name	String		1	o	#IPR.source.name ExampleName	Name of the source providing the data.
#IPR. source.URL	String		1	o	#IPR. source.URL www.example.com	URL of the source.
#IPR.copyrightText	String		1	o	#IPR.copyrightTextcopyright Creative Commons License	Copyright information.
#IPR.contact	String		1	o	#IPR.contact	Contact for copyright issues.

Table 3 – Location fields

Field name	Data type	Unit	Complexity level	mandatory/ optional	Example	Description
#location.latitudeDegrN	Float	degreeNorth	1	m	#location. latitudeDegrN 48,3	Latitude in degree: North positive, South negative.
#location.longitudeDegrE	String	decimal degree	1	m	#location. longitudeDegrE 8,3	Longitude in degree: East positive, West Negative.
#location.elevationMAMSL	Float	meter	1	m	#location.elevation 100	Elevation in metres above mean sea level.

Table 4 – Time fields

Field name	Data type	Unit	Complexity level	mandatory/ optional	Example	Description
#time.timezone	String [UTC+/-hh:mm]		1	m	#time.timezone UTC+01:00	Timezone of all timestamps in the document relative to UTC. Timezone switching within a file (e.g. daylight saving time) is not allowed.
#time.tst	yes/no		1	o	#time.tst yes	Indicates if true solar time is used in the field. "#time.timezone" has no meaning is this case.
#time.resolutiontype	String		1	m	#time.resolutiontype fixed	"fixed" if the time resolution is the same throughout the data file. "mixed" if time resolution changes.
#time.resolutionSec	Float	seconds	1	m	#time. resolutionSec 3600	If "#time.resolutiontype" is set to "fixed", this keyword describes the integration interval between two lines. It is set in seconds.
#time.averaging	String		1	m	#time.averaging yes	Options are "yes", "no" and "sums". "yes" if the data represent averages sampled during the intervals of length "#time.resolution". "no" if the data represent instantaneous measurements collected at the given time stamps. "sums" means that the temporal integral of the parameter within the defined time interval is provided.
#time.completeness	String		1	o	#time.completeness no	Describes if the data set is complete without missing timestamps. Default is no.
#time.calender.leap_years	String		1	o	#time.calender.leap_years yes	Describes if the data file contains leap years. The default is yes.

Table 5 – Gap treatment

Field name	Data type	Unit	Complexity level	mandatory/ optional	Example(s)	Description
#gap.notanumber	String		1	m	#gap.notanumber NaN #gap.notanumber-9999,9	Defines how invalid or missing values are treated. Can be overwritten for each individual channel by specific channel directive. Recommended value is -9 999,9.
#gap.treatment	String		1	m	#gap.treatment missingline	Options are "missingline" and "lineWithNaN". "missingline" means that lines can be missing (only valid for "#time.resolutiontype" fixed). For "lineWithNaN", all values for a missing or invalid timestamp are given as the selected value from "#gap.notanumber".
						"missingvalue" means gaps are filled with special values (see channel specific description).
						"interpolated" means gaps are interpolated.

Table 6 – Quality control

Field name	Data type	Unit	Complexity level	mandatory / optional	Example(s)	Description
#QC.type.*number*	String		1	o	#QC.type.1 MESoR	Type of quality control applied, for example "BSRN", "MESoR", "SANDIA".
					#QC.type.2 BSRN	If multiple QCs have been applied, several lines of QC.type are allowed. QC.type lines should be numbered as QC.type.1, QC.type.2, ….
#QC.reference.*number*	String		1	o	#QC.type.1 http://www.mesor.org/MESoR_QC.pdf	Reference to type of applied QC tests (citation of paper or URL).
						If multiple QCs have been applied, several lines of QC.reference are allowed. QC.reference lines should be numbered as QC.reference.1, QC.reference.2, …. Numbers should correspond to QC.type.
#QC.operator.*number*	String		1	o	#QC.operator.1 John Smith	Who applied the QC. Indicates name and affiliation or email.
#QC.reviewer.*number*	String		1	o	#QC.reviewer.1 Thomas Williams	Indicates reviewer name and affiliation or email.
#QC.checkedat.*number*	Date		1	o	#QC.checkedat.1 2016-02-08	YYYY-MM-DD.
#QC.approver.*number*	String		1	o	#QC.approver.1 –Tim Harris	
#QC.approvaldate	Date		1	o	#QC.approvaldat.1 2016-02-09	YYYY-MM-DD.
#QC.inchannel.*number*	String		2	o	#QC.inchannel.1 MESoRQCflag	Cross-reference to the channel which contains the results of the QC.

Table 7 – Key words for the channel description

Field name	Data type	Unit	Complexity level	mandatory / optional	Example	Description
#channel.*sign*.name	String		1	m	#channel.ghi.name Global horizontal irradiance	channels in the order they appear in the data section. sign is something like a sign in Formula, e.g. ghi. Suggested values for sign are described below. *description* is a description of the data "Global horizontal irradiance"
#channel.*sign.units*	String		1	m	#channel.ghi.unit W/m2	Unit of the channel. Note that the units for signs listed in Table 7 are mandatory. It is also mandatory to state the unit especially if the sign is user defined.
#channel.*sign*.type	String		1	o	#channel.ghi.type global horizontal irradiance	Indicates the type of meteorological variable which is recorded in the channel.
#channel.*sign*.calibration.text	String		1	o	#channel.ghi.calibration.text The sensor has been calibrated according to....	Description of the calibration applied, including date. Sign has to be equal to the corresponding channel.
#channel. *sign*.calibration.date	String	DATE as YYYY-MM-DD	1	o	#channel.dni.calibration.date 2014-12-02	When the calibration certificate/protocol was created.
#channel. *sign*.calibration.responsivity	Float	Given in #channel. *sign*.calibration.unit	1	o	#channel.dni.calibration.responsivity 10.1	Responsivity of the instrument derived in the specified calibration protocol/certificate.
#channel. *sign*.calibration.unit	String		1	o	#channel.dni.calibration.unit 10E-6 V/W/m^2	Unit of #channel. *sign*.calibration.responsivity.
#channel.*sign*.calibration.*XXX*	Tbd		2	o	#channel.ghi.calibration.offset	XXX can be further user defined fields. If these fields are used, then #user_defined_extensions should be set to yes.
#channel.*sign*.correction.text	String		1	o		Description of correction functions applied; sign has to be equal to the corresponding channel.
#channel.*sign*.correction.XXX	Tbd		1	o	#channel.ghi.correction.shadowbandwith 10	XXX can be further user defined fields. If these fields are used, then #user_defined_extensions should be set to yes.
#channel.*sign*.comment	String		1	o	#channel.ghi.comment This is a comment	Channel specific comments.

Field name	Data type	Unit	Complexity level	mandatory / optional	Example	Description
#channel.*sign*.QC..text.*number*	String		2	o	#channel.ghi.qc.text.1 Specific comment to the QC of this channel	Quality control type for specific channel.
#channel.*sign*.QC.inchannel.*number*	String		2	o	#channel.ghi.qc.inchannel.1 GHIQCflag1	Cross-reference to the channel which contains the results of the QC.
#channel.*sign*.QC.reference	String		2	o	#channel.ghiqfcflag1.qc.reference ghi	Cross-referece from the QC channel back to the channel the QC belongs to.
#channel.*sign.QC.XXX.number*	Tbd		2	o	#channel.ghi.qc.tolerance 0.05	XXX can be further user defined fields. If these fields are used, then #user_defined_extensions should be set to yes.
#channel.*sign*.missing_value	String		1	o	#channel.ghi.missing_value -9999.9	Defines how missing values are treated for this channel, for example with -9 999,9
#channel.*sign*.instrument.text	String		1	o	#channel.ghi.instrument.text ventilated ACME X1	Description of the instrument used for this channel.
#channel.sign.instrument.azimuth Degr	Float	degree	1	o	#channel.ghi.instrument.azimuthDegr 0	Azimuth orientation of a tilted instrument. Angle in degrees measured from north towards east.
#channel.sign.instrument.zenithDe gr	Float	degree	1	o	#channel.ghi.instrument.zenitDegr 45	Zenith angle of a tilted instrument. Angle relative to the horizontal plane in degrees.
#channel.*sign*.instrument.*XXX*	Tbd		2	o	#channel.ghi.instrument.serial 123456789	XXX can be further user definded fields. If these fields are used, then #user_defined_extensions should be set to yes.
#channel.*sign*.interpolation.text	String		2	o	#channel.ghi.interpolation.text Missing values have been filled by linear interpolation.	Description of interpolation used, for example for missing values.
#channel.*sign.interpolation.XXX*	Tbd		2	o	#channel.ghi.interpolation.maxslots 3	XXX can be further user defined fields. If these fields are used, then #user_defined_extensions should be set to yes.
#channel.*sign*.uncertainty	Float		1	o	#channel.ghi.uncertainty 2.0	Estimate for the measurement uncertainty of the measurands. Note that the real uncertainty of the measurands depends heavily on the measurement conditions in most cases and shall therefore be given as a time series.
#channel.*sign*.uncertaintyunit	String		1	o	#channel.ghi.uncertaintyunit percent	Unit of the estimate for the measurement uncertainty of the measurands. For relative uncertainties use the unit percent (spelled out).

Field name	Data type	Unit	Complexity level	mandatory / optional	Example	Description
#channel.*sign*.status_update	String		1	o	#channel.ghi.status_update 2015-01-01 12:45 2015-01-03 9:00 sensor failure	Status information similar to the general field #status_update, here channel specific.

For channels, calibration and correction information, the following signs in Table 8 shall be used. The sign values are inspired by the climate and forecasting conventions at http://cfconventions.org. Only the irradiance fields follow the usual definitions in solar energy.

The list is user extendable. Measurand and parameters that are not contained in the list can be included with self-defined signs. This sign should follow the conventions for the used string, the data type and its unit to ease data interoperability.

Table 8 – Meteorological file format: variables

Sign	Data type	Unit	Description
time	TIME (ISO 8601)	YYYY-MM-DDThh:mm:ss	Timestamp to which the data in each line belongs. ISO 8601 format shall be used, YYYY-MM-DDTHH:MM:SS.ssss. If #time.averaging yes, then the timestamp is related to the end of the integration period. Shall be the first column from the left in the data section.
begin_time	TIME (ISO 8601)	YYYY-MM-DDThh:mm:ss	Timestamp of the beginning of the integration interval.
end_time	TIME (ISO 8601)	YYYY-MM-DDThh:mm:ss	Alternative to time if begin_time is used.
julian	Float	day	Julian date. The timestamp refers to the end of the integration period.
begin_julian	Float	day	Julian date at the beginning of the integration interval.
end_julian	Float	day	Julian data at the end of the integration interval.
time_orig	TIME (ISO8601)	YYYY-MM-DDThh:mm:ss	Additional timestamp for each line. Depending on the setting for "#datasource", the sign corresponds to the following explications. For "synthetic" or "mixed", this timestamp refers to the time from which the data has been taken, for example to create a typical meteorological year. For "forecast", the timestamp indicates the time at which the forecast was created. For this timestamp, the ISO 8601 format shall be used (YYYY-MM-DDTHH:MM:SS.ssss). If the data in the line belongs to an integration period (setting #time.averaging yes), then the timestamp is related to the end of the integration period. This sign is mandatory if "#datasource" is "synthetic", "mixed" or "forecast".
ghi	Float	W/m²	Global horizontal irradiance: Solar radiation from upper hemisphere on a horizontal plane. Equal to total irradiance or shortwave downwelling in climatology.
dni	Float	W/m²	Direct normal solar irradiance: Radiation on a plane always normal pointing towards the sun.
dhi	Float	W/m²	Diffuse irradiance on a horizontal plane.
gtiXX	Float	W/m²	Global tilted irradiance on a plane inclined towards the equator. The XX denotes the inclination in degrees. 0° is a horizontal plane. gti00 equals GHI.

Sign	Data type	Unit	Description
ghiqcflag	Float		Flag for quality control.
dniqcflag	Float		Flag for quality control.
dhiqcflag	Float		Flag for quality control.
gtiXXqcflag	Float		Flag for quality control.
relative_humidty	Float	percent	Ambient air relative humidity in percent.
air_temperature	Float	degree Celsius	Ambient air temperature in °C.
air_pressure	Float	hPa	Ambient air pressure in hPa.
wind_speed	Float	m/s	Wind speed in m/s.
wind_from_direction	Float	degree	Wind direction in degree north.
wind_speed_of_gust	Float	m/s	Maximum wind speed in the integration interval.
dew_point_temperature	Float	degree Celsius	Dew point temperature in °C.
solar_elevation_angle	Float	degree	Average solar elevation in the integration interval.
number_of_observations	Float		If data is aggregated from a higher temporal resolution, the number of values which were used, for example if minute data are aggregated to hourly values, it should be 60 if no data were missing.
precipitation	Float	mm	Precipitation.
solar_azimuth_angle	Float	degree	Solar azimuth angle, measured from north and eastward.
solar_zenith_angle	Float	degree	Solar zenith angle.
NOTE The given units are mandatory.			

The next box gives an example of such a data file.

```
#MET_IEC.ver1  headerlines:63
#characterset ISO/IEC-8859-1
#delimiter space
#endofline \n
#title Example
#history.2015-10-29T09:45:07 converted from original by MDMS
#history.2015-10-29T09:45:093 by John Doe
#datasource measured
#user_defined_fields yes
#IPR.institution.name ExampleName
#IPR.copyrightText ExampleCR
#IPR.contact someone@example.com
#location.latitudeDegrN 37.5987
#location.longitudeDegrE -2.3744
#location.elevationMAMSL 498
#time.timezone UTC+01:00
#time.resolutiontype fixed
#time.resolutionSec 3600
#time.averaging yes
#time.completeness no
#time.calender.leap_years no
#gap.notanumber -9999.9
#gap.treatment missingline
#channel.time.name time
#channel.time.unit YYYY-MM-DDThh:mm:ss
#channel.ghi.name global horizontal irradiance
#channel.ghi.unit W/m2
#channel.ghi.calibration.text Calibrated by manufacturer
#channel.ghi.calibration.responsivity 10.2
#channel.ghi.calibration.unit 10E-6 V/W/m^2
#channel.ghi.calibration.date 2014-12-02
#channel.ghi.correction.text none
#channel.ghi.instrument.text ACME ModelX1, ventilated with ACME Y3 (10 W heating)
#channel.ghi.instrument.manufacturer ACME
#channel.ghi.instrument.model Model X1
#channel.ghi.instrument.serial 12345678
#channel.dni.name direct normal irradiance
#channel.dni.unit W/m2
#channel.dni.calibration.text Calibrated by manufacturer
#channel.dni.calibration.responsivity 10.3
#channel.dni.calibration.unit 10E-6 V/W/m^2
#channel.dni.calibration.date 2014-12-01
#channel.dni.correction.text cosine correction according to manufacturer
#channel.dni.missing_value -9999.9
#channel.dni.instrument.text ACME ModelX2 on solar tracker model Y1 with sun sensor from ACME
#channel.dni.instrument.manufacturer ACME
#channel.dni.instrument.model ACMEModelX2
#channel.dni.instrument.serial 12345678
#channel.dhi.name diffuse horizontal irradiance with shadowball
#channel.dhi.unit W/m2
#channel.dhi.calibration.text Calibrated by manufacturer
#channel.dni.calibration.responsivity 10.3
#channel.dhi.calibration.unit 10E-6 V/W/m^2
```