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SUPPORT THE DISSEMINATION AND ROLL-OUT OF THE SET OF ENERGY PERFORMANCE OF BUILDING STANDARDS DEVELOPED UNDER EC MANDATE M/480

Report on Case Study to EN ISO 52010-1 – Climatic Data

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Abbreviations and acronyms in this document:

CEN	**European standards organization**
EN	**European standard**
EPBD	**Energy Performance of Buildings Directive**
EPB standard	**Standard for the calculation of energy performance of buildings, that complies with the requirements given in ISO 52000-1, CEN/TS 16628 and CEN/TS 16629 or later updates**
ISO	**International organization for standardization**
MS	**EU Member State(s)**
NA (/ND)	**National Annex or National Datasheet for EPB standards**
NSB	**National Standards Body of CEN and/or ISO**
TRY	**Test Reference Year**
TMY	**Typical Meteorological Year**
TR	**Technical report (of CEN and/or ISO)**

1 Introduction

This document is intended to present the case study and to discuss the contents of EN ISO 52010-1:2017, *Energy performance of buildings — External climatic conditions — Part 1: Conversion of climatic data for energy calculations*.

It also shows how the output can be directly used as input for EN ISO 52016-1 *Energy performance of buildings — Energy needs for heating and cooling, internal temperatures and sensible and latent heat loads — Part 1: Calculation procedures (ISO 52016-1:2017).* The climatic data are obviously an important input for the calculation of the energy needs and internal temperatures of a building.

However, the output is also intended to be used as input for other EPB standards, such as the standards on photovoltaic systems and thermal solar systems.

EN ISO 52016-1 contains a choice between a monthly or hourly calculation interval. An hourly calculation interval is strongly preferred for reasons explained e.g. in webinars 4 and 8 [7]. An hourly calculation interval requires that hourly climatic data are available. Consequently, in this document also attention is paid to demonstrate how publicly available hourly datasets for all locations in Europe (and beyond), made available by the EC Joint Research Centre can be easily generated, converted and used.

Some of the work has been applied in the frame of webinars from the EPB Center, recordings of which are available under https://epb.center/support/webinars/.

2 Executive summary

The case study on this EPB standard concentrated on the demonstration of the calculation procedures applied to different sources of data:

- The Test Reference Years according to NEN 5060:2018 in The Netherlands,
- The reference climate for the IEA / ANSI BESTEST cases (Dry Cold climate of Denver, Col., USA).
- Three datasets generated by the JRC TMY climatic data generator.

The main objective was to show that the module correctly handles the hourly input data for a full year and to show that the conversion of hourly solar irradiance on a horizontal plane to the solar irradiance of a plane at any arbitrary orientation and tilt angle works correctly and easily.

The calculations also demonstrate that the hourly output from EN ISO 52010-1 can be used (read in) directly as input for other EPB standards, in particular EN ISO 52016-1 (including hourly solar position, distinction between direct and diffuse irradiance (for shading by obstacles and for control of blinds).

The calculations with the datasets generated by the JRC TMY climatic data generator also demonstrate that the working of the conversion tool that has been made to convert the output from the JRC generator into input for EN ISO 52010-1.

Note that this means that a general-purpose tool is now available to generate climatic data for any location in Europe and beyond. This might be very important for countries that intend to use the hourly calculation procedures, but until now did not have hourly climatic data (publicly) available.

This tool has been used throughout the other case studies: to produce input for the energy needs for heating and cooling, but also to produce input for the thermal solar and photovoltaic systems.

3 The context of the case study

ISO 52010-1:2017 specifies a calculation procedure for the conversion of climatic data for energy calculations.

The main element in ISO 52010-1:2017 is the calculation of solar irradiance on a surface with arbitrary orientation and tilt. A simple method for conversion of solar irradiance to illuminance is also provided.

The solar irradiance and illuminance on an arbitrary surface are applicable as input for energy and daylighting calculations, for building elements (such as roofs, facades and windows) and for components of technical building systems (such as thermal solar collectors, PV panels).

Other parameters of climatic data needed to assess the thermal and moisture performance of buildings, building elements or technical building systems [like wind, temperature, moisture and long-wave (thermal) radiation] are to be obtained according to the procedures in ISO 15927-4. These data are listed in ISO 52010-1:2017 as input and passed on as output without any conversion.

The reason for passing these data via ISO 52010-1:2017 is to have one single and consistent source for all EPB standards and to enable any conversion or other treatment if needed for specific application.

Note that it is not the intention of this case study to explain the calculation procedure of the standard. This is extensively done in the technical report that accompanies the standard: CEN ISO/TR 52010-2.

4 Coverage of the scope

4.1 Introduction

Main element of the scope:

> The main part of the scope of EN ISO 52010-1 is the calculation of solar irradiance on a surface with arbitrary orientation and tilt, based on hourly total and diffuse solar irradiance on a horizontal surface as input data.
>
> So what has to be tested and demonstrated is the capability of the calculation procedures in EN ISO 52010-1 to calculate the solar irradiance on an arbitrary plane, using available hourly input data.

Effect of solar shading:

> Optionally the standard includes the effect of shading by distant objects.
>
> However, in case of overlapping shading objects, serious errors may occur if the impact of shading objects is calculated separately. For instance: the calculation of the impact of a hill as part of EN ISO 52010-1 and as a separate next step, as part of EN ISO 52016-1, the impact of an adjacent building which lies in the same direction. Therefore, it is recommended that the calculation of the effect of shading by external objects is done in the application standard where the position, location and all surroundings of the irradiated surface are known and can be taken into account in a combined way.
>
> This is covered in a separate case study on EN ISO 52016-1/solar shading.
>
> Nevertheless, solar shading cannot be disregarded when it comes to the required input from EN ISO 52010-1 in standards: to enable the calculation of the impact of solar shading by obstacles, the output of EN ISO 52010-1 provides the hourly solar irradiance not only as a total, but also as diffuse component. Further output needed for the calculation of the impact of shading is the position of the sun. So this case study will show that these data are also available.

Because all other than solar irradiance data are transferred without any conversion from the source climatic dataset to the output of EN ISO 52010-1 these are left out from the case study. With exception for the conversion of relative to absolute humidity (see 6.1.2.2).

The other climatic data than solar irradiance that are transferred in line with EN ISO 52010-1, for the purpose of energy calculations are:

- Air temperature
- Wind speed
- Wind direction
- Air pressure
- Air moisture content

Plus:

- Solar altitude
- Solar azimuth
- Solar reflection coefficient of the ground (optional, if not assumed to be constant)

4.2 Coupling and complementing

The coupling of the calculation procedures of EN ISO 52010-1 to the application, such as EN ISO 52016-1 is illustrated in Figure 1.

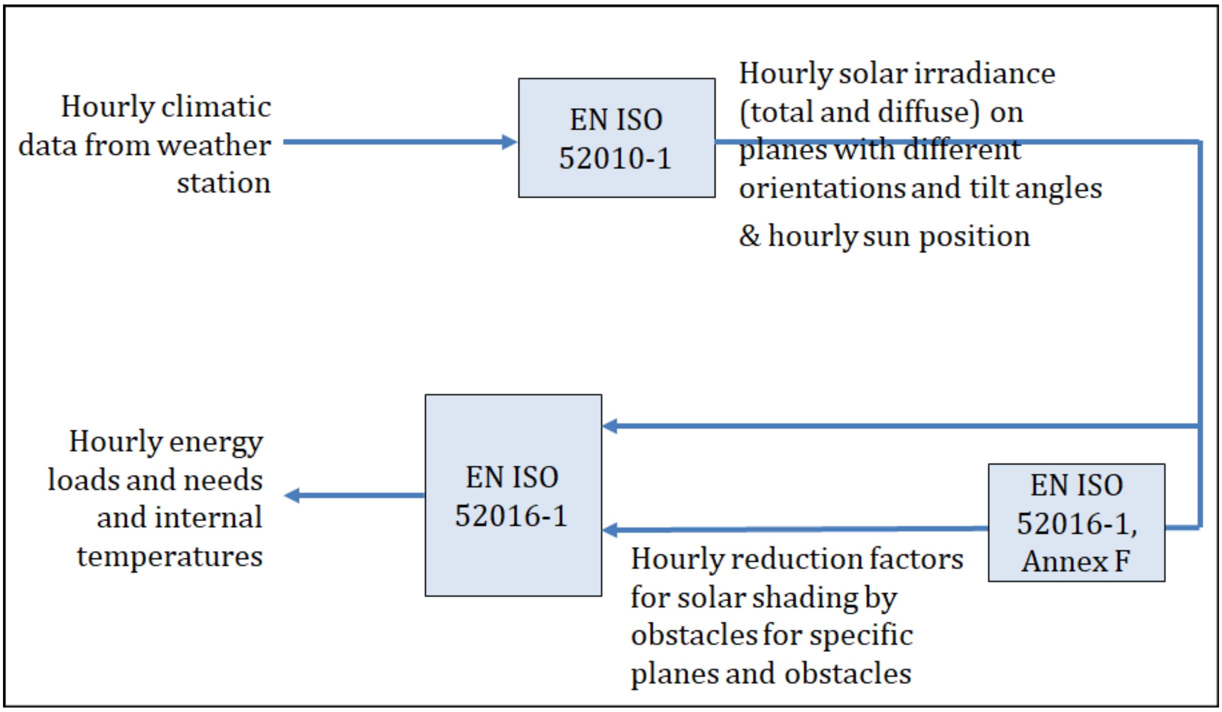


Figure 1 - Principle of the coupling of the calculation modules linked to EN ISO 52010-1; for example: with EN ISO 52016-1

In this case study the calculations are limited to the output of EN ISO 52010-1. As can be seen from Figure 1 the data stream is one-directional: no interactions involved, other than the orientation and tilt angles of the planes (the building elements in EN ISO 52016-1, the collectors in thermal solar systems, the PV panels in the standard(s) on photovoltaic systems, etc.

5 Definition of the cases

5.1 Rationale of the selection of cases

For the demonstration of the intended effects, a selection of climates and a series of planes with different orientation and tilt angles is needed. For the selection of climates, sources of input data are needed.

5.2 Sources of input data

Test Reference Years

As a first choice of input data, two examples of a so called Test Reference Year (**TRY**) are taken.

In short, a test reference year is composed of hourly measured data from a specific weather station, covering a series of successive (e.g. 20) years. For each month (January, February, ...), a month from the dataset is selected that is the most representative for the whole multi-year period. This procedure is described in EN ISO 15927-4. The test reference year is the combination of the 12 months that have been selected in this way.

EXAMPLE Period of data 1990-2014. TRY: Jan. 2012 + Feb. 2005 + March 1998 + ...

For this case study the **TRY** data from weather station **De Bilt** (The Netherlands, [7]) have been chosen. These are described in a national standard, NEN 5060:2018, that is in line with EN ISO 15927-4. Earlier versions of these data were also used for the examples in CEN ISO/TR 52016-2:2017.

As a second example of the use of **TRY** data, the reference climate for the IEA / ANSI BESTEST cases (**Dry Cold** climate of Denver, Col., USA, [8]) is taken. These data were also used for the reference cases in EN ISO 52016-1:2017.

Both data files were also used as examples for the EN ISO 52010-1 spreadsheet tool distributed on Nov.20, 2019.

JRC TMY dataset generator:

To solve any concern about the availability of hourly climatic data, another source is taken to provide hourly input climatic datasets:

A set of meteorological data (a Typical Meteorological Year, **TMY**), with data values for every hour in a year for a given geographical location, can be generated using a tool developed and made available by the EC Joint Research Centre (**JRC**).

This procedure, based on the relevant EN-ISO standards, allows to quickly generate the climatic data (both hourly and monthly) for a standardized energy performance calculation, for virtually any location in the world from a single official EU source.

Link:https://re.jrc.ec.europa.eu/pvg_tools/it/#TMY

The EPB Center has developed a spreadsheet tool to process and convert it to a file that can be readily used as input for the Excel file on EN ISO 52010-1 (conversion of measured climatic data to climatic data needed for energy calculations).

Link: https://epb.center/support/documents/tmy-iso-52010-1_conversion/

See illustration in Figure 2.

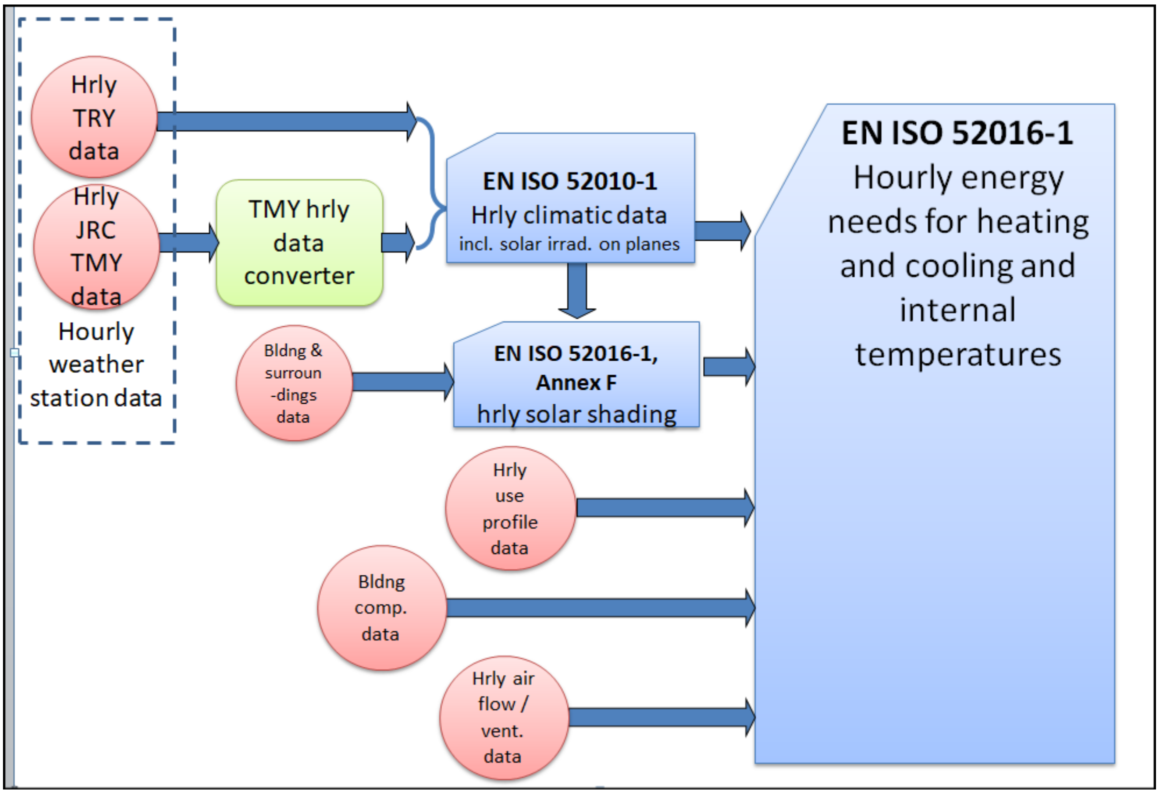


Figure 2 - The application of the TMY hourly climatic data converter

5.3 Climates

Three basic climatic data sets have been prepared for typical cold (**Oslo**), average (**Strasbourg**) and warm (**Athens**) climate. See also the Case Studies Preparation document [9].

They have been compared with data used for Eco-design and Ecolabeling purpose.

These data sets were also used as examples for the conversion tool distributed on Jan. 5, 2021 (but now with a minor error in time zone for Athens removed).

5.4 Planes

Selected orientation and tilt angles:

- the 4 main orientations North, East, South and West, vertical
- the 4 main orientations North, East, South and West, 45 degrees tilted towards the sky
- horizontal, facing upwards

The calculated solar irradiance for the horizontal orientation is interesting, because the output can be compared with the input data (solar irradiance on a horizontal plane).

5.5 List of selected cases and variants

5.5.1 Case 1, Test Reference Years

5.5.1.1 Variant 1, De Bilt (NL)

- Calculation of annual minimum, average and maximum of the hourly values.
- Comparison of the hourly values of measured (input) and calculated irradiance on a horizontal plane.
- Examples of plots of diffuse versus total solar irradiance
- Monthly mean total solar irradiance values

5.5.1.2 Variant 2, DRY COLD (ASHRAE 140)

- Comparison against BESTEST reference results

5.5.2 Case 2, TMY-JRC datasets

5.5.2.1 Oslo

- Example of time series of the most relevant climatic data.
- Comparison with (BIN) data used for Eco-design and Ecolabeling purpose

5.5.2.2 Strasbourg

Similar as for Oslo

5.5.2.3 Athens

Similar as for Oslo

6 Calculation details

6.1 Calculation tools

6.1.1 EN ISO 52010-1 spreadsheet

6.1.1.1 Introduction

The version of the spreadsheet about EN ISO 52010-1 published in November 2019 has been used for the case study on EN ISO 52010-1.

Link: https://epb.center/support/documents/demo-en-iso-52010-1/

6.1.1.2 Explanation and demonstration

6.1.1.2.1 General

The spreadsheet has as input the hourly total and diffuse solar irradiance on a horizontal plane. These are common data from a weather station.

Also the other relevant weather input data from the weather station are read in, but only to be transferred in a common format to the output file. In this way, the output file is directly suited as input file for an application such as the spreadsheet on EN ISO 52016-1 (calculation of energy needs for heating and cooling and internal temperature) but e.g. also as input for the spreadsheet on EN ISO 52016-1, Annex F (calculation of the solar shading reduction factors) as shown in the previous Figure 2.

6.1.1.2.2 Stand-alone use

The spreadsheet tool can be run as a stand-alone tool: the location and time zone of the weather station data are filled in, as well as the orientation and tilt angle of the plane for which the solar irradiance is to be calculated and the hourly solar irradiance data are copied into the spreadsheet. The calculation will then produce the hourly (total and diffuse) solar irradiance on this plane, as well as other information needed in the application, such as the hourly sun position.

The kind of input data are illustrated in Figures 3 to 5:

	A	B	C	D	E
10	Latitude (N=90, S=-90)	φ_{w}	deg	37,976	-90 to +90
11	Longitude (E=pos., W=neg.)	λ_{w}	deg	23,736	-180 to +180
12	Elevation (in meters above sea level)	h_{w}	m	96	-500 to +9000
13	Time zone	TZ	h	2	-12 to +12
14					
15	**Calender details**	**Symbol**	**Unit**	**Value**	**Typical range**
16	Day of the week for January 1	n_{wkday1}		1	Monday to Sunday (day 1 to 7)
17	Daylight saving time?			Time is derived from UTC and the Time zone without taking into account daylight saving time. Daylight saving time can be taken into account in the application	Example of possible input: — Applicable for this station and taken into account *<not supported in the spreadsheet on ISO 52010-1!>*; — Applicable for this station but disregarded; — Not applicable for this station.
18	Leap day included			No	Yes/No *<"Yes" is not supported in the spreadsheet on ISO 52010-1!>*

Figure 3 - Example of part of the input (1): weather station details (in this case: Athens).

Identifier for Orientation & Tilt (free choice of short abbrev., same as used in applic., e.g. XLS on ISO 52016-1)	*id*	-	S45	text
Orientation angle of the inclined surface, expressed as the geographical azimuth angle of the horizontal projection of the inclined (S=0, E=pos., W=neg.)surface normal	γ_{ic}	deg	**0**	-180 to +180
Tilt angle of the inclined surface from horizontal, measured upwards facing (Hor.facing upw=0, Vert=90, hor.facing down =180)	β_{ic}	deg	**45**	0 to 180

Figure 4 - Example of part of the input (2): orientation and tilt angle of the plane (in this case: South, 45 degrees tilt angle).

	Optional									
Dry bulb air temperature	Relative humidity of air	Global horizontal irradiance	Direct (beam) normal Irradiance	Diffuse horizontal irradiance	Long-wave irradiance from the atmosphere on a hor. plane	Windspeed at 10 m height	Wind direction from North (N=360, E=90, S=180, W=270, zero=0, variable=990)	Air pressure	Air moisture content or mixing ratio	Ground solar reflectivity
θ_a	φ_a	$G_{sol;g}$	$G_{sol;b}$	$G_{sol;d}$	$G_{l;a}$	u_{10}	D	p_{atm}	$x_a \cdot 10^3$	$\rho_{sol;grnd}$
°C	%	W/m²	W/m²	W/m²	W/m²	m/s	deg	Pa	g/kg dry air	-
9,98	96,7	0	0	0	338,43	6,71	26	100877	7,387	0,2
9,9	96,42	0	0	0	339,29	6,56	24	100884	7,325	0,2
9,82	96,14	0	0	0	340,16	6,41	19	100788	7,271	0,2
9,74	95,86	0	0	0	341,02	6,26	19	100772	7,212	0,2
9,67	95,58	0	0	0	341,89	6,11	19	100755	7,158	0,2
9,59	95,31	0	0	0	342,75	5,96	19	100769	7,098	0,2
9,51	95,03	0	0	0	343,61	5,81	19	100782	7,037	0,2
9,44	94,75	0	0	0	344,48	5,66	20	100795	6,982	0,2
9,36	94,47	24	0	24	345,34	5,51	20	100831	6,921	0,2
9,28	94,19	201	579,44	68	346,21	5,36	20	100867	6,86	0,2
11,98	90,79	349	737,59	86	347,1	5,43	19	100904	7,924	0,2
12,43	86,34	416	607,34	147	350,4	5,05	19	100874	7,762	0,2
12,89	81,89	433	501,37	191	353,7	4,66	18	100844	7,588	0,2
13,34	77,44	390	371,96	214	357	4,28	17	100815	7,389	0,2
13,1	80,57	377	554,19	147	349,78	3,99	19	100811	7,571	0,2
12,86	83,71	55	0	55	342,57	3,71	21	100808	7,746	0,2

Figure 5 - Example of part of the input (3): hourly solar irradiance data from weather station (horizontal, total and diffuse); the other variables are just to pass on the complete set of climatic data and can be ignored for the calculation of the solar irradiations at the plane with specified orientation and tilt

The output is illustrated in Figures 6 and 7:

AN	AO	AP	AQ	AR	AS	AT
S45 (0,45)	S45 (0,45)	S45 (0,45)	S45 (0,45)	S45 (0,45)	S45 (0,45)	
I_{dir}	I_{dif}	$I_{dif;grnd}$	I_{circum}	$I_{dif;tot}$	$I_{dir;tot}$	I_{tot}
26	34	35	36	38	37	39
W/m2	W/m2	W/m2	W/m2	W/m2	W/m2	W/m2
0,0	0,0	0,0	0,0	0,0	0,0	0,0
0,0	0,0	0,0	0,0	0,0	0,0	0,0
0,0	0,0	0,0	0,0	0,0	0,0	0,0
0,0	0,0	0,0	0,0	0,0	0,0	0,0
0,0	0,0	0,0	0,0	0,0	0,0	0,0
0,0	0,0	0,0	0,0	0,0	0,0	0,0
0,0	0,0	0,0	0,0	0,0	0,0	0,0
0,0	0,0	0,0	0,0	0,0	0,0	0,0
0,0	19,1	0,7	0,0	19,8	0,0	19,8
405,0	103,7	6,7	51,4	59,0	456,4	515,3
621,4	125,3	10,9	62,1	74,1	683,6	757,6
566,0	194,2	12,5	91,4	115,3	657,4	772,7
481,8	254,2	12,7	132,0	134,9	613,8	748,8
345,2	281,1	11,3	150,5	141,8	495,7	637,5
462,7	177,0	10,5	65,4	122,1	528,1	650,2
0,0	43,9	1,6	0,0	45,5	0,0	45,5
0,0	29,0	1,0	2,3	27,7	2,3	30,0
0,0	0,0	0,0	0,0	0,0	0,0	0,0
0,0	0,0	0,0	0,0	0,0	0,0	0,0

Figure 6 - Example of part of the output (1): hourly solar irradiance for the plane South 45 degrees (including the more refined composition of the direct and diffuse irradiance components (see explanation in CEN ISO/TR 52010-2)

t_{sol}	ω	$\sin(\alpha_{sol})$	α_{sol}	$\cos(\theta_{sol;ic})$	$\theta_{sol;ic}$	m	I_{ext}	θ_z		$\sin(\varphi_{sol;aux1})$	$\cos(\varphi_{sol;aux1})$	$\varphi_{sol;aux2}$	φ_{sol}
9	10	11	11	17	17	20 - 21	27	12		13	14	15	16
h	deg		deg		deg	-	W/m2	deg		-	-	deg	deg
0,531733333	179,524	-0,966311	0	-0,8651979	149,9053	36,510325	1415,203	90		0,02969746	0,99955893	1,70179	178,298
1,531733333	164,524	-0,94004	0	-0,8321210	146,3172	36,510325	1415,203	90		0,71980929	0,69417187	46,0387	133,961
2,531733333	149,524	-0,866138	0	-0,7390713	137,6524	36,510325	1415,203	90		0,93361673	0,35827337	69,0058	110,994
3,531733333	134,524	-0,749639	0	-0,5923899	126,3268	36,510325	1415,203	90		0,99109549	0,133153	82,3482	97,6518
4,531733333	119,524	-0,598484	0	-0,4020730	113,7078	36,510325	1415,203	90		0,99930485	-0,0372803	87,8635	87,8635
5,531733333	104,524	-0,422973	0	-0,1810904	100,4333	36,510325	1415,203	90		0,98289686	-0,1841569	79,388	79,388
6,531733333	89,524	-0,235067	0	0,0554984	86,81854	36,510325	1415,203	90		0,94653776	-0,322593	71,1802	71,1802
7,531733333	74,524	-0,047572	0	0,2915703	73,04801	36,510325	1415,203	90		0,88769298	-0,4604359	62,5848	62,5848
8,531733333	59,524	0,126735	7,280970373	0,5110372	59,26706	7,460959	1415,203	82,71903		0,79938034	-0,6008253	53,071	53,071
9,531733333	44,524	0,275975	16,0201509	0,6989430	45,65774	3,623511	1415,203	73,97985		0,67121076	-0,7412666	42,1606	42,1606
10,53173333	29,524	0,389978	22,95315313	0,8424821	32,59684	2,564245	1415,203	67,04685		0,49237211	-0,8703848	29,4966	29,4966
11,53173333	14,524	0,460975	27,45003393	0,9318726	21,27138	2,169316	1415,203	62,54997		0,26000785	-0,9656065	15,0705	15,0705
12,53173333	-0,476	0,484127	28,95527375	0,9610226	16,04962	2,065575	1415,203	61,04473		-0,0087354	-0,9999618	-0,5005	-0,5005
13,53173333	-15,476	0,457856	27,24885087	0,9279457	21,88318	2,184092	1415,203	62,75115		-0,2761453	-0,9611159	-16,03	-16,03
14,53173333	-30,476	0,383953	22,57877368	0,8348960	33,39499	2,604484	1415,203	67,42123		-0,5053616	-0,8629077	-30,355	-30,355
15,53173333	-45,476	0,267455	15,51285982	0,6882147	46,51105	3,738952	1415,203	74,48714		-0,6807531	-0,732513	-42,903	-42,903

Figure 7 - Example of part of the output (2): hourly intermediate calculation results, enabling to follow the calculation step by step. Here you find also the sun position (altitude and azimuth angle) that is needed for the application: calculation of solar shading reduction factors

					South is 0, East pos; in CAD conventions North = 0								
	Monthly total (kWh/m2)				0 = horizontal up , 90 vertical, 180 facing down								Monthly av
	Measured			Calculated									Calculated
				Plane (azim, tilt):	S45 (0,45)	S45 (0,45)	S45 (0,45)	S45 (0,45)	S45 (0,45)	S45 (0,45)	S45 (0,45)		S45 (0,45)
	$G_{sol;g}$	$G_{sol;b}$	$G_{sol;d}$	(*)	$H_{dir;m}$	$H_{dif;m}$	$H_{dif;grnd;m}$	$H_{circum;m}$	$H_{dif;tot;m}$	$H_{dir;tot;m}$	$H_{tot;m}$		$I_{tot;m}$
	kWh/m²	kWh/m²	kWh/m²		kWh/m²	kWh/m²	kWh/m²	kWh/m²	kWh/m²	kWh/m²	kWh/m²		W/m²
Jan.	68	86	32		73	39	2	17	24	90	114		153,1
Feb.	74	71	39		57	43	2	17	28	73	102		151,4
March	138	139	56		105	59	4	25	38	131	168		226,4
April	168	156	67		103	65	5	26	44	129	173		239,6
May	218	212	69		126	64	6	25	45	151	196		263,3
June	247	261	60		145	55	7	25	38	170	208		288,7
July	242	256	64		143	59	7	26	40	169	209		281,3
Aug.	228	258	55		163	56	7	28	35	191	226		303,8
Sept.	154	152	59		113	61	5	27	39	140	179		248,7
Oct.	127	154	45		120	53	4	24	32	144	176		237,1
Nov.	78	101	34		84	41	2	18	25	102	127		176,9
Dec.	63	90	28		75	35	2	15	22	90	112		150,3
Year	**1805**	**1936**	**608**		**1308**	**630**	**53**	**273**	**410**	**1581**	**1990**		**227,2**

Figure 8 - Example of part of the output (3): monthly total values, of input (horizontal solar irradiance) and output (total and diffuse solar irradiance on the specified plane

Table 1 gives an example of the files needed and typical names of these files, that otherwise might be confusing, since the ***output*** file for one tool is the ***input*** file for another tool. In this case, it is only one file, as the term stand-alone already suggests.

What	Typical file name	Explanation
Calculation file	Demo_ISO_52010-1_Calc_2019.11.20_run_2021-10-01.xlsm	The actual calculation according to EN ISO 52010-1. First part of the file name is the version of the tool

		Second part of the file name is the identification of the case (in case of automated run: just for the record, because the output Contains a macro (xlsm) for the automated calculation (see next paragraph). The macro may be disabled for the stand-alone use

Table 1: Example of file needed for stand-alone use and typical naming of the file

6.1.1.2.3 Automatic calculation for multiple planes

However, in particular for both applications mentioned here, the calculation needs to be repeated for a **range of orientations and tilt angles**, corresponding to the planes of the building (windows and other façade and roof elements) that are irradiated.

To facilitate this process, the calculation is automatically repeated for all planes, to produce a single file as output that can be readily used as input for the application.

This is illustrated in Figure 9.

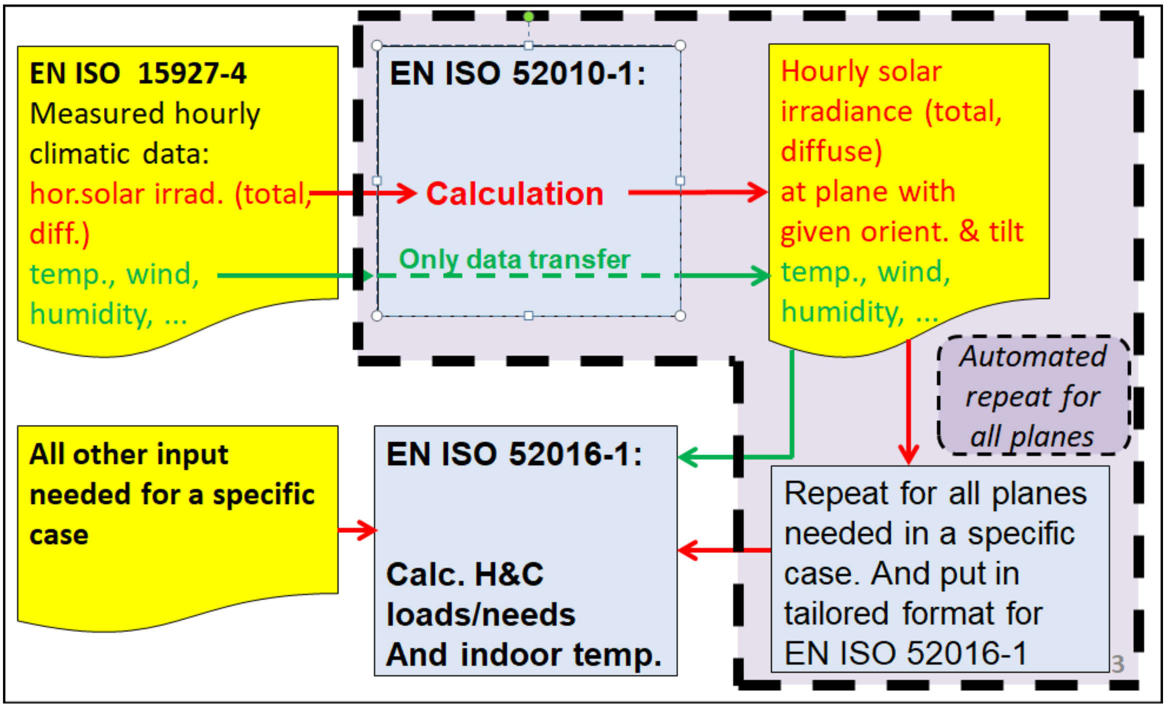


Figure 9 - The routing of the data into and from the spreadsheet on EN ISO 52010-1, with EN ISO 52016-1 as example of the application

To start up this repeated calculation a small configuration file needs to be filled in, that tells the name of the weather data file, the orientation and tilt angles of the planes to be included in the output file and a few other 'administrative' details, see Figure 9.

Format version	2,0	
Name of Excel file with calculation procedures	Demo_ISO_52010-1_Calc_2019.11.20.xlsm	
Name of Excel file with input climate data	Demo_ISO_52010-1_Input_TMY_Athens_2021-10-01_15-40-58.xlsx	
Name of the Excel sheet in that file	data	**Explanation:**
Output file with initialization period (TRUE or FALSE)?	TRUE	If TRUE: in the output file preceded by a copy of the by ISO 52016-1)
Id.	NV	Identifier for orientation
γ_{ic}	180	Orientation angle of the i the geographical azimuth projection of the inclined
β_{ic}	90	Tilt angle of the inclined s measured upwards facing
Id.	EV	As many choices as you li
γ_{ic}	90	
β_{ic}	90	
Id.	SV	As many choices as you li
γ_{ic}	0	

Figure 10 - A small configuration file is used to automatically run the EN ISO 5201-1 spreadsheet multiple times for planes with different orientation and tilt angles and to produce a single output file. The requested input data is in red font on yellow background

The weather station input data are now automatically copied from a separate spreadsheet file that has the same layout as the input data sheet of the tool (compare Figures 3 and 5).

The result is now a separate single Excel file that can be readily used as input for the application, including the hourly solar irradiance for each of the planes listed in the configuration file.

This is illustrated in Figures 11 and 12:

Station name:	Athens
Station note(1):	JRC TMY, selected months, years: 1 = 2013; 2 = 2012; 3 = 2013; 4 = 2011; 5 = 2009; 6 = 2009; 7 = 2013; 8 = 2011; 9 = 2009; 10 = 2007; 11 = 2012; 12 = 2012;
Station note(2):	Selected period 2005-2014
Station note(3):	None
Latitude (degr.):	37,976
Longitude (degr.):	23,736
Elevation (m):	96
Timezone (hr):	2
Calender details------:	
Day/wk Jan.1:	1
DST?:	Time is derived from UTC and the Time zone without taking into account daylight saving time. Daylight saving time can be taken into account in the application
Leapday incl.?:	No
Specific other info:	None
Ref.(e.g.applic.):	Data source: "Photovoltaic Geographical Information System (PVGIS)" https://ec.europa.eu/jrc/en/pvgis European Commission, Joint Research Centre (JRC) PVGIS © European Union, 2001-2020.

Figure 11 - Example of part of the output file that is fit as input file readily usable as input e.g. for the spreadsheets on EN ISO 52016-1 and EN ISO 52016-1, Annex F. (1) part of the weather station details

									Isol = Calculated irradiance (tot. resp. diff.)											
							Identification of orientation & tilt ->	Id:	NV	NVd	EV	EVd	SV	SVd	WV	WVd	N45	N45d	E45	E45d
							Azimuth (orient.) angle, degrees, S=0, E=pos, W=neg ->	Gamma:	180	180	90	90	0	0	-90	-90	180	180	90	90
							Tilt angle, degrees from horiz. ->	Beta:	90	90	90	90	90	90	90	90	45	45	45	45
Week	Air temp.	Wind speed	Wind dir.	Air pressure	Air moist. content	Solar alt	Solar azim	Grnd refl.	Isol_tot	Isol_dif	Isol_tot	Isol_dif	Isol_tot	Isol_dif	Isol_tot	Isol_dif	Isol_tot	Isol_dif	Isol_tot	Isol_dif
-	Degr. C	m/s	Degrees	Pa	g/kg	degrees	degrees	-	W/m2	W/m2	W/m2	W/m2	W/m2	W/m2	W/m2	W/m2	W/m2	W/m2	W/m2	W/m2
6	8,36	4,37	140	101032	5,969	0	98,6416	0,2	0	0	0	0	0	0	0	0	0	0	0	0
6	8,65	4,24	145	101019	6,117	0	88,9582	0,2	0	0	0	0	0	0	0	0	0	0	0	0
6	8,94	4,11	150	101006	6,268	0	80,0299	0,2	0	0	0	0	0	0	0	0	0	0	0	0
6	9,23	3,97	155	100993	6,423	0,92384	71,0157	0,2	0	0	0	0	0	0	0	0	0	0	0	0
6	9,91	4,71	162	101019	6,667	11,7302	61,2208	0,2	19,2134	19,2134	19,2134	19,2134	19,2134	19,2134	19,2134	19,2134	30,5533	30,5533	30,5533	30,5533
6	10,59	5,45	168	101045	6,917	21,4871	49,9599	0,2	15,5368	15,5368	15,5368	15,5368	15,5368	15,5368	15,5368	15,5368	24,7435	24,7435	24,7435	24,7435
6	11,26	6,19	175	101072	7,171	29,6027	36,571	0,2	46,7247	46,7247	46,9211	46,7247	46,9895	46,7247	46,7247	46,7247	73,7592	73,7592	74,0305	73,7592
6	11,43	6,05	180	101045	7,158	35,2872	20,6905	0,2	51,0261	51,0261	51,1773	51,0261	51,4265	51,0261	51,0261	51,0261	80,4115	80,4115	80,7327	80,4115
6	11,6	5,9	185	101019	7,143	37,7098	2,83336	0,2	119,951	119,951	121,935	119,951	160,04	119,951	119,951	119,951	183,957	183,957	207,304	183,957

Figure 12 - Example of part of the output file that is fit as input file readily usable as input file e.g. for the spreadsheets on EN ISO 52016-1 and EN ISO 52016-1, Annex F. (2) part of the hourly data (weather and solar irradiance on successive planes)

Table 2 gives an example of the files needed and typical names of these files, that otherwise might be confusing, since the ***output*** file for one tool is the ***input*** file for another tool.

What	Typical file name	Explanation
Weather data file	Demo_ISO_52010-1_Input_TMY_Oslo_2021-10-01_15-38-03.xlsx	The file with the weather data, in the format suited to be read in as input for the calculation spreadsheet
Configuration file	Demo_ISO_52010-1_Config_V2.0_TMY_Example_calcs_9_planes_2021-10-01.xlsm	Configuration file specifying which weather data file to read and for which planes the solar irradiance needs to be calculated. The version number refers to the version of the tool. The weather data file is checked if it has compatible version number
Calculation file	Demo_ISO_52010-1_Calc_2019.11.20_run_2021-10-01.xlsm	The actual calculation according to EN ISO 52010-1. First part of the file name is the version of the tool Second part of the file name is the identification of the case (in case of automated run: just for the record, because the output Contains a macro (xlsm) for reading the instructions from the configuration file and to produce the output file.
Output file with climatic data for energy calculations	Demo_ISO_52010-1_Output_TMY_Oslo_2021-10-01.xlsx	The output file with hourly data that can be readily imported as input for an application such as the spreadsheet on EN ISO 52016-1
Input climatic data file for application	Demo_ISO_52010-1_Output_TMY_Oslo_2021-10-01.xlsx	The output from EN ISO 52010-1 is the input for e.g. EN ISO 52016-1. The same name is kept for the file

Table 2: Examples of files needed and produced for the automated runs and typical naming of the files

6.1.2 JRC TMY conversion tool

6.1.2.1 Introduction

For the conversion of the JRC TMY data, the conversion tool was used that has been published in January 2021.

Link: https://epb.center/support/documents/tmy-iso-52010-1_conversion/

6.1.2.2 Explanation and demonstration

The JRC TMY data can be obtained from the JRC website for almost any location in the world.

Disclaimer:

- The European Commission accepts no responsibility or liability whatsoever with regard to the information on their websites (Legal notice)
- The EPB Center is not responsible for the content of external resources or any external site. Any external links are only for the users' convenience and the EPB Center does not endorse or warrant the accuracy or validity of materials posted on any external site (General disclaimer)

Link:

JRC landing page: https://ec.europa.eu/jrc/en/PVGIS/tools/tmy

The JRC tool: https://re.jrc.ec.europa.eu/pvg_tools/en/#TMY

The procedure is simple and on line: select a location, a period of successive years, choose TMY and choose csv as output format. See example in Figure 13:

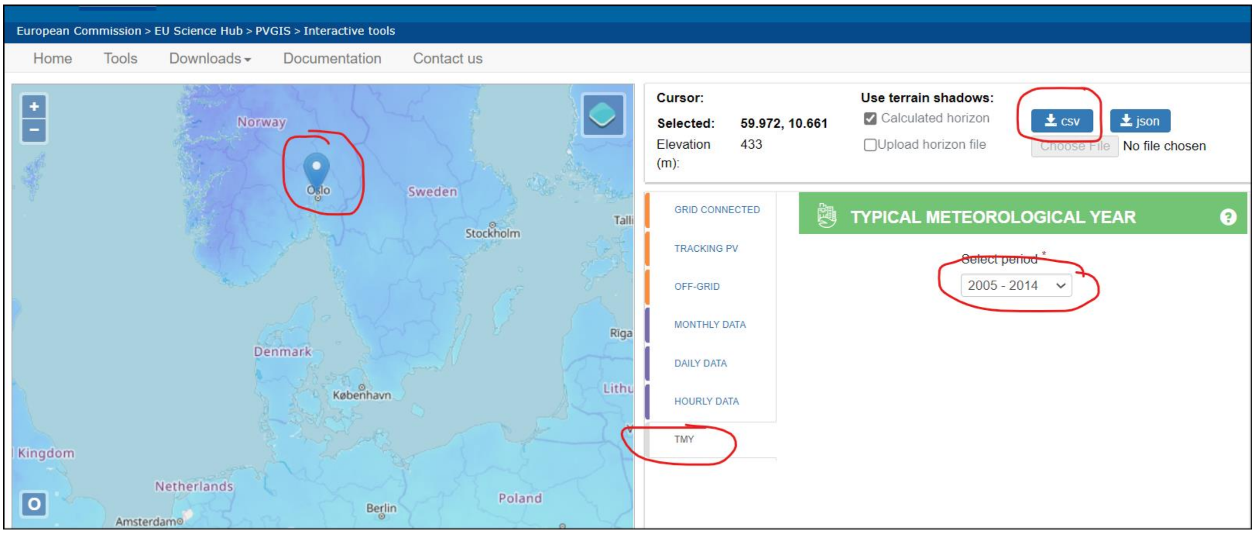


Figure 13 - Example how to obtain a set of JRC TMY climatic data for any location

5.2

The resulting csv file contains the details of the location and chosen parameters plus the hourly weather data, for the most representative months from the multi-year period (like explained in 5.2 for TRY). See example in Figure 14:

	A	B	C	D	E	F	G	H
1	Latitude (decimal degrees): 59.912							
2	Longitude (decimal degrees): 10.750							
3	Elevation (m): 14.0							
4	month,year							
5	1,2008							
6	2,201							
7	3,2009							
8	4,201							
9	5,2012							
10	6,2007							
11	7,2014							
12	8,2007							
13	9,2008							
14	10,2009							
15	11,2013							
16	12,2008							
17	time(UTC),T2m,RH,G(h),Gb(n),Gd(h),IR(h),WS10m,WD10m,SP							
18	20080101:0000,-5.18,85.76,0.0,-0.0,0.0,295.22,3.69,26.0,103388.0							
19	20080101:0100,-5.13,85.26,0.0,-0.0,0.0,294.62,3.88,25.0,103378.0							
20	20080101:0200,-5.07,84.76,0.0,-0.0,0.0,294.02,4.07,24.0,103368.0							
21	20080101:0300,-5.02,84.26,0.0,-0.0,0.0,293.42,4.25,24.0,103378.0							
22	20080101:0400,-4.96,83.76,0.0,-0.0,0.0,292.82,4.44,24.0,103388.0							
23	20080101:0500,-4.91,83.26,0.0,-0.0,0.0,292.22,4.62,24.0,103398.0							
24	20080101:0600,-4.86,82.76,0.0,-0.0,0.0,291.62,4.81,25.0,103412.0							
25	20080101:0700,-4.8,82.26,0.0,-0.0,0.0,291.02,5.0,25.0,103425.0							
26	20080101:0800,-3.28,82.54,0.0,-0.0,0.0,325.6,4.74,26.0,103438.0							
27	20080101:0900,-2.63,82.09,3.0,0.0,3.0,323.25,4.86,27.0,103425.0							
28	20080101:1000,-1.99,81.63,13.0,0.0,13.0,320.9,4.98,29.0,103412.0							
29	20080101:1100,-1.34,81.18,15.0,0.0,15.0,318.55,5.1,30.0,103398.0							
30	20080101:1200,-1.4,81.78,35.0,8.94,34.0,318.38,5.09,32.0,103365.0							
31	20080101:1300,-1.47,82.39,7.0,0.0,7.0,318.22,5.09,33.0,103332.0							
32	20080101:1400,-1.53,82.99,0.0,0.0,0.0,318.05,5.08,34.0,103298.0							

Figure 14 - Example of csv file with JRC TMY climatic data for a given location and multi-year period (in casu: Oslo)

The only step needed now is to convert these data to the common format that is used as input for the spreadsheet on EN ISO 52010-1. , as illustrated in Figure 2 in 5.2. For this purpose the EPB Center developed a simple dedicated spreadsheet tool. See illustrations in Figures 15 and 16.

Climatic data conversion from JRC TMY csv to input file for spreadsheet on ISO 52010-1		
Information	See sheet **Explanation**	
Conversion steps:		
1	Create a csv file with TMY data	
2	Place the csv file in the same folder as this conversion file; ***if the file is opened: please close it***	
3	Place a **Demo_ISO_52010-1_Input file**, as template, in the same folder (an emptied file or an e	
4	Fill in the requested data here below (fields with red font)	
5	Press button "Start conversion"	
6	The result will be stored in a new file (file name includes date and time)	
Description	**Input**	**Explanation**
Conversion format version	2,10	Fixed, used for compatibility check
XLS 52010-1 input format version	2,00	
Source:		
Name of Excel file with JRC TMY data	tmy_37.976_23.736_2005_2014_Athens.csv	Filename
Data missing in the JRC TMY CSV file:		
Climate station name	Athens	Free text
Optional special notes (1)		Will be used to list the selected years per
Optional special notes (2)	Selected period 2005-2014	Free text
Optional special notes (3)	None	Free text

Time zone (h)	2	Only integer values are supported. **Time zon saving time!** The JRC TMY data are in UTC, but in the outpu be presented in the local Time zone time (excl Note that this implies that for Time zone N wi hours of Dec.31 are in fact the first hours of Ja versa for N < 0)
Day of the week for January 1	1	Monday to Sunday (day 1 to 7); relevant for u buildings. For an artificial set of climatic data, is just a conventional value. For comparison i harmonize this information
Daylight saving time (DST)?	Time is derived from UTC and the Time zone without taking into account daylight saving time. Daylight saving time can be taken into account in the application	Fixed input for JRC TMY data
Leap day included	No	Attention: "Yes" is neither supported in the TI the spreadsheet on ISO 52010-1!
Specific other information	None	Free text
Reference to documentation on application range and type of data	Data source: "Photovoltaic Geographical Information System (PVGIS)" https://ec.europa.eu/jrc/en/pvgis European Commission, Joint Research Centre (JRC) PVGIS © European Union, 2001-2020.	Fixed text to acknowledge the source of the da
Ground reflection	0,2	between 0,0 and 1,0 (usually: 0,2). Fixed valu because not available (but assumed) in JRC TI
Destination:		
Name of Demo_ISO_52010-1 Input data file template	TMY-ISO-52010-1_input_Template_2021-10-01.xlsx	Filename (the template for the output of this c
Name of the Excel sheet in that file	Template	Sheetname
Short identifier	Athens	Will be included in the output file name, with conversion. A filename cannot contain any of the followin * ? " < > |
	Start conversion	

Figure 15 - Illustration of the conversion tool. The requested input data is in red font on yellow background

Few details:

- The TMY data in the csv file are given in hours for UTC instead of in hours of local time UTC+N. Consequently a time shift of N hours has been made to obtain the values in local time, starting at the first hour of January 1.
- The conversion of relative to absolute humidity is performed with the formula given in 6.5.14 of EN ISO 52016-1 :2017, on the basis of air temperature and pressure.

The result is an input file for the spreadsheet on EN ISO 52010-1, similar as shown in Figures 3 and 5.

Table 3 gives an example of the extra files needed (compared to Table 2) and typical names of these files, that otherwise might be confusing, since the ***output*** file for one tool is the ***input*** file for another tool.

What	**Typical file name**	**Explanation**
Weather data from JRC TMY	tmy_59.912_10.750_2005_2014_Oslo.csv	The csv file as generated on line at the JRC website
Conversion tool	TMY-ISO-52010-1_conversion_2021-10-01.xlsm	The tool to convert the weather date into a weather data file that can be read by the EN ISO 52010-1 calculation spreadsheet tool. Contains a macro (xlsm) for the reading, conversion and writing
Template of weather data file for EN ISO 52010-1	TMY-ISO-52010-1_input_Template_2021-10-01.xlsx	This template is used by the conversion tool to have the correct layout of the input file with weather data that it has to produce (see next line)
Weather data file	Demo_ISO_52010-1_Input_TMY_Oslo_2021-10-01_15-38-03.xlsx	The file with the weather data, in the format suited to be read in as input for the calculation spreadsheet
Next: see Table 2	*Next: see Table 2*	*Next: see Table 2*

Table 3: Examples of extra files needed and produced for the conversion of TMY data and typical naming of the files

6.1.3 Coupling

No special coupling needed, other than explained above.

6.1.4 Supporting calculations

No special supporting calculations needed, other than explained above

6.2 Results

6.2.1 Case 1, Test Reference Years

6.2.1.1 Calculation results and discussion

6.2.1.1.1 De Bilt

The data file is available as example in the EN ISO 52010-1 spreadsheet tool distributed on Nov.20, 2019.

Calculation of annual minimum, average and maximum of the hourly values:

See table 4:

Or./tilt	NV	EV	SV	WV	N45	S45	E45	HOR
	Isol_tot	Isol_tot	Isol_tot	Isol_tot	Isol_tot	Isol_tot	Isol_tot	Isol_tot
	W/m2	W/m2	W/m2	W/m2	W/m2	W/m2	W/m2	W/m2
min.	-49	0	-41	-49	-7	-3	0	-5
average	40	86	96	61	62	132	113	113
max.	314	909	1144	795	405	1095	1058	914

Table 4: Minimum, average and maximum hourly solar irradiance, for 8 orientations, full year of 8760 values

Discussion:

The results are trustworthy.

The negative minimum values are anomalies that could have been avoided by forcing a minimum value of zero W/m2 on the hourly values from the calculation. However, further analysis shows that negative values below -10 W/m2 only occur during 8 hours per year. And then it is better not to hide these values, to avoid that potential other errors are also covered up.

These negative values appear to occur always at the first or second hour after sunrise: at very low sun position (e.g., a few degrees above horizon), the conversion of solar direct normal beam irradiance to irradiance at horizontal plane (multiplication by the sinus of solar altitude) is extremely sensitive for the correct calculation (and correct measurement) of the solar time. A few minutes difference can already have a significant effect. Also the apparent size of the sun disc may play a role. So this may even result in small negative values of the diffuse irradiance.

It has to be taken into account that a perfect conversion should not be expected, because of the use of several empirical correlation coefficients (Perez model), as explained in CEN ISO/TR 52010-2.

Comparison of the hourly values of measured (input) and calculated irradiance on a horizontal plane:

Another basic test is the calculation of the hourly total irradiation on a horizontal plane. These values should match the measured hourly values that are used as the source for the calculation of irradiation on tilted and vertical planes.

See Figures 16 and 17.

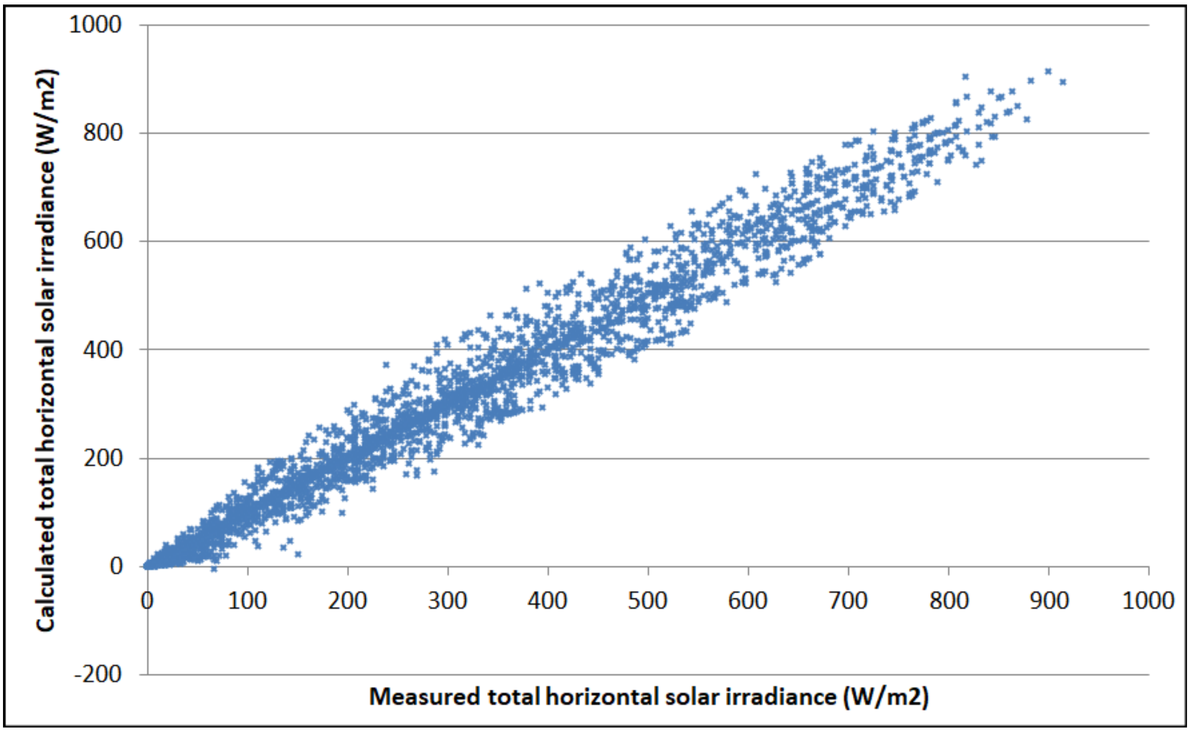


Figure 16 — Sample output of calculated irradiance: comparison of measured and recalculated global irradiance (total irradiance on horizontal plane); 8760 hourly values, in W/m^2

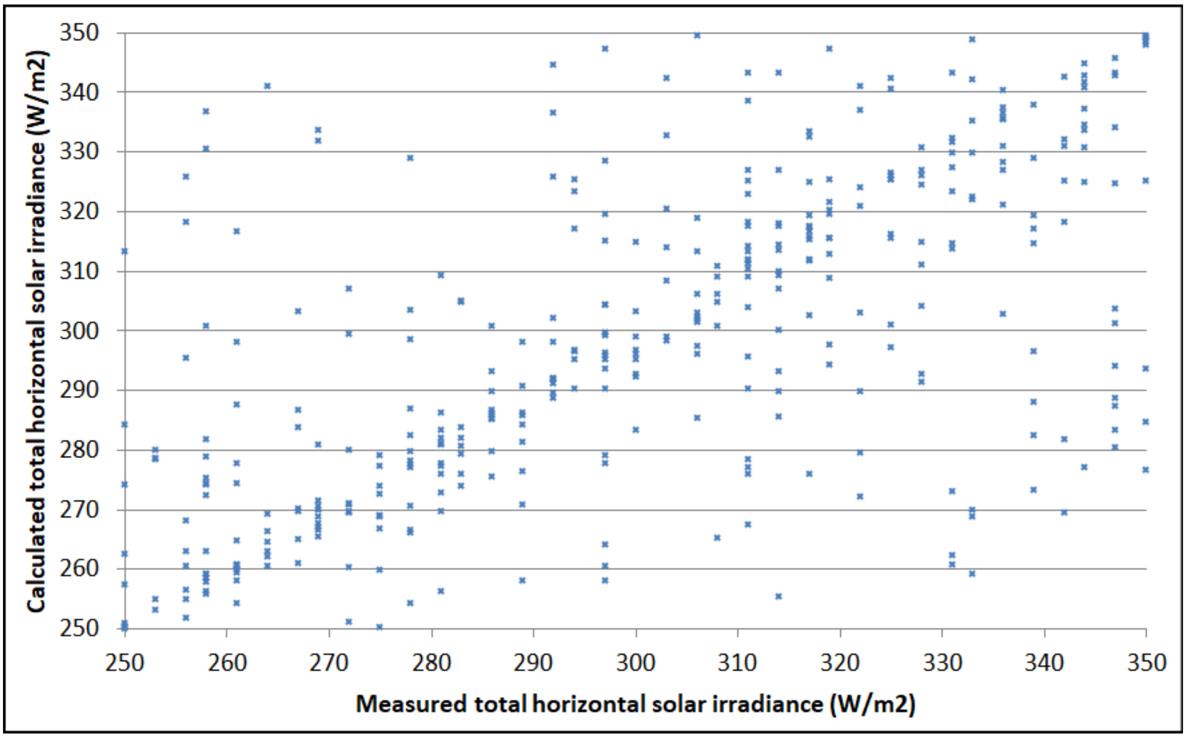


Figure 17 — Same as Figure 16, but zoomed in on the 250 - 350 W/m2 region

Discussion:

This test gives sufficiently satisfying results, again taking into account that a perfect match should not be expected, because of the use of several empirical correlation coefficients (Perez model).

The effects when the time series is applied on a building or system component is normally negligible.

Examples of plots of diffuse versus total solar irradiance:

The diffuse part of the solar irradiance should of course never exceed the total irradiance. Moreover, the lower the total solar irradiance level, the more likely it concerns an hour with cloudy sky or an hour with lateral solar angle compared to the plane.

See Figure 18 for a South and Figure 19 for a North vertical plane.

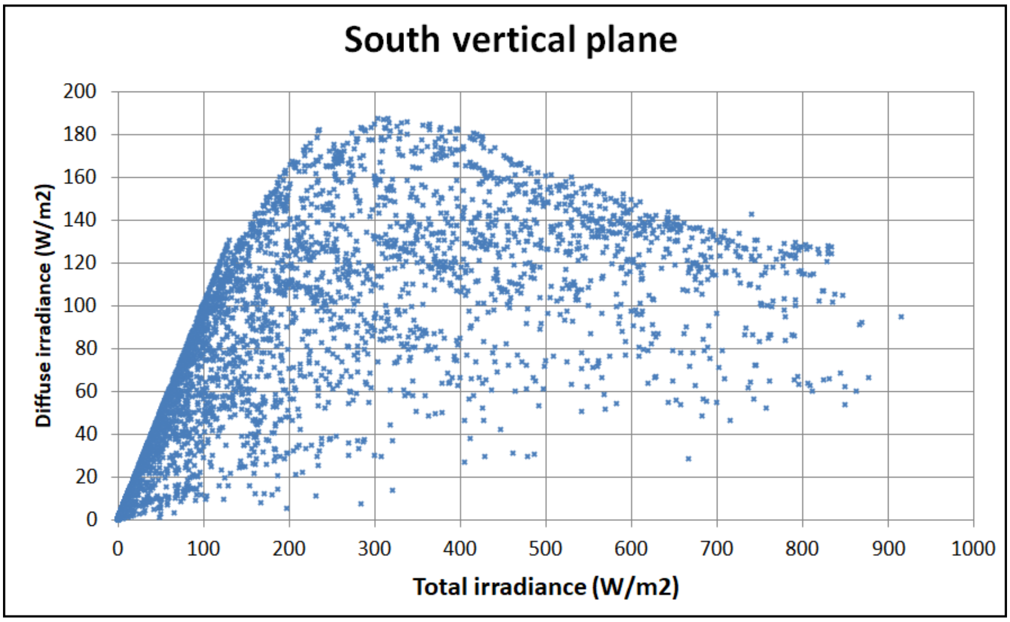


Figure 18 — Sample output of calculated irradiance: comparison of diffuse and total irradiance, South vertical plane; 8760 hourly values, in W/m²

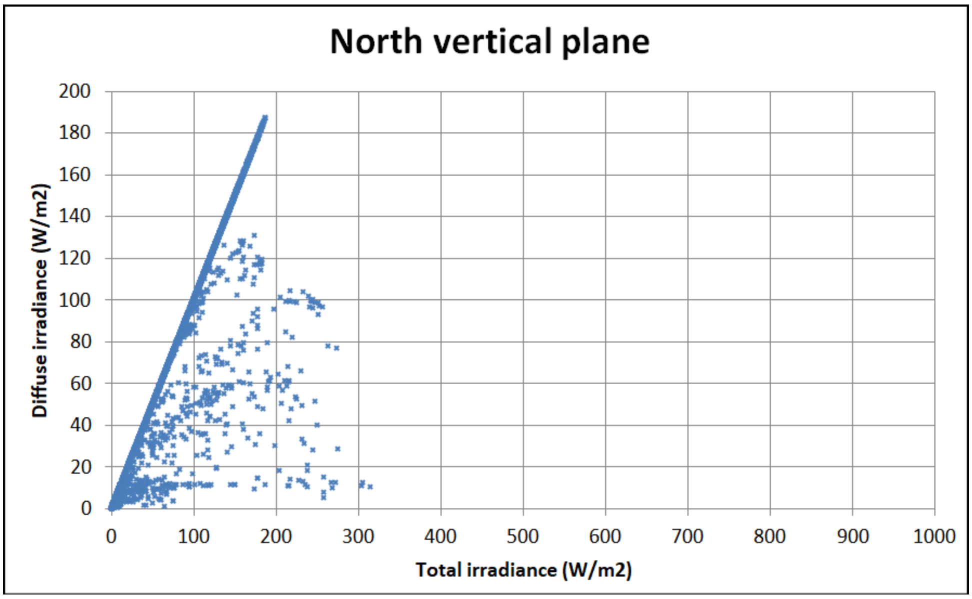


Figure 19 — Sample output of calculated irradiance: comparison of diffuse and total irradiance, South vertical plane; 8760 hourly values, in W/m²

Discussion:

The results look fine and as expected.

Monthly mean total solar irradiance values

The monthly irradiance values derived from the hourly values are shown in Table 5.

NOTE The output file of the current version of the EN ISO 52010-1 calculation spreadsheet does not provide these data. However, when imported in the calculation spreadsheet on EN ISO 52016-1 they are calculated, for information, but also as input for the monthly method to calculate the energy needs for heating and cooling.

H_{sol}, kWh/m²	NV	EV	SV	WV	N45	S45	E45	HOR
Jan.	7,8	20,7	44,1	12,1	10,4	42,3	23,9	20,2
Feb.	12,6	32,2	43,7	17,2	17,0	48,3	37,8	32,1
March	25,1	65,4	72,7	35,2	32,3	90,5	79,6	69,5
April	36,7	91,0	95,0	61,2	50,3	133,1	117,4	113,2
May	48,1	98,2	91,7	73,0	85,4	149,2	138,8	145,2
June	55,7	95,3	81,9	83,1	102,1	142,8	135,9	150,8
July	54,1	97,2	80,7	76,3	95,0	136,5	134,6	141,7
Aug.	44,0	89,3	98,0	77,9	69,1	147,4	122,7	133,5
Sept.	30,2	73,8	87,2	49,8	38,0	112,4	92,9	88,6
Oct.	18,8	49,9	70,5	27,5	24,1	79,5	60,7	52,9
Nov.	9,3	22,7	41,3	12,2	12,6	42,2	27,7	24,0

Dec.	6,1	16,2	33,4	7,9	8,4	31,6	18,6	15,0
Annual	**348,6**	**752,0**	**840,3**	**533,4**	**544,6**	**1155,8**	**990,5**	**986,7**

Table 5: monthly solar irradiance, for 8 orientations, derived from the hourly values

Discussion:

The results look fine and as expected.

6.2.1.1.2 DRY COLD

The data file is available as example in the EN ISO 52010-1 spreadsheet tool distributed on Nov.20, 2019.

As described in CEN ISO/TR 52010-2 [2], the calculation procedures have been validated by using relevant cases from the so called BESTEST series.

The BESTEST cases are well established since decades (several IEA ECBCS annexes and IEA SHC tasks), widely used worldwide, well described (e.g., ANSI-ASHRAE 140 [7]) and regularly extended with additional cases.

The successive series of test cases are also very powerful as diagnostic tool. Renowned institutes participate in the set-up of the test cases.

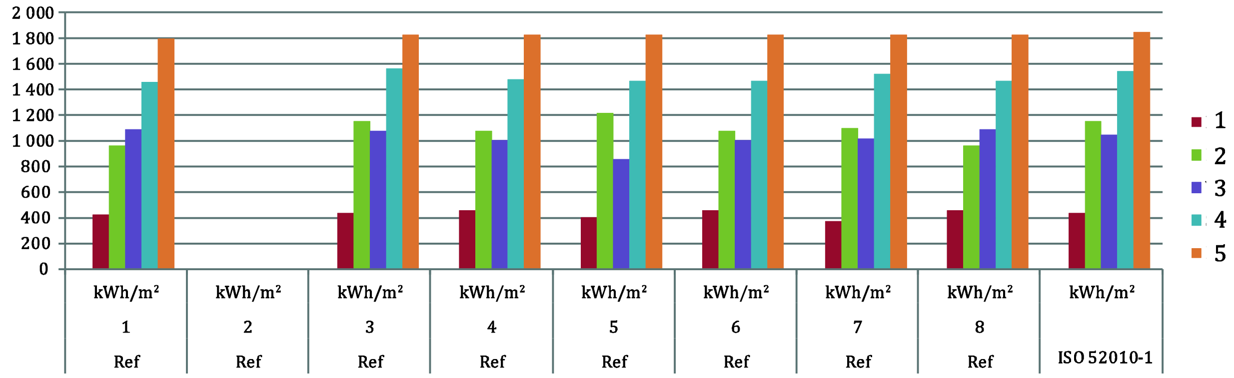
The calculation results of several renowned software tools are available for comparison.

Examples of input data for BESTEST cases are available for several building simulation tools and within different ICT environments. The "drawback" of the BESTEST series is that there is no single reference "true" result and there are no acceptance criteria.

Relevant BESTEST cases are also chosen for the validation of the hourly calculation procedures of ISO 52016-1 [3] with results presented in ISO/TR 52016 2 [4].

The relevant BESTEST cases are the calculation of the solar irradiation at vertical planes, using the measured data from the climate file provided for this purpose: DRYCOLD.TMY (Denver, Col., USA).

Figures 20 - 23 show examples of the validation results.



Key

1	North
2	East
3	West
4	South
5	horizontal plane

Figure 20 — BESTEST validation result: Annual solar radiation on five different planes

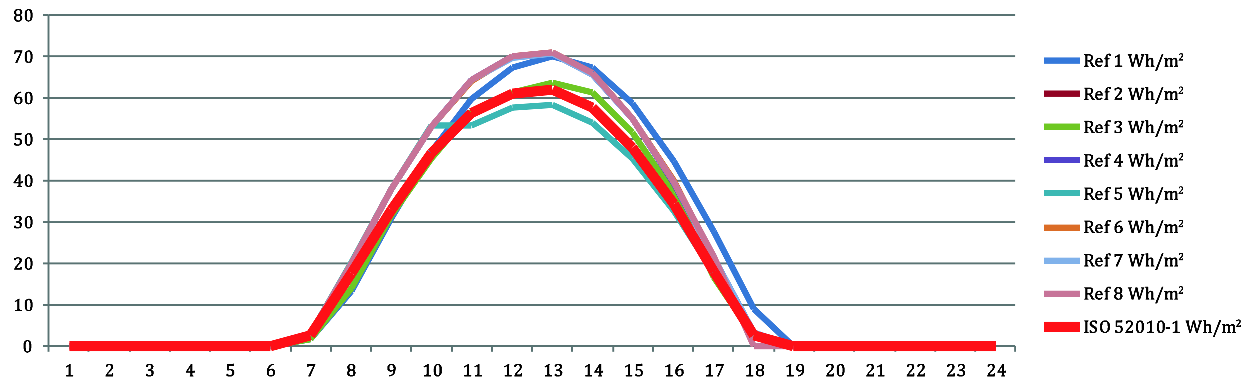


Figure 21 — BESTEST validation result: Hourly irradiation on vertical West plane, cloudy day

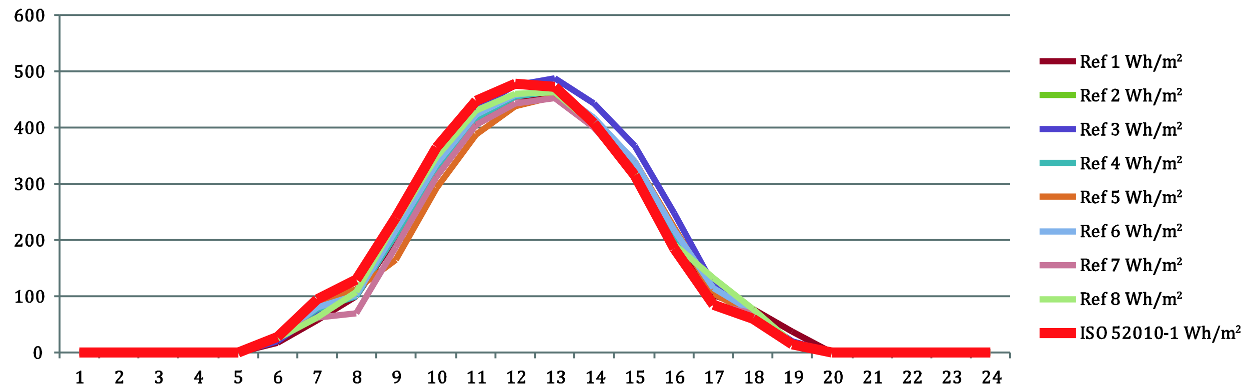


Figure 22 — BESTEST validation result: Hourly irradiation on vertical South plane, clear day

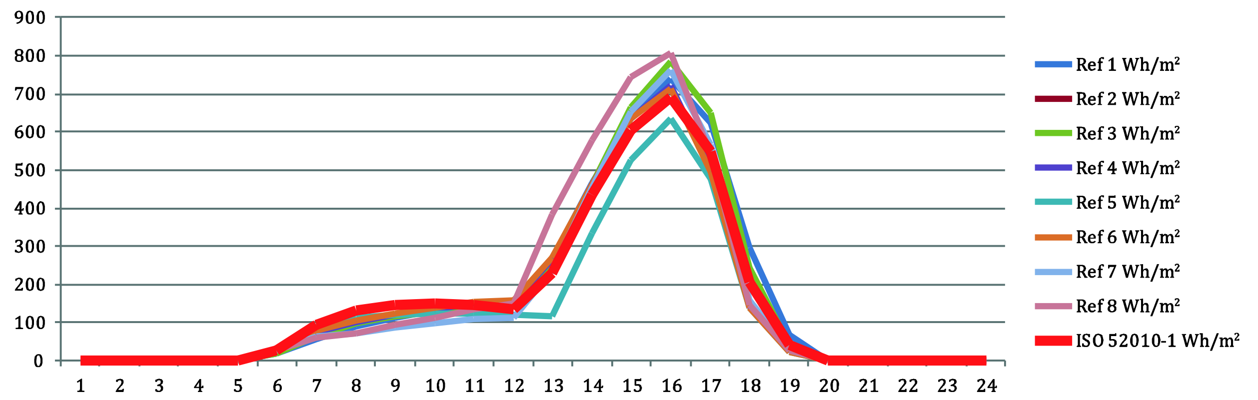


Figure 23 — BESTEST validation result: Hourly irradiation on vertical West plane, clear day

Discussion:

The results of the comparison show that the hourly method in EN ISO 52010-1 is fit for purpose.

It should be taken into consideration that not each software program whose results are available for the comparison use nowadays state-of-the-art algorithms (in that sense these are not reference results!). This is because these base cases of the BESTEST series were created and tested many years ago.

6.2.2 Case 2, TMY-JRC datasets

6.2.2.1 Calculation results

For these three climates the times series of climatic data that are most relevant for energy calculations are presented for one week in winter and one week in summer. Note that the JRC TMY datasets are composed of representative months from a series of successive years, which are therefore not the same for each climatic data set. The chosen year for each month is given in the climatic data file: Oslo: Jan. = 2008, July = 2014; Strasbourg: Jan. = 2011, July = 2007; Athens, Jan. = 2013, July = 2013).

The only additional specific aspect of these data sets is that they have been selected to represent three typical climates in Europe, using a similar choice as done for purpose to assess products like heat pumps.

Therefore, comparison with the data used for Eco-design and Ecolabeling Eco-design and Ecolabeling purpose is the main issue to be checked and demonstrated for these climatic data files.

Those data are provided in so called BINs, see Figure 24.

Shift bin edge	0,5		Check:			
			8760	6446	4910	3590
Temperature Bins	Condition	Hours below bin temperature	Bin duration	Cold	Average	Warm
°C		h	h	h	h	h
-4	<-4,0	888	202	278	91	0
-3	<-3,0	1117	229	306	89	0
-2	<-2,0	1416	299	454	165	0
-1	<-1,0	1815	399	385	173	0
0	<0,0	2333	518	490	240	0
1	<1,0	2805	472	533	280	0
2	<2,0	3206	401	380	320	3
3	<3,0	3640	434	228	357	22
4	<4,0	4079	439	261	356	63
5	<5,0	4421	342	279	303	63
6	<6,0	4743	322	229	330	175
7	<7,0	5021	278	269	326	162
8	<8,0	5264	243	233	348	259
9	<9,0	5521	257	230	335	360
10	<10,0	5791	270	243	315	428
11	<11,0	6068	277	191	215	430
12	<12,0	6324	256	146	169	503
13	<13,0	6592	268	150	151	444
14	<14,0	6859	267	97	105	384
15	<15,0	7120	261	61	74	294
16	<16,0	7414	294			
17	<17,0	7666	252			

Figure 24 — Number of hours with external air temperature within a given bandwidth ("BIN") as used in the context of Eco-design and Ecolabeling, for cold, average and warm climate

In a version of the template for an input file for the spreadsheet on EN ISO 52010-1 (e.g. TMY-ISO-52010-1_input_Template_2021-10-01.xlsx mentioned and shown in 6.1.2.2) this BIN table, as shown in Figure 24, is added and compared with the BINs that can be derived for the selected JRC TMY dataset. The results are shown below.

Oslo:

Figures 25 and 26 show the time series for the first weeks in January and July respectively.

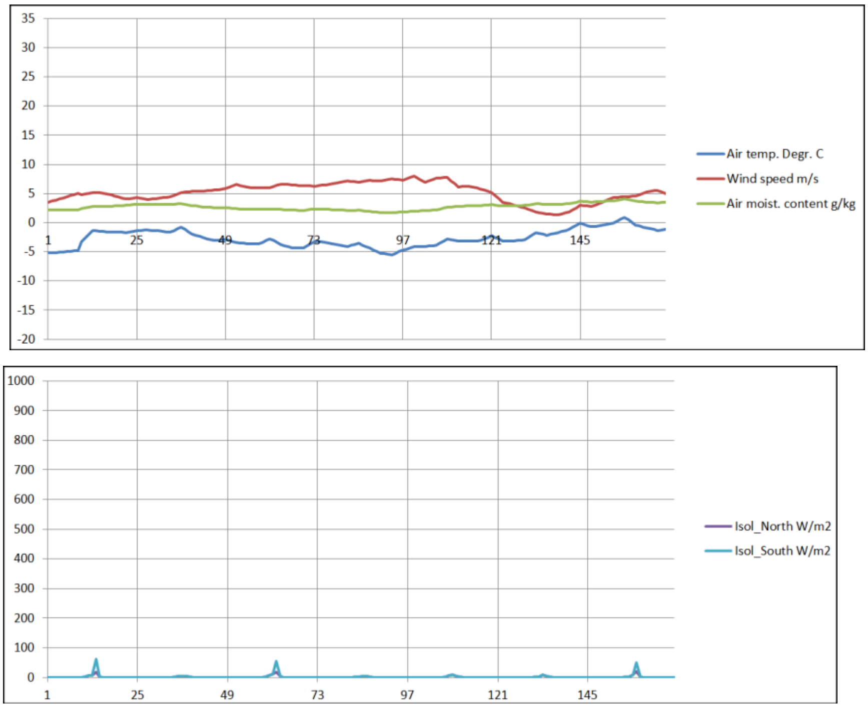


Figure 25 — Time series of climatic data for first week in January, Oslo

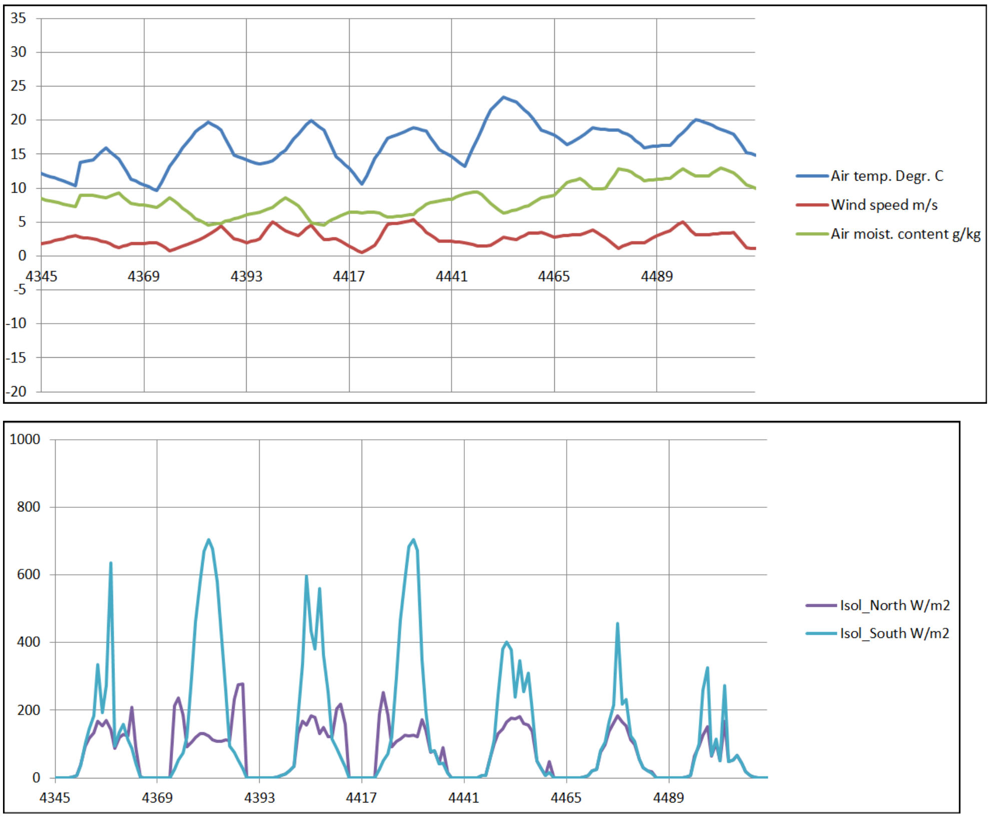


Figure 26 — Time series of climatic data first week in July, Oslo

Comparison with the (BIN) data used for Eco-design and Ecolabeling is given in Figure 27.

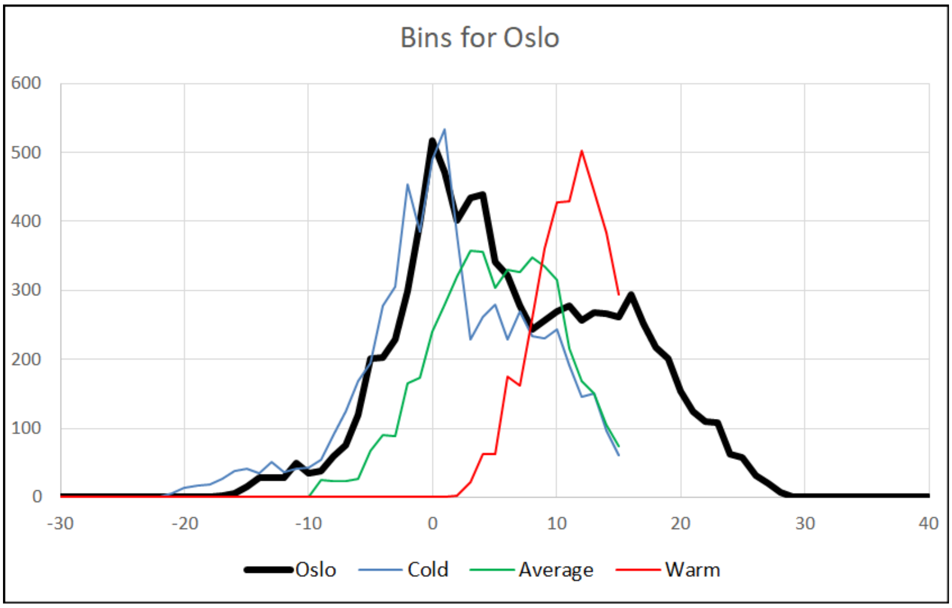


Figure 27 — BINs used in the context of Eco-design and Ecolabeling, for cold, average and warm climate compared with the BINs for the generated weather data file for Oslo

Note that Ecolabeling regulations only define the bins for the conventional heating season whilst the bins from JRC-TMY cover the entire year. That is why the JRC-TMY bins extend towards high temperatures (summer) but they encompass quite well the Ecolabeling bins for the winter part.

Strasbourg:

Figures 28 and 29 show the time series for the first weeks in January and July respectively.

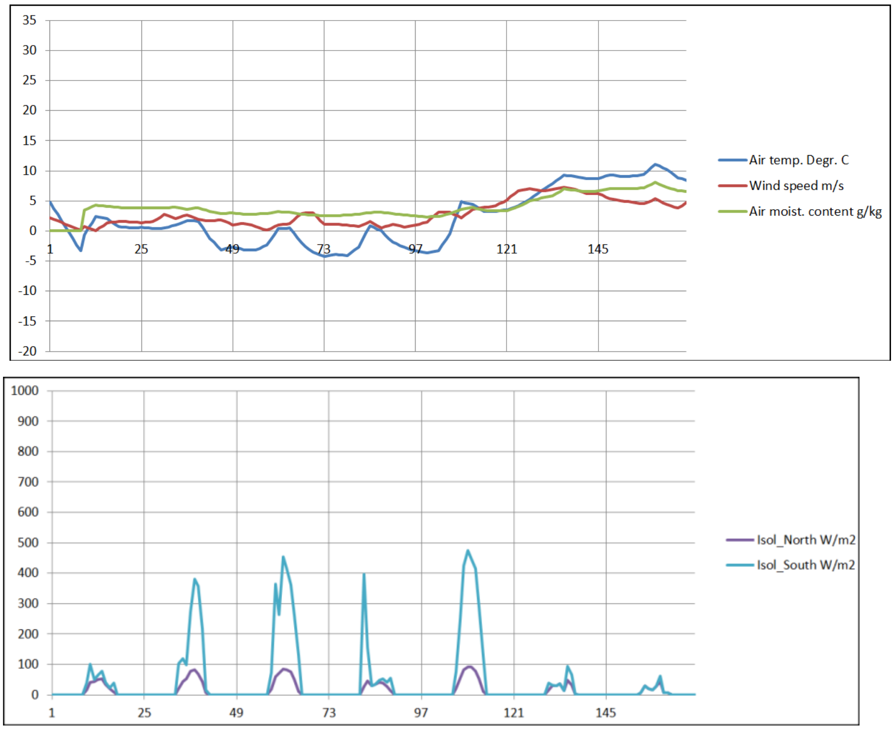


Figure 28 — Time series of climatic data for first week in January, Strasbourg

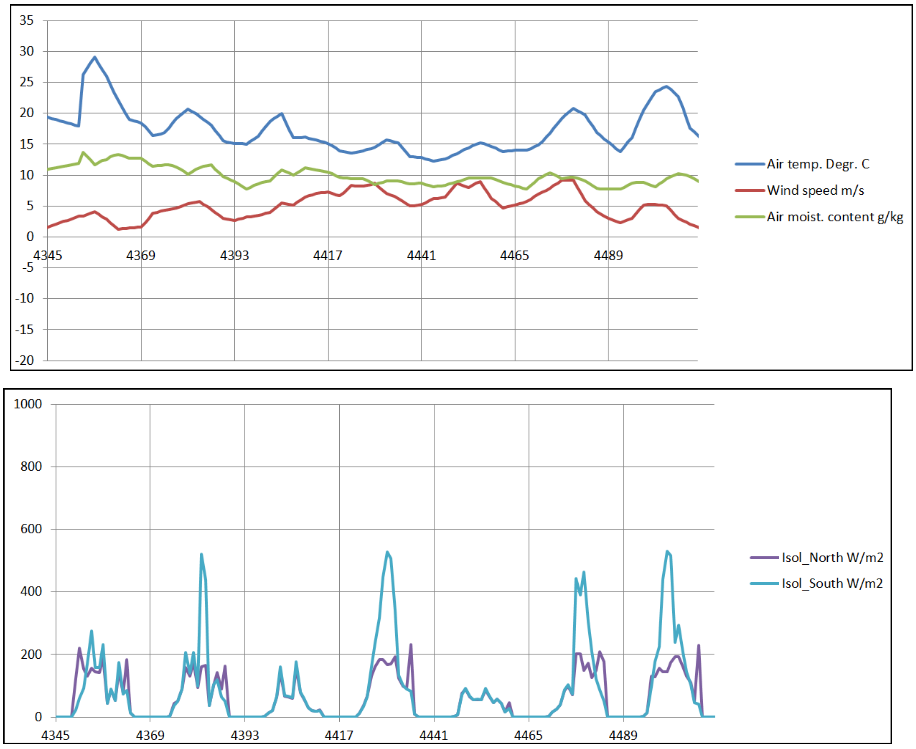


Figure 29 — Time series of climatic data first week in July, Strasbourg

Comparison with the (BIN) data used for Eco-design and Ecolabeling is given in Figure 30.

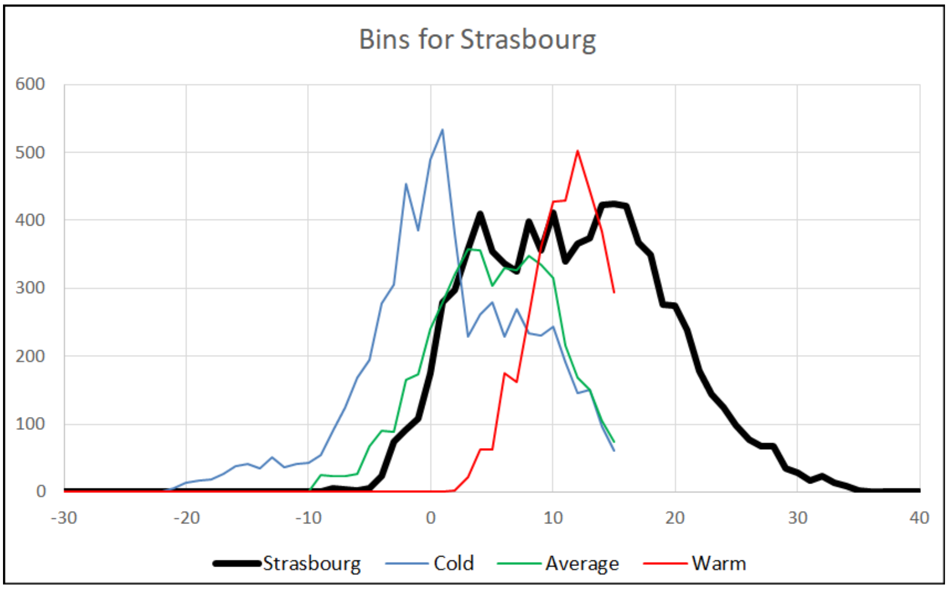


Figure 30 — BINs used in the context of Eco-design and Ecolabeling, for cold, average and warm climate compared with the BINs for the generated weather data file for Strasbourg

See note below Figure 27.

Athens:

Figures 31 and 32 show the time series the first weeks in January and July respectively.

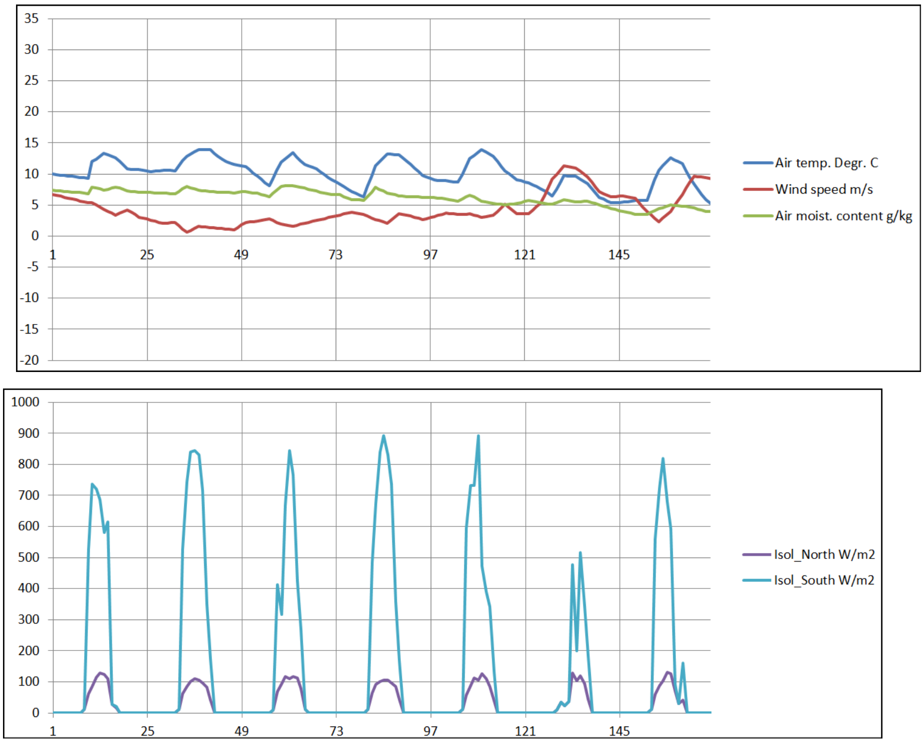


Figure 31 — Time series of climatic data for first week in January, Athens

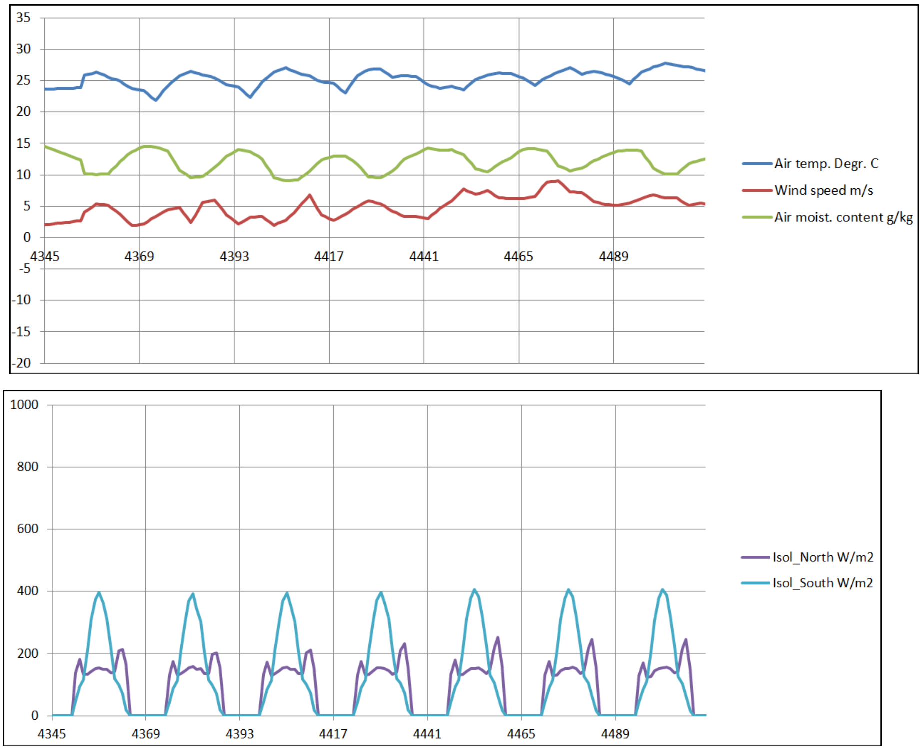


Figure 32 — Time series of climatic data for first week in July, Athens

Comparison with the (BIN) data used for Eco-design and Ecolabeling is given in Figure 33.

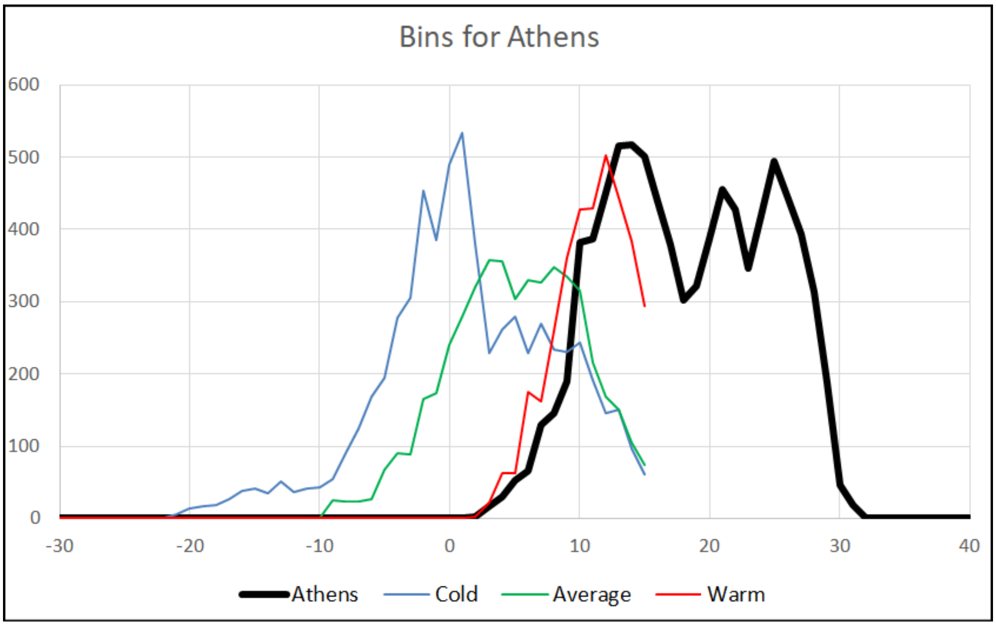


Figure 33 — BINs used in the context of Eco-design and Ecolabeling, for cold, average and warm climate compared with the BINs for the generated weather data file for Athens

See note below Figure 27.

6.2.2.2 Discussion

The time series look fine and as expected with regard to temperature, wind speed and humidity. The solar irradiance on the South and North vertical planes is, as expected, a clear function of climate and sun position (solar height and azimuth).

Of course, these two weeks are chosen rather arbitrary and (1) are not necessarily representative and (2) are based on different years for the different climates.

The agreement of the BINs for each of the three selected climates with the values used in the context of Eco-design and Ecolabeling is quite good.

Consequently these three climates have been chosen for all the case studies, where applicable.

7 Analysis

7.1 Functionality

The spreadsheet on EN ISO 52010-1 enabled to check the functionality of EN ISO 52010-1.

This case study demonstrates that the standard EN ISO 52010-1 provides the necessary (hourly and monthly) information for the other EPB standards, on the basis of available input data.

7.2 Completeness

This case study demonstrates that the standard EN ISO 52010-1 provides all the data that are needed, for any climate, any location and any plane.

The spreadsheet does not cover situations where the weather data contains only the total solar irradiance on a horizontal plane ("global irradiance"). An algorithm to split the global irradiance into a direct and diffuse component is available in the standard, and alternative methods are allowed (Annex A choice). However, there has been no concrete request for such added functionality.

No tests were done for locations in the Southern hemisphere. However, during the preparation of the calculation procedures tests have been performed which give confidence that the procedures are universally valid.

7.3 Sensitivity

The standard and spreadsheet can handle any variety of weather data. The calculated solar irradiance can be given for any plane with arbitrary orientation and tilt angle. The calculated solar irradiance is given as total irradiance and diffuse irradiance. However (not part of this case study), a more a refined split between the various components of the calculated irradiance (direct beam, circumsolar, near-horizon diffuse, hemispheric diffuse, ground reflected diffuse) is also provided in the spreadsheet for special cases.

7.4 Usability

This case study has shown that the spreadsheet, combined with the JRC TMY conversion tool, gives very easy access to hourly climatic datasets for almost any location in the world, thanks to the on line Typical Meteorological Years (TMY) generator developed and made available by the EC Joint Research Centre (JRC).

Moreover, the spreadsheet produces a result file that can be readily used as input for energy calculations, for instance the calculation of the energy needs for heating and cooling and internal temperatures (EN ISO 52016-1), calculation of hourly solar shading reduction factors (EN ISO 52016-1, Annex F), but also for thermal solar collectors and photovoltaic panels.

8 Conclusions and recommendations

The standard covers adequately the scope and produces results that can be readily used in other EPB standards.

The spreadsheet and TMY conversion tool make it very easy to get access to a weather file of hourly data for any location and convert that to the data needed for the energy calculations.

All data and tools are publicly available for customized exercises and for practical use.

Bibliography

[1] (EN) ISO 52010-1:2017, *Energy performance of buildings — External climatic conditions — Part 1: Conversion of climatic data for energy calculations*

[2] (CEN) ISO/TR 52010-2:2017, *Energy performance of buildings — External climatic conditions — Part 2: Explanation and justification of ISO 52010-1*

[3] (EN) ISO 52016-1:2017, *Energy performance of buildings — Energy needs for heating and cooling, internal temperatures and sensible and latent heat loads — Part 1: Calculation procedures*

[4] (CEN) ISO 52016-2:2017, *Energy performance of buildings — Energy needs for heating and cooling, internal temperatures and sensible and latent heat loads — Part 2: Explanation and justification of ISO 52016-1 and ISO 52017-1*

[5] EPB Center webinars, in particular webinar 4, https://epb.center/news/news_events/fourth-webinar-epb-standards-hourly-vs-monthly-met/

[6] ISO 15927-4, *Hygrothermal performance of buildings — Calculation and presentation of climatic data — Part 4: Hourly data for assessing the annual energy use for heating and cooling*

[7] NEN 5060:2018, *Hygrothermische eigenschappen van gebouwen - Referentieklimaatgegevens (Hygrothermal performance of buildings - Climatic reference data)*, NEN, The Netherlands

[8] ANSI/ASHRAE standard 140, *Standard Method of Test for the Evaluation of Building Energy Analysis Computer Programs*, 2014

[9] ENERC32017-437-SI2-785.185, Case studies Preparatory work
October 31, 2021

Please check the EPB Center website for the overview and most recent versions of the other case study reports.

Link: EPB Center support documents

NOTE References to the applied tools and supporting data are provided in the relevant paragraphs of this document.

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