PUBLIC DOCUMENT

Service Contract ENER/C3/2017-437/SI2-785.185

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

Report on Case Studies - Preparatory work

October 31st, 2021

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Final report

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This document has been produced under contract with the European Commission (service contract ENER/C3/2017-437/S12-785.185).

Contents

Page

Introduction

This document covers general topics and criteria for the selection of case studies, such as services to consider, climatic data, use profiles and sample buildings.

Case studies shall help show and/or demonstrate:

- functionality,
- sensitivity,
- and usability

of individual calculation modules and of the whole calculation procedure.

Functionality means that

- the calculation works all together on practical cases;
- features are available to describe energy properties of buildings and HVAC installations.

Sensitivity measures the impact of single data or group of data on selected calculation results.

Usability means

- a clear data input;
- being able to describe practical system configurations;
- being able to obtain useful results;
- avoiding unnecessary input complexity.

The excel spreadsheets can demonstrate the functionality and sensitivity of individual calculation modules and of their combination.

The usability of accompanying spreadsheets can be improved by adding dedicated sheets for the input and output data interface but the possibility of the interface of an Excel spreadsheet are limited indeed. However, it has to be noted that practical usability of any calculation procedure is strongly dependent on the quality of the user interface of the available software. It is worth noting that to perform an energy performance calculation you have to:

- describe the building envelope;
- describe the technical systems.

Usability issues are quite different:

- defining the building envelope is a task that is conceptually simple but very extensive because it requires the input of a long list of elements that make the building envelope and their geometrical relationship (for shadings);
- defining the technical systems is a task that is relatively short but very intensive because it requires the selection between several alternatives.

To demonstrate functionality and sensitivity of the calculation procedure, it is not necessary to have a large and complex building.

The target of this document is to define a set of case studies and to check that it is representative indeed of most situations that may occur during energy performance calculation of buildings.

1 Objectives

1.1 Expected output of case studies

1.1.1 General

The expected output is a set of commented calculations on example buildings and systems that demonstrate that:

- individual modules work properly;
- coordination between modules works;
- calculation procedures fit real cases;
- the input for the hourly calculation does not require a too high amount of work;
- the procedure is sensitive to technologies.

The set of case studies shall also help understand the influence and consequences of national choices, especially for EPB standards mentioned in Annex I of the European Directive on Energy Performance of Buildings (EPBD).

A full demonstration of the whole set of (CEN and ISO) EPB standards is not expected. The effort will be concentrated on critical modules and coordination issues.

1.1.2 Testing individual modules

Testing individual modules is done for:

- modules where parameters are used to weight contributions to the overall energy balance and may have a large impact.
  Example: overall energy balance EN ISO 52000-1;
- modules for special and new technologies, to understand if the modules react correctly to product data and operating conditions.
  Example: heat pumps EN 15316-4-2

Individual modules are tested with the original spreadsheets, after review and intended/possible improvements.

1.1.3 Coordination between modules

Several modules may be tested together to see the effect of interrelation between modules, typically to see the effect of operating conditions.

Collections of modules are tested by connecting the original spreadsheets. Software or simplified models have been used to generate relevant input.

This means:

- identifying the set of modules to be tested together;
- preparing a way of connecting several spreadsheets;
- identifying appropriate calculation cases and related input data sets.

1.1.4 Application of the calculation procedure to whole building cases

A calculation on a whole building can be either done by using software or simulated by coordinating tests on single modules or group of modules (feeding the output of the test of one module as an input to the following modules in the calculation chain). Some simplification is needed to avoid or limit iterations between group of modules which make the process too long.

The calculation on a whole building is interesting to show the relative importance of services, therefore the potential impact of requirements. Application should be on a realistic size of the building.

1.1.5 Impact of hourly calculation on input effort

A concern to be addressed is the frequent remark that an hourly procedure will require a huge input effort. This is not a justified concern for the set of EPB standards and it can be checked directly on the input data list of the standards.

In most cases the additional input is only apparent or limited to a preparation work. Examples are climatic data and use profile.

The external air temperature requires 12 values for a monthly method and 8760 values for an hourly method. This is true but in practice:

- determining the 8760 values of external air temperature for a location is a task for those preparing the default data for the standardised calculation (technical committees of National Standards Bodies);
- for the assessors, the task is only to select the location in the available list, and this single action actually selects all the 12 values or all the 8760 values.

The case studies show that there are tools to facilitate the preparation work.

It is also important to highlight those hidden complexities and assumptions which are embedded in “averaging coefficients” of monthly methods (they actually take care of the dynamic effects within a month) that can be removed by using an hourly method. An example is the hourly profile for intermittent use of the building. It is much easier and transparent to define an explicit hourly profile rather than assuming an average operation time.

1.1.6 Sensitivity of the procedure to technologies

This is done by selecting:

- a number of alternative technologies;
- and of system configurations;

and testing how the relevant advantages / disadvantages of each alternative are evaluated.

Examples of alternative technologies are:

- a different set of generation devices (boiler versus heat pump);
- a different type of heat emitters;
- a different set of layers of the building envelope (external versus internal insulation).

Besides sensitivity to product data and technologies, there are also system configuration and operational issues (hydraulic connections) and control strategies with a relevant impact on energy performance. A well-structured calculation procedure has the potential to highlight these aspects as well.

Examples of alternative system configurations are:

- autonomous versus centralized production of a service;
- the extension and layout of a domestic hot water distribution network (strongly influences losses);
- the operation time of a heat pump, that influences the average power, hence the temperatures and the efficiency of the heat pump;
- the hydraulic connection of a heating or cooling generator, that may affect flow and return temperature and hence efficiency;
- the configuration and control of the ventilation system, that may cause reheat.

1.2 Specific requests

Direct requests received from EU member states mostly concern practical usability and effort required to who is performing the calculation (the assessor).

The real concern is not the structure and complexity of the calculation method but the effort required for data input by the assessor.

1.3 Presentation of results

Results of the work consist of worked-out test cases that can be used to repeat the calculation changing parameters.

Test cases are documented with:

- description of the test case and its intent;
- a collection of:
  - excel spreadsheets;
  - sets of interconnected spreadsheets;
    with preloaded calculation values
- comments on the test case results.
- optional explanation videos;

2 Analysis of the impact of services

To check the coverage of selected case studies, it is useful to analyse the relevance of considered services and their relation with climate and building use (space categories).

The services considered by the European Directive EPBD are heating, cooling, domestic hot water, ventilation, humidification, dehumidification, lighting (non-residential).

A quick qualitative evaluation of the relative impact of these services is given in table 1.

These evaluations are qualitative and refer to most common conditions. The insulation level of the building envelope (e.g. old / new buildings) and climate do change the relative importance of services.

Table 1 – Dependency of services on climate and building envelope

Service	Dependency on climate	Building envelope influence	General notes
Heating	High Main influence factor is temperature (external and internal) Tends to be small in southern EU climate.	High Well insulated and well exposed buildings have little heating needs also in cold climates.	Building mass is usually enough to smooth the influence of intermittent operation on heating needs. An effective building envelope requires both insulation and optimisation of solar gains. A good indoor temperature control subsystem is required.
Cooling	High Parameters are temperature and humidity No cooling needs in cold EU climate.	Moderate (for EU climates) Well insulated buildings tend to increase cooling needs. Cooling needs may occur in cold climate as well if not prevented by technical measures such as shadings to limit solar gains or free cooling.	Building mass may help overcoming daily transient loads (peak shaving).
Domestic hot water	Marginal, due to cold water temperature linked to yearly average external temperature	No effect of the envelope on needs.	Losses of domestic hot water distribution network may contribute significantly to loss in performance and to overheat a well-insulated building in summer.

Service	Dependency on climate	Building envelope influence	General notes
Ventilation	Thermal effect is part of heating and cooling. Energy for air transfer (mechanical ventilation) is not sensitive to climate	No effect on minimum requirements (OA flow rate) Tightness of envelope required to avoid bypassing heat recovery and keep control of OA flow rate.	An air tight envelope requires a mechanical ventilation system to avoid IAQ issues. Outdoor air flow rate shall be linked to occupancy. Too less means discomfort, too much means severe degradation of energy performance
Humidification	May be required in winter, for cold climate and high occupancy buildings.	No effect of the building envelope on humidification needs.	
Dehumidification	Contributes significantly to cooling needs in hot and humid climates	No effect of the building envelope on de-humidification needs.	Dehumidification may require reheat when latent loads are high.
Lighting	Some dependency on latitude.	Envelope may optimise the use of solar light	Lighting and cooling energy efficiency requirement are often in conflict.
Non EPB uses	No dependency	Non EPB uses are gains in the context of energy performance calculation. They help fulfil heating needs and they increase cooling needs.	

The climate is usually mentioned/assumed as the main influence factor. Actually, there are other relevant influence factors. The Nearly Zero Energy Building (NZEB) concept always includes a well-insulated building envelope, which is basically intended to reduce heating needs. The effect on other services deserves being mentioned as well.

Table 2 – Qualitative estimation of the impact of individual services on the total energy performance of a building, depending on building use and for average climate

Service	Residential	Offices	Commercial	Schools	Hotels	Restaurant
Heating,	(i) Low (ni) High	Low	Medium	Low to medium	High	Medium to low
Cooling	(i) Medium (ni) Low	Medium to High	High	Low (a)	High	
Domestic hot water	(i) Medium (ni) Low	Low	Low to none	Low	Very high	High
Ventilation	(i) Medium (ni) Low	High	Medium to high	High	Low	Medium to high

Humidification	Low to none	Low	Low	Low	Low	Low
Dehumidification	Low to none	Low to medium	Low	Low (a)	Low	High
Lighting	(i) Medium (ni) Low	High	High	High	High	High
Non EPB uses	(i) High (ni) Low	High	Low	Low	Low	Low
(i) insulated building (ni) non-insulated building (a) usually closed in summer						

(1) Usually closed in summer

The combination residential + office covers most of the buildings and all relevant services

Table 3 – Relevance of intermittency and hourly calculation

Service	Effect of intermittent use of the building	Impact of hourly calculation	General notes
Heating	Low Very long set-back intervals are required to have a significant reduction of needs.	Hourly method is needed to show the potential of BACS (Building Automation and Control, e.g. start and stop optimisation) and system control in case of intermittent operations.	Continuous heating is often the correct solution with well insulated buildings. At least the bin method is required to enable the monthly procedure to calculate multiple generators
Cooling	High In the European context cooling needs are mostly peak needs in some hours.	Hourly method is needed to evaluate correctly cooling needs	
Domestic hot water	Dhw is a service with an intrinsically extreme intermittency	Correct evaluation of storage behaviour and thermal solar systems depending on sizing and use pattern	Evaluation of storage needs dynamics, especially in connection with thermal solar
Ventilation	Determining needs, since no accumulation is possible	It is simple to follow use schedule. Evaluating the actual impact of BACS requires an hourly calculation to identify dynamics	
Humidification			Usually not relevant except for special circumstances (high air exchange rate / process requirements)

Service	Effect of intermittent use of the building	Impact of hourly calculation	General notes
Dehumidification	Determining needs, since no accumulation is possible	Energy use depending on air treatment strategy can be identified correctly only by hourly calculation	This service may use large amounts of energy in warm and humid climate.
Lighting	Determining needs, since no accumulation is possible	Easy to describe use patterns.	
Non EPB uses	High	Needed to take into account the contribution to overheating when cooling	Though not considered in the energy performance, they may heavily influence the thermal balance.

This table shows several reasons for an hourly method: emerging services (air conditioning), high insulation of buildings and BACS need an hourly calculation procedure for a correct evaluation.

Dynamics (e.g. calculation at one time step depending on the previous time step) is required for building needs (H&C), (de)humidification, heat storage.

Additionally, worth and effect of the interaction with the electric grid due to local generation of electricity is strongly dependent on timing. An hourly method is needed to identify and account exported energy correctly.

The set of EPB standards published in 2017 includes a dynamic hourly calculation procedure but still provides (residual) support for a monthly procedure

Table 4 – Main influence factors on needs

Service	Main influence factor(s)	Notes
Heating	Climate and building envelope	High performance building envelope may reduce dramatically heating needs.
Cooling	Climate, occupancy, building use (including non EPB uses), building envelope	
Domestic hot water	Building use	Needs may be partly reduced only with heat exchangers on showers.
Ventilation	Occupancy	
Humidification	Building use (occupancy) and climate	This service may be required in very cold climate or for special uses (high occupancy)
Dehumidification	Building use (occupancy) and climate	This service may be required also depending on humidity of summer climate
Lighting	Building use (occupancy and task)	
Non EPB uses	Building use (occupancy and task)	

Climate is an influencing factor but building use is at least as much relevant for performance evaluation. EN 16798-1 includes several user profiles.

3 Climatic data

The effect of varying climate is to shift the energy use between some services (heating versus cooling) and change their relative importance when dealing with the whole building.

The calculation procedure for heating is a relatively well known and consolidated, both for needs and technical systems. One cold climate can be enough. The European Ecodesign Directive uses Helsinki as a reference for cold climate.

An intermediate climate is useful to test condition where both heating and cooling are required. Ecodesign uses Strasbourg as a reference for average climate.

The warm climate is required to test the standards about cooling and ventilation. Eco-design uses Athens as a reference for hot climate. Two variants of warm climate should be investigated: dry and humid.

Climatic data shall include the parameters required by EN ISO 52010-1, which will be used to feed EN ISO 52016-1 (energy needs for H&C) and other EPB standards like EN 15316-4-3 (thermal solar and PV).

The source of data will be :

- climatic data obtained from https://re.jrc.ec.europa.eu/pvg_tools/it/#TMY
- available hourly dataset from countries that already developed them.

Ecodesign data for space heaters (see European Commission delegated regulation (EU) N° 811/2013 of the 18th of February 2013) cannot be used directly because they are given only as bins for the winter season. Some countries already developed typical years for the hourly calculation (example, Italy, France, etc.).

JRC TMY (European Joint Research Centre's Typical Meteorological Years) data is used instead, because

- it is a universal source of data, valid for the whole Europe and beyond;
- it is freely available;
- the data provided fits with the data required by EPB standards.

For coherence purpose, monthly data will be extracted from the hourly data.

Proposed choice for the climate is in table 5.

Table 5 – Climate choice

Climate	Location	Source
Cold	**Oslo**	JRC–TMY - 2005-2014
Average	**Strasbourg**	JRC-TMY – 2005-2014
Warm	**Athens**	JRC-TMY– 2005-2014

Compared to Ecodesign selection, the difference is using Oslo instead of Helsinki, which gives a better match between Ecodesign data and these case studies.

The following figures show the comparison between the bin climatic data used for Ecodesign purpose (Cold, Average and Warm) and the full-year bins of the data listed in table 5. Please note that the Ecodesign bin data only include winter season whilst the JRC-TMY bin data include the full year. Therefore the JRC-TMT data extend further in summer but they clearly encompass Ecodesign data in the winter season.

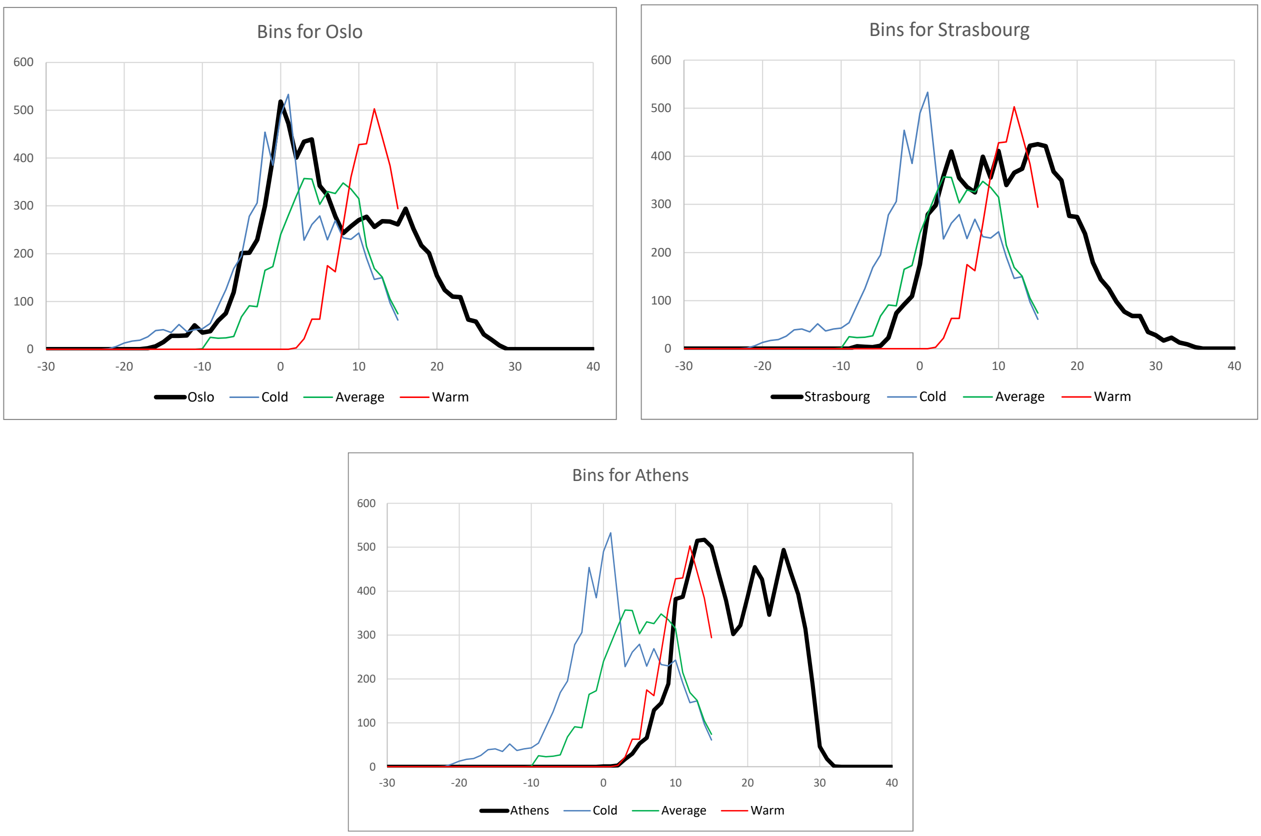


Figure 1 - Bins for Oslo, Strasbourg and Athens compared to bins for cold, average and warm climate

NOTE 1: For comparison with measured energy performance, local actual climatic data would be required. Since no such comparison is envisaged then JRC data is enough.

NOTE 2: JRC yearly data are generated by assembling, for each month, the most representative in a time span of 10 years. Selection was among years 2005-2014. The selection of months from different years causes jumps when changing month.

See annex A to this document for more details on the selected climatic data. The complete hourly climatic data-set used can be found in the accompanying spreadsheet to the case studies.

See case study on EN ISO 52010-1 for specific details on climatic data calculation.

4 Use profiles

4.1 Selected profiles

Use profiles include:

- one example of continuous use, residential;
- one example of intermittent use.

The profiles are the default given in annex B of EN 16798-1.

For the continuous use, residential is the natural choice.

For the intermittent use, the following categories are eligible

- residential, taking into account a night set-back for heating;
- offices: intermittent use, high internal loads for appliances, no domestic hot water.
- schools: very intermittent use, low internal loads for appliances, high internal loads for people (ventilation), no or very little domestic hot water
- hotels: intermittent use, low internal loads for appliances, medium internal loads for people, very high domestic hot water use.

The preferred choice is the office building because there is the largest variability of system configurations, they represent a high percentage of non-residential buildings and all services are required, except domestic hot water which is already analysed in the residential case.

4.2 Definition of profiles

The definition of use profiles given in EN 16798-1 have been completed with the following features:

- Separation of the profiles for:
  - occupancy, actual number of people inside a building at a given time
    They are given as hourly profiles for weekdays and holidays in annex B of EN 16798-1;
  - required comfort schedule, e.g. time of day when comfort is required because the indoor space shall be available for occupants.
    They are given by time on, time off and a possible break in annex B of EN 16798-1;
  - system operation schedule (per technical system), e.g. the set point schedule needed to obtain comfort at the required time.
    These have been added because they are necessary for technical system calculation.
- Handling daylight saving time option;
- Handling a specific reference year so that the first day of the year is a well defined day of the week;
- Handling holidays;
- Inclusion of domestic hot water profiles taken from EN 15378-3.

All these features are included in a new demo spreadsheet for standard EN 16798-1.

For the purpose of the case studies, the following options were selected:

- Occupancy profiles are those given in EN 16798-1, annex B;
- Required comfort schedule is based on information given in EN 16798-1, annex B;
- System operation schedule takes into account limitations given in EN 16798-1, annex B for non-occupancy periods and is based on an estimation of the required anticipated operation of systems to restore comfort;
- EU daylight saving time is not included;
- The selected reference year is 2018, non-leap year where the first day of the year is a Monday
- No special holidays have been considered. No distinction is made between Saturdays and Sundays
- Annex B of EN 12831-3 doesn't provide default tapping profiles for all building categories. A tapping profile was built for office.

See case study on EN 16798-1 for more details on use profiles.

4.3 Available tools

A demo spreadsheet has been developed for EN 16798-1 to generate full year hourly profiles.

This spreadsheet builds on the one developed within the European CEN-CE project to calculate domestic hot water needs according to EN 12831-3. The parts on calendar and generation of hourly profile have been recovered and extended with data for all the required profiles and additional functions such as:

- generating also the data for the stabilisation period at the beginning of the hourly calculation;
- possibility to have an independent schedule for Saturdays;
- possibility to include extra holidays;
- possibility to have daylight saving time;
- separation between use profiles, comfort requirement profile and system operation profile..

4.4 Details on user profiles

Use profiles are based on:

- a number of properties given in a reference condition, such as occupancy in persons per m^2, appliance sensible gains in W/m^2; the reference condition is usually the maximum use of the building;

- e number of hourly profiles that specify a relative value or an operation level for each hour.

Occupancy is the assumed presence of persons.

Other data directly or indirectly linked to occupancy are:

- occupant gains, sensible and latent;
- appliances sensible gains;
- moisture production;
- CO_2 production.

The required comfort profile are the required indoor conditions as a function of time which are used to detect any discomfort situation.

It is not always true that when occupancy is non-zero then the comfort requirement is normal. There might be

- periods with low or seldom occupancy so that it is accepted that full comfort is not granted;
- period where even if normal comfort level is not provided, occupants are in a condition where they will not feel a discomfort (e.g. reduced temperature during the night in the residential sector).

As an example, reduced temperature during the night may be handled:

- either as a reduced comfort requirement (e.g. 16 °C instead of 20 °C)
- or as no requirement at all, assuming that building time constant and duration of no comfort interval will prevent a too high temperature drop and an actual discomfort.

The actual values for the required comfort depend on the comfort category:

- Category I is a high quality comfort.
- Category II is a normal quality comfort. This is the usual reference for standard evaluation.
- Category III is a low quality comfort.
- Category IV is the lowest quality comfort which is usually considered as not acceptable.

Category II is the default choice.

The potential impact of selecting other categories is investigated in the case study on EN 16798-1.

Operation set-point profile is the actual set-point for the operation of technical systems.

The operation set-points are given as “levels”.

- Level 0 means that the technical system is completely de-energized, including all auxiliaries (“power off mode”).
- Level 1 means that the system is not providing any service but is ready to react upon request (“stand-by” operation). Both auxiliary and main energy may be used in this condition. An example is a generation system kept warm when no distribution is asking for heat.
- Level 2 is the reduced mode, e.g. operation with a lower set-point than for normal comfort condition. An example is reduced ventilation when the building is not occupied.
- Level 3 is normal operation mode, with the set-point matching the required comfort level.
- Level 4 is boost mode: an increased set-point may be used to store energy in the building.
- Level 5 and 6 are reserved for custom special levels.

The operation set-point matches the comfort profile when comfort is required. The operation set-point shall anticipate the required comfort set-point to allow recovery of indoor conditions in due time. A default anticipation is included in the base profiles. This anticipation should be defined for each technical system in the respective general part and possibly be calculated according to a building automation function.

See the case study on EN 16798-1 for more details on use profiles.

5 Sample buildings

5.1 Simple Best test case

It consists of a simple rectangular building (a “shoebox”). It is used in EN ISO 52016-1, clause 7.

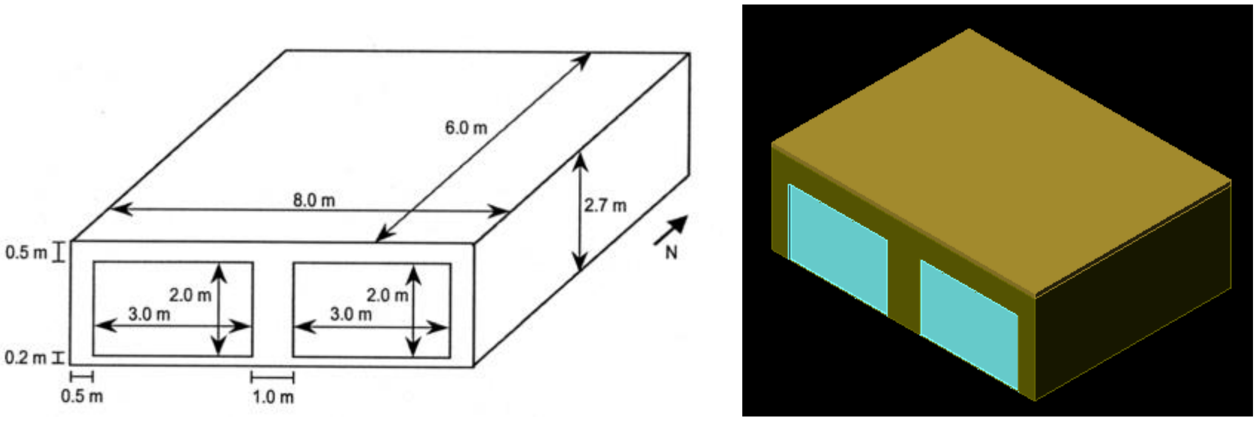


Figure 2 - Best test example geometry and 3d representation in software

This example is focused on testing specific features of the calculation procedure. It is not realistic in size and layout to represent an actual building, so it cannot be used to represent significantly real building cases.

5.2 Single family house - SFH

This is the example defined in CEN ISO/TR 52016-2, clause 9.

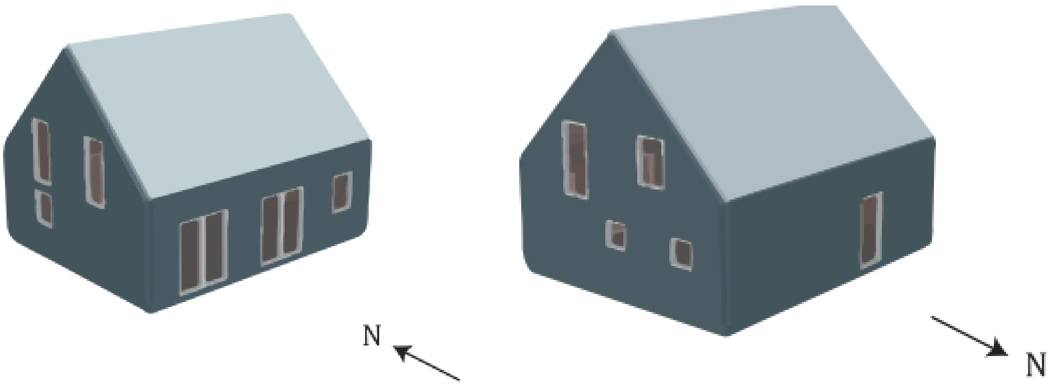


Figure 3 - Single family house view

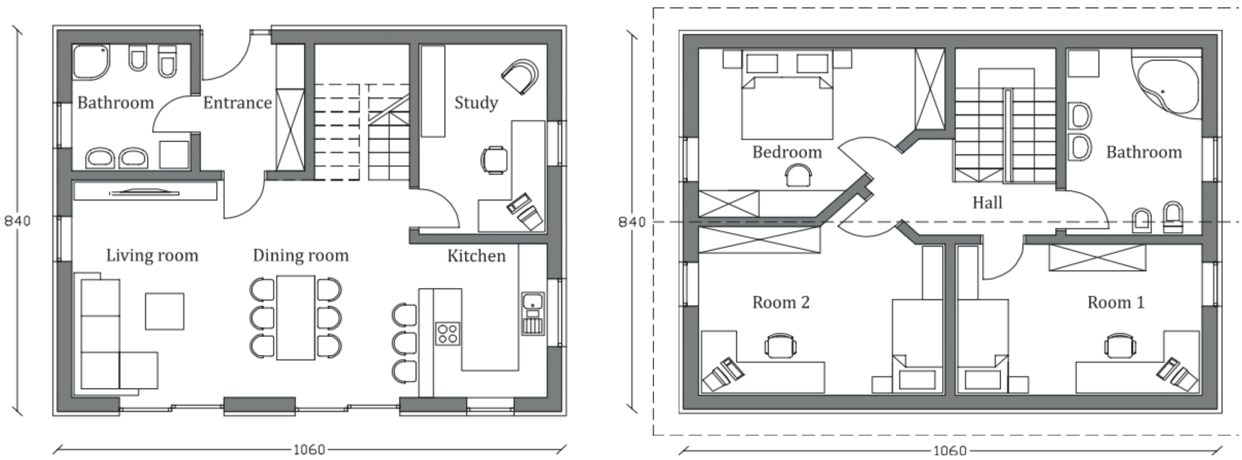


Figure 4 - Single family house, plans

This example is used to test all services and features of the calculation procedure. It is realistic in size and layout, so it represents significantly a real case.

The services include heating, domestic hot water and possibly mechanical ventilation and cooling.

This example is used to generate realistic needs to test the whole set of EPB standards.

Needs for the same building have also been calculated with a commercial software based on EN ISO 52016-1 to check the average values for shading factors used in the case studies.

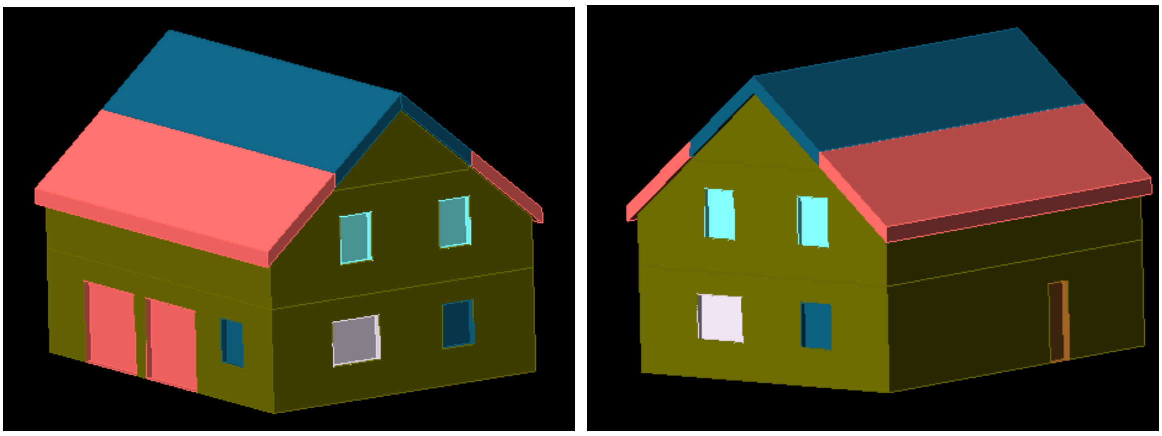
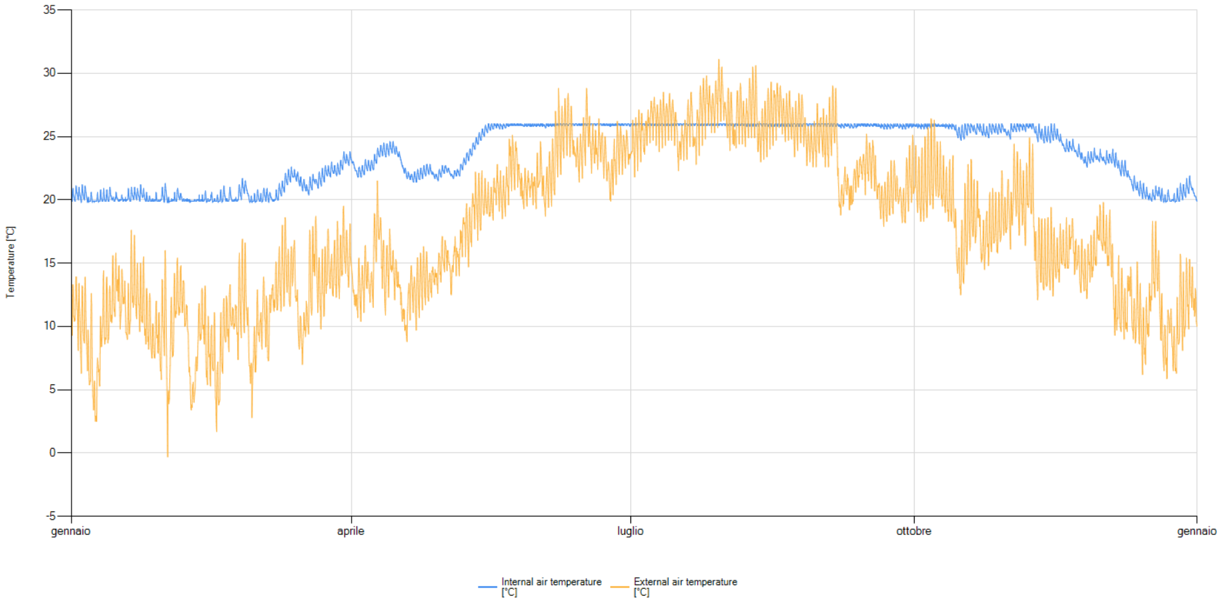


Figure 5 - 3D model of the SFH building generated by the software

After the alignment of data, the following results were obtained:



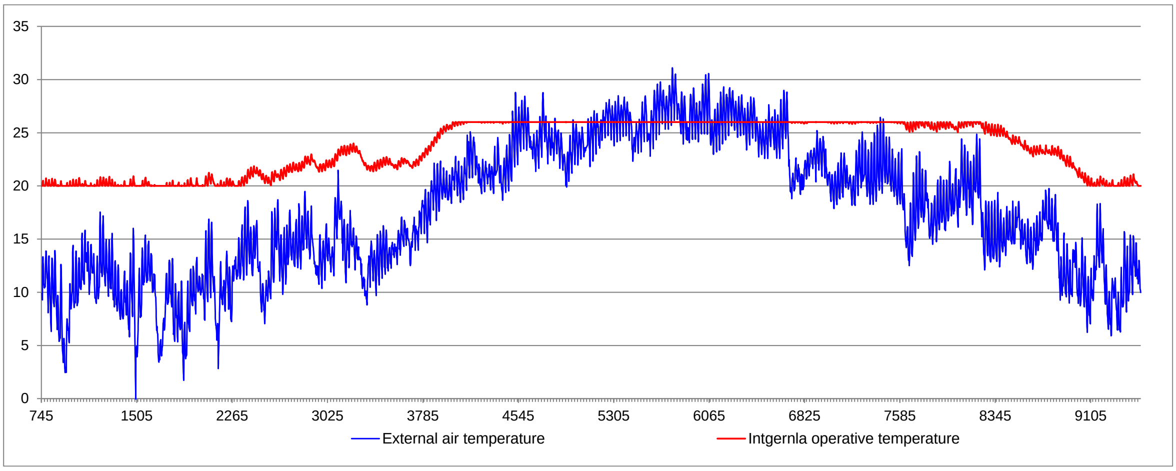


Figure 6 - Hourly profiles for external and internal temperature obtained with the accompanying Excel and with a software based on EN ISO 52016-1.

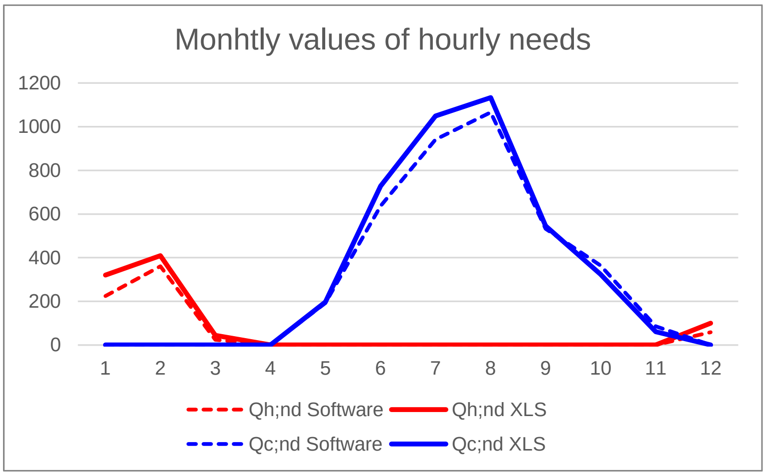


Figure 7 - Cumulated monthly values of hourly needs, obtained with the with the accompanying Excel and with a software based on EN ISO 52016-1.

The match is quite good and the residual differences are due to the different calculation method of shadings.

The intent was not to have an exact comparison of software against the Excel modules but to be sure that the software provides comparable energy needs patterns for multizone buildings that include several types of spaces, where the use of the Excel would be heavy.

The software could not be used for the complete building calculation because only the calculation of heating and cooling needs was available with the hourly method.

5.3 Office building - OFF

This example is taken from the EU ALDREN project, example B1, and is realistic in size. The original ALDREN example has been modified to have adequate space for realistic technical installations:

- a technical room was added on each floor to provide a vertical connection and space for technical systems cabinets;
- the height of floors was increased by 40 cm to allow false ceilings for ventilation and other technical installations (sprinkler, lighting, heating / cooling distribution, etc.);

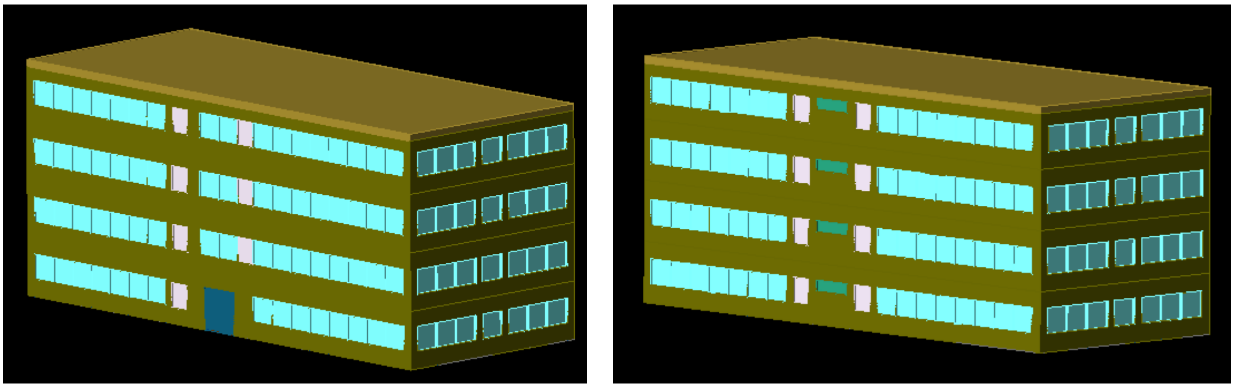


Figure 8 - Office block

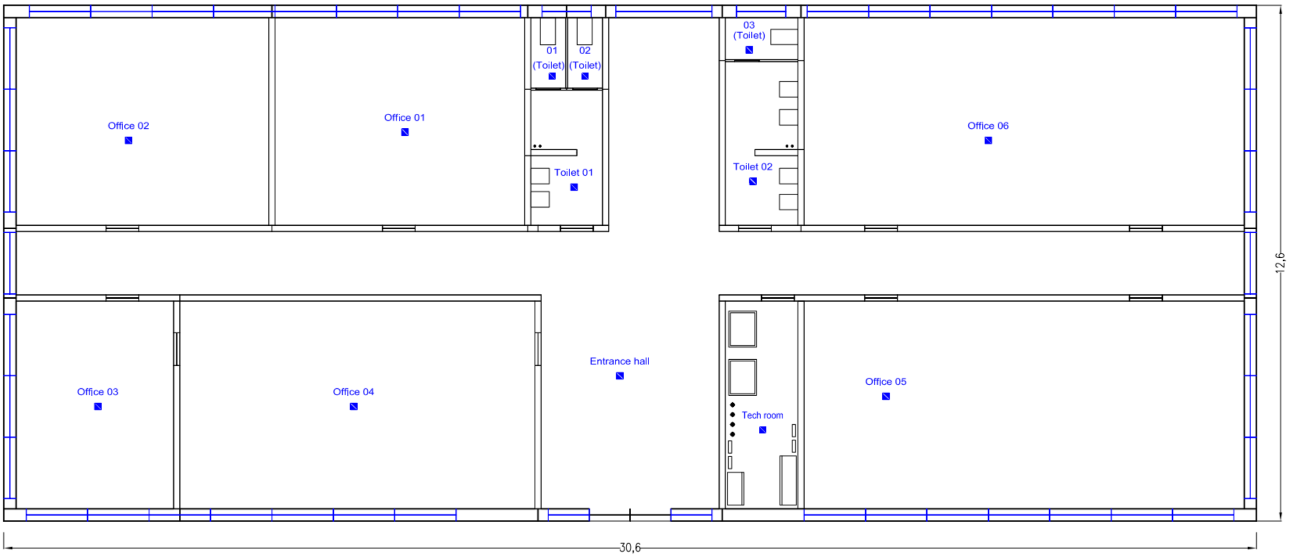


Figure 9 - Office block – Ground floor plan

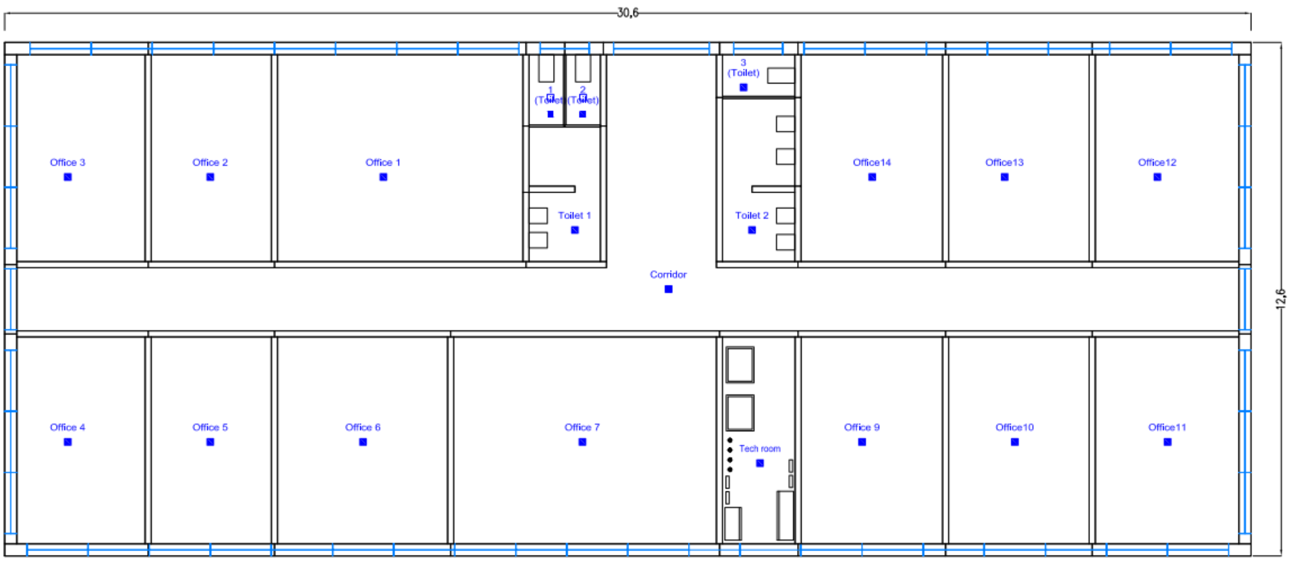


Figure 10 - Office block – Typical floor plan

See case study on Office Building for further details.

5.4 Multi-family house (MFH - residential block building)

No specific documented example was found as publicly available. A sample residential block building has been created starting from the same shape of the office building and assuming a credible internal layout.

The assumed layout of the 4 floors are shown in figure 11.

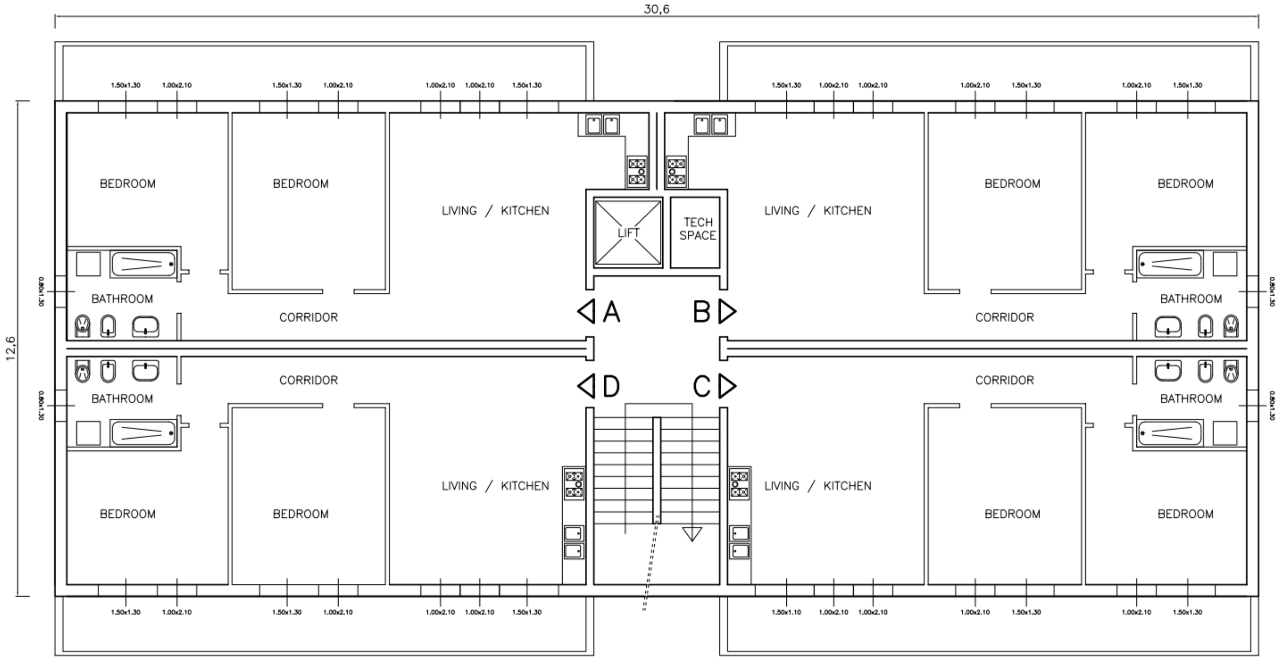


Figure 11 - Multi-family house: layout of the typical floor

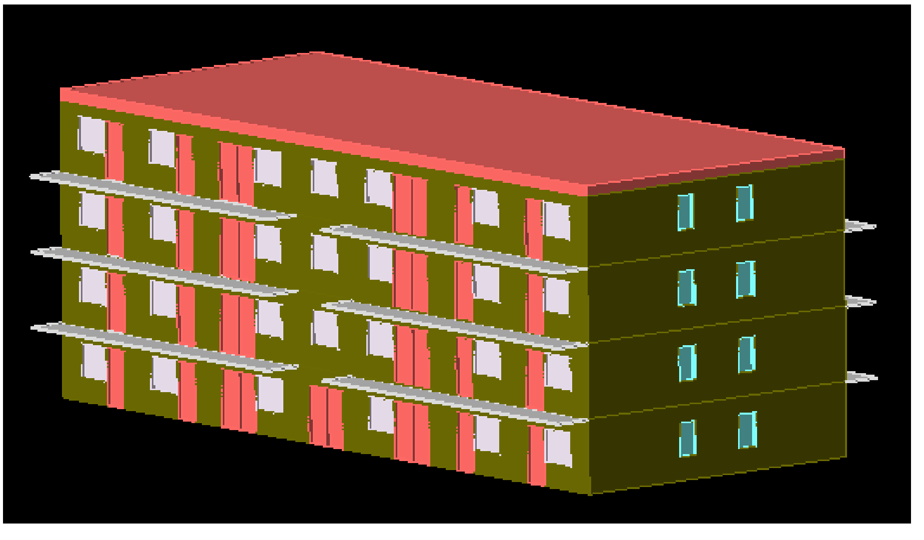


Figure 12 - Multi-family house, front view (entrance)

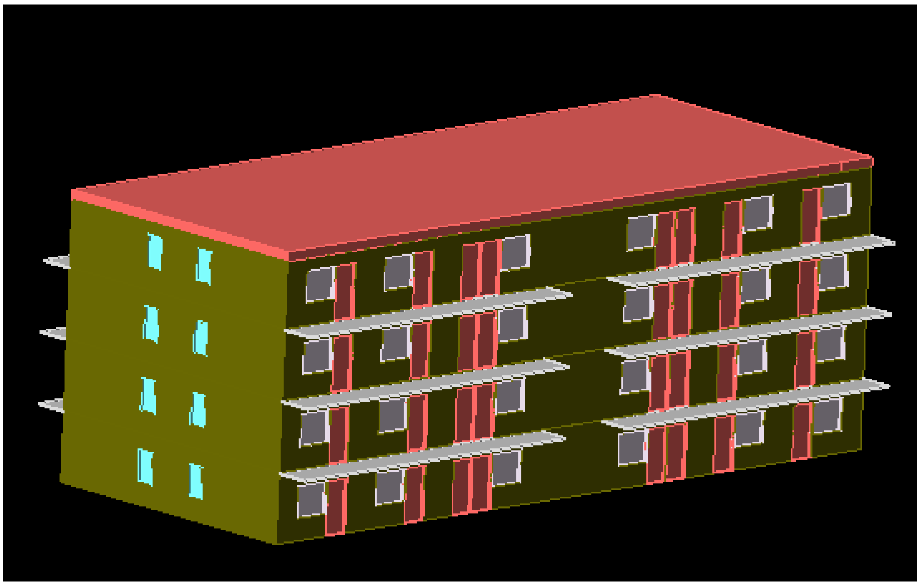


Figure 13 – Multi-family house, rear view

The result is a block of 16 apartments having the following size:

- total net floor area: 1326 m^2
- total gross volume: 4620 m^3
- heat loss area: 1807 m^2
- shape factor: 0,39 m^{-1}

Each apartment consists of two bedrooms, a living room with cooking and a bathroom. The net floor area is 76,6 (A and B) or 73,6 m^2 (C and D).

For the sake of simplification, the central stairs and technical area has been considered as a 17th zone ("common areas").

An input configuration file for the XLS on EN ISO 52016-1 has been generated both for the whole building and for each apartment.

The assumed use profile is apartment for workers (source: annex B to EN 16798-1).

The calculations have for the case studies have been performed either with the demo XLS or with commercial software.

See case study on multi-family house further details.

Annex A

Climatic data specification

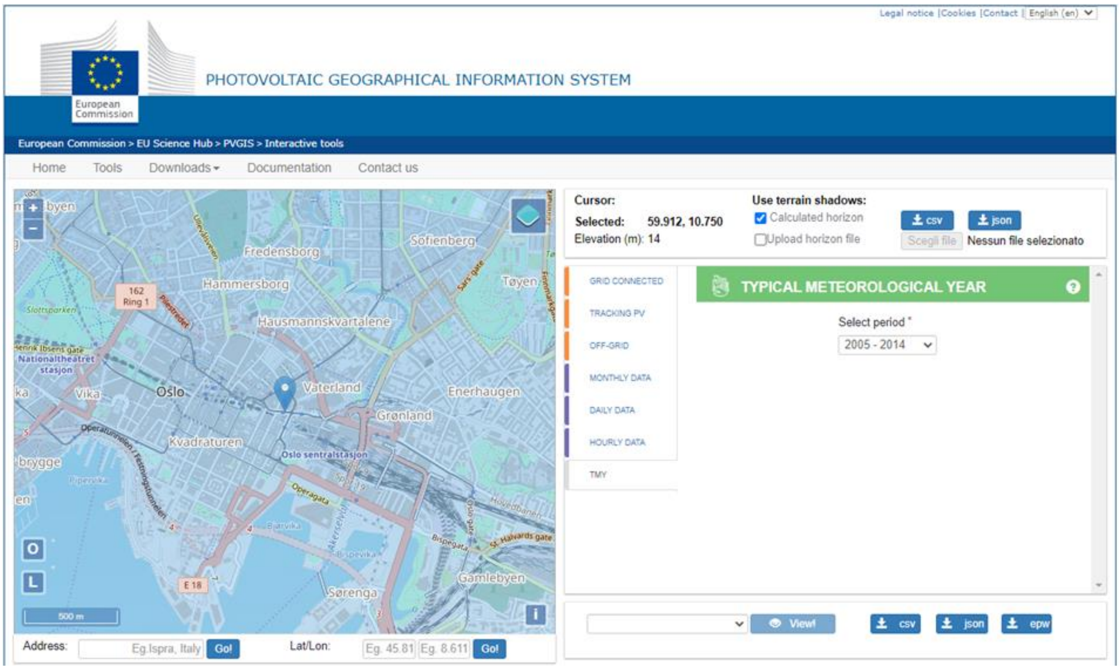
This annex contains the specification of the basic climatic data.

Data is taken from https://re.jrc.ec.europa.eu/pvg_tools/it/#TMY with the option years 2005 to 2014.

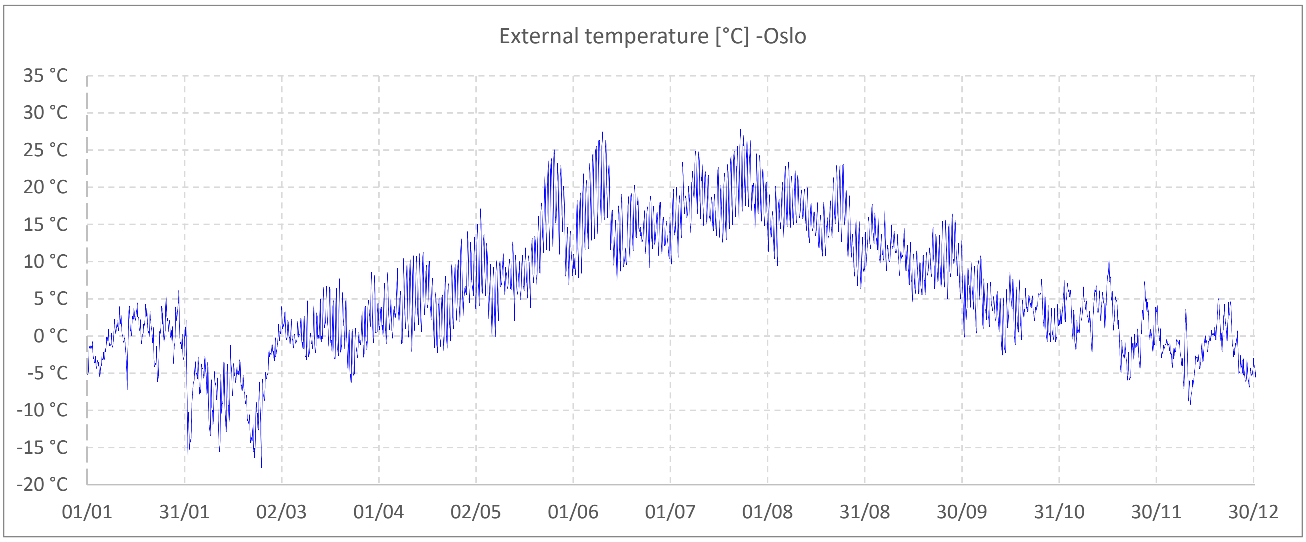
- Data has been processed with file TMY-ISO-52010-1_conversion_2020-08-19.xlsm that accepts as an input the CSV file generated according to the selected location
- provides as an output the required block of data for use in the file Demo_ISO_52010-1_Calc_2019.11.20.xlsm

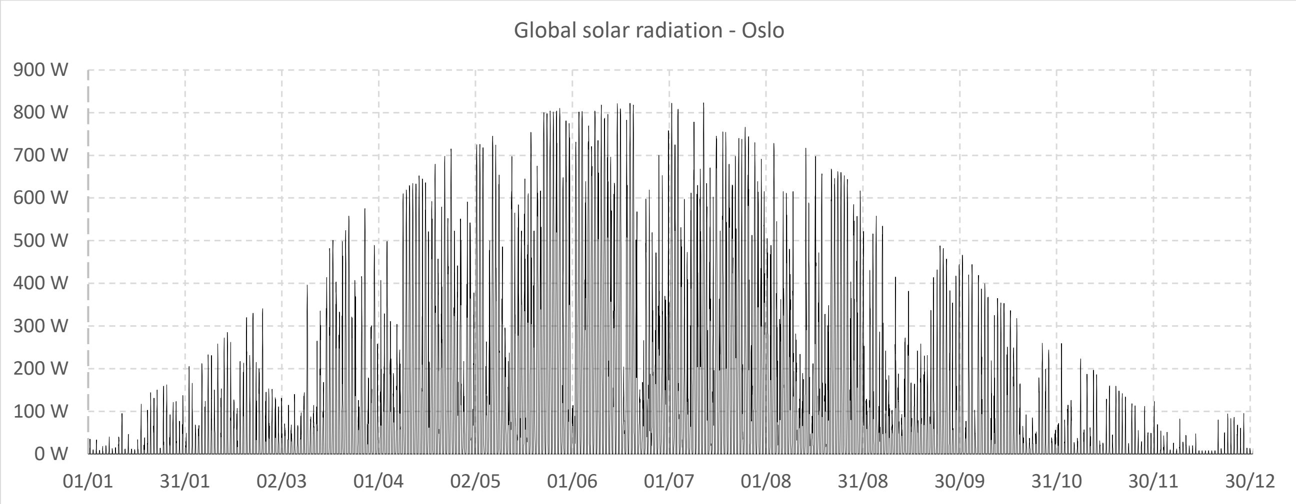
Then the file Demo_ISO_52010-1_Calc_2019.11.20.xlsm is used to provide the insolation data on a set of custom oriented planes (azimuth and tilt) for use in specific standards such as EN ISO 52016-1 (heating and cooling needs), EN 15316-4-3 (thermal solar and PV), etc.

A.1 Cold climate: Oslo



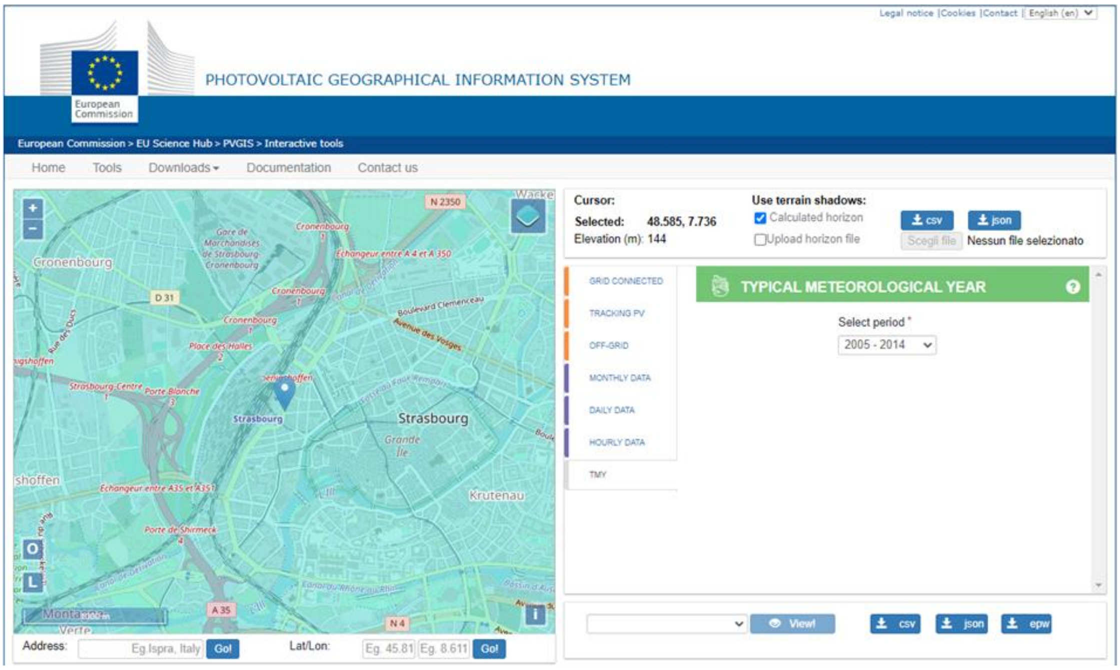
Weather station data	Symbol	Unit	Value	Typical range
Station and/or file name			Oslo	
Optional special notes			JRC TMY, selected months, years: 1 = 2008; 2 = 2010; 3 = 2009; 4 = 2010; 5 = 2012; 6 = 2007; 7 = 2014; 8 = 2007; 9 = 2008; 10 = 2009; 11 = 2013; 12 = 2008;	
Optional special notes			Selected period 2005-2014	
Optional special notes			None	
Latitude	φ_w	deg	59,912	-90 to +90
Longitude	λ_w	deg	10,75	-180 to +180
Elevation (in meters above sea level)	h_w	m	14	-500 to +9000
Time zone	TZ	h	1	-12 to +12



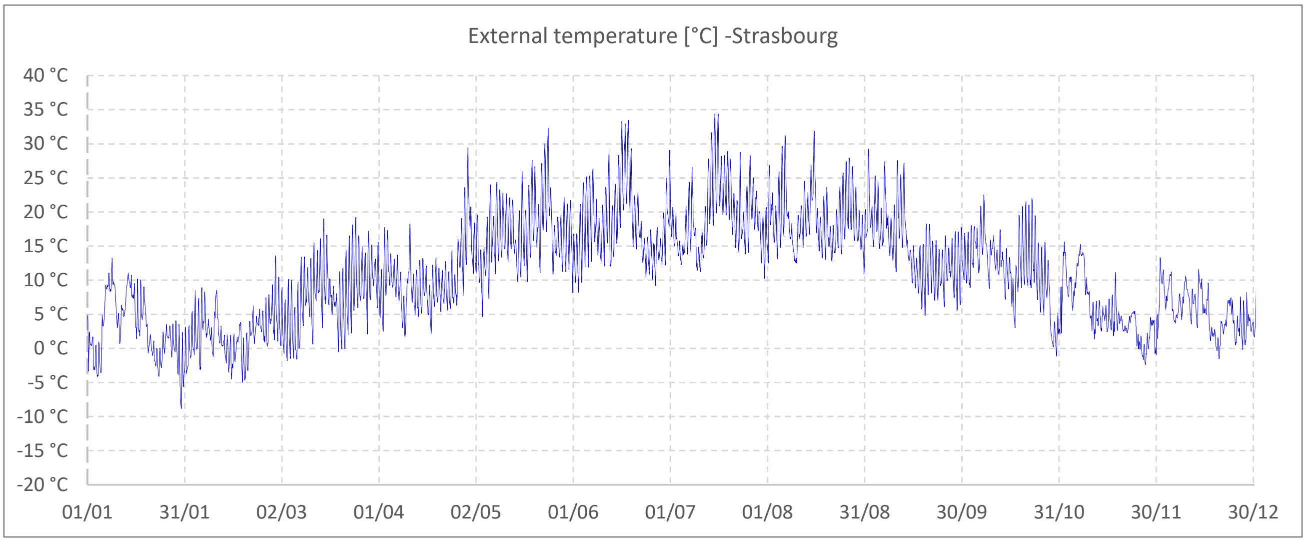


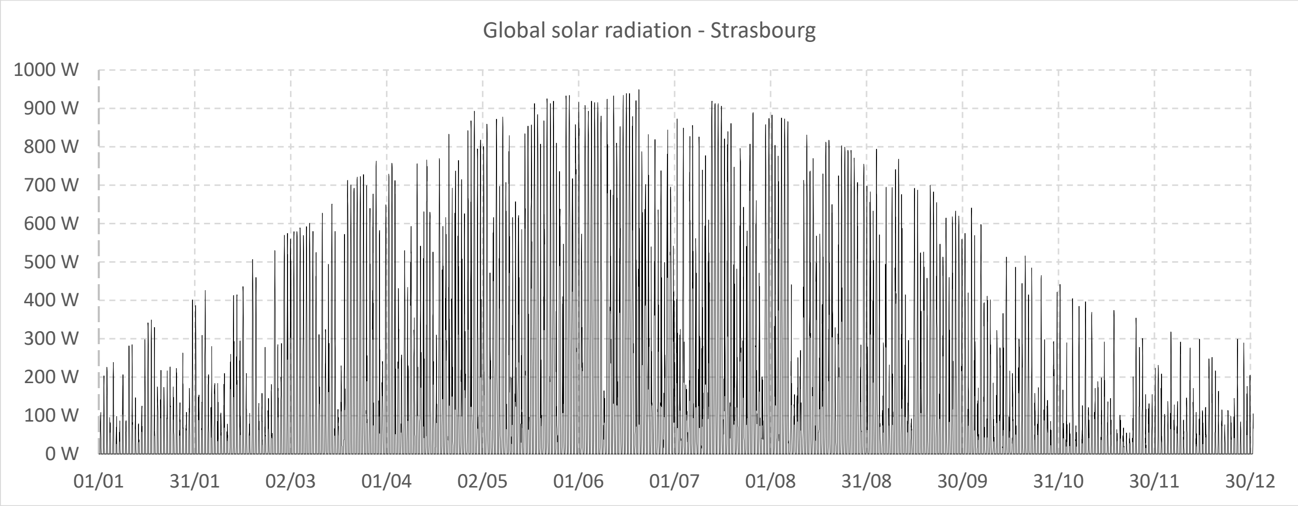
Month	Temperature	Relative humidity	Global radiation horizontal plane	Diffuse radiation horizontal plane	Direct (beam) radiation	Wind speed
	°C	RH %	W	W	W	m/s
JAN	-0,21	85,9	9	6	20	5,35
FEB	-7,73	83,8	38	23	68	2,95
MAR	0,53	78,7	76	41	92	3,61
APR	4,58	69,6	155	76	166	3,00
MAY	10,86	64,5	216	97	210	2,80
JUN	15,65	65,1	232	100	227	2,71
JUL	18,84	70,4	230	106	219	2,25
AUG	15,56	72,3	161	82	158	3,61
SEP	10,73	81,1	82	51	81	3,12
OCT	3,69	84,9	54	24	99	3,36
NOV	1,94	85,3	17	10	41	2,83
DEC	-2,04	90,7	4	3	13	3,34
Max	27,8	100,0	823	395	998	12,4
Average	6,1	77,7	107	52	116	3,2
Min	-17,7	21,1	0	0	0	0,1
	Total radiation [kWh/m²]		934	453	1.020	

A.2 Average climate: Strasbourg



Weather station data	Symbol	Unit	Value	Typical range
Station and/or file name			Strasbourg	
Optional special notes			JRC TMY, selected months, years: 1 = 2011; 2 = 2009; 3 = 2011; 4 = 2012; 5 = 2009; 6 = 2013; 7 = 2007; 8 = 2007; 9 = 2008; 10 = 2012; 11 = 2013; 12 = 2011;	
Optional special notes			Selected period 2005-2014	
Optional special notes			None	
Latitude	φw	deg	48,585	-90 to +90
Longitude	λw	deg	7,736	-180 to +180
Elevation (in meters above sea level)	h_w	m	144	-500 to +9000
Time zone	TZ	h	1	-12 to +12

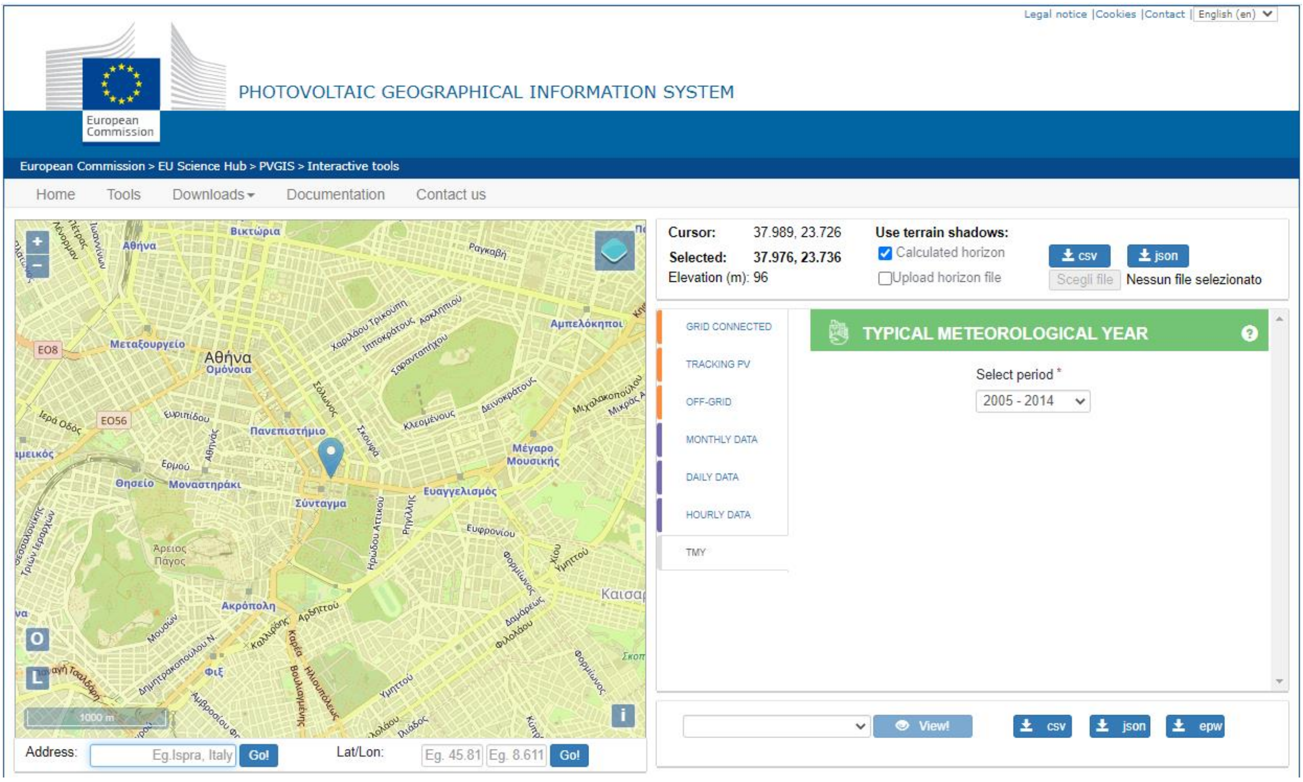




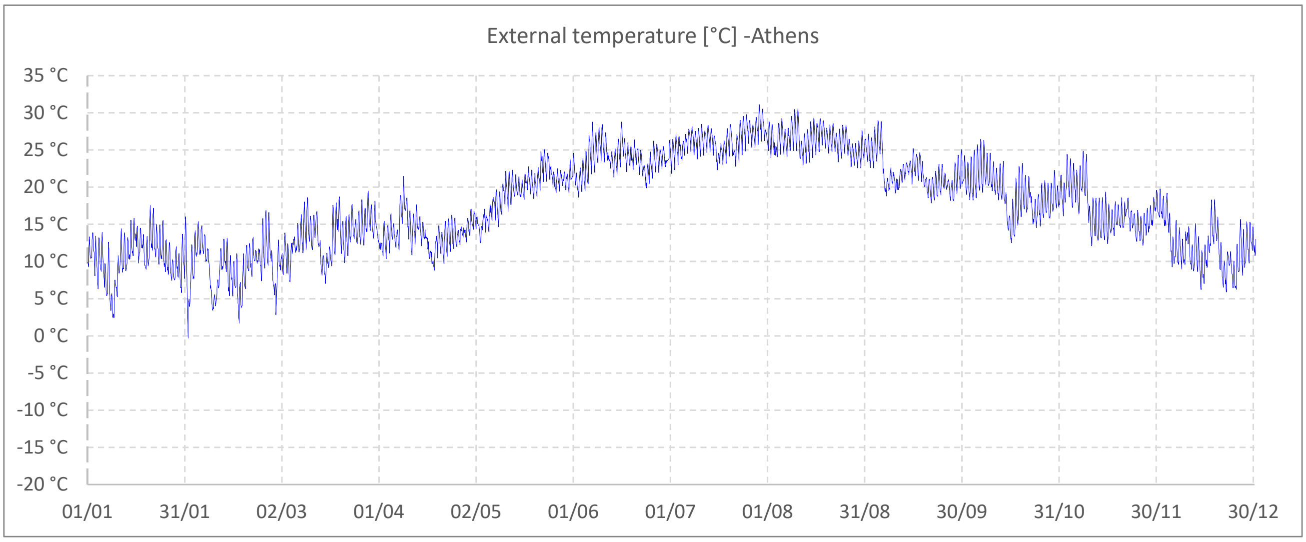
Aggregated monthly values

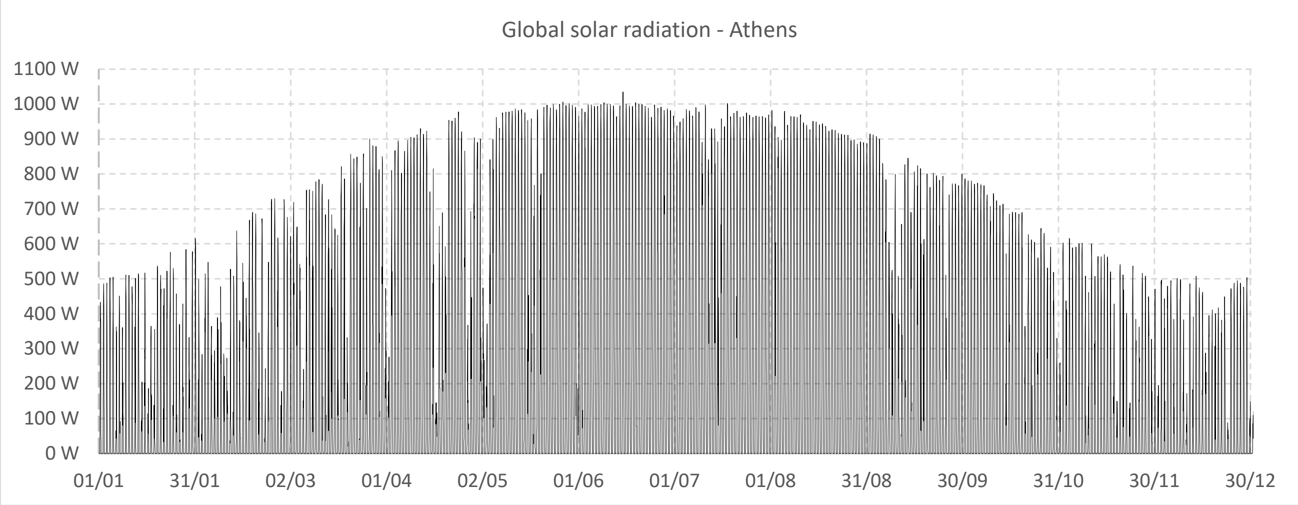
Month	Temperature	Relative humidity	Global radiation horizontal plane	Diffuse radiation horizontal plane	Direct (beam) radiation	Wind speed
	°C	RH %	W	W	W	m/s
JAN	2,70	86,6	41	27	51	3,17
FEB	2,02	84,5	60	37	61	2,99
MAR	7,66	71,3	146	58	185	2,96
APR	10,12	70,1	166	92	126	3,15
MAY	17,09	73,3	233	103	198	2,74
JUN	18,10	72,4	256	108	222	2,28
JUL	19,48	72,6	202	98	160	3,49
AUG	18,90	76,3	195	86	174	2,42
SEP	14,75	76,9	141	71	136	2,96
OCT	11,47	82,0	78	48	74	2,71
NOV	5,45	89,4	38	24	47	3,13
DEC	5,39	90,2	30	22	35	3,92
Max	34,4	99,9	949	453	989	14,1
Average	11,2	78,8	132	65	123	3,0
Min	-8,8	0,5	0	0	0	0,1
	Total radiation [kWh/m²]		1.160	567	1.076	

A.3 Warm climate: Athens



Weather station data	Symbol	Unit	Value	Typical range
Station and/or file name			Athens	
Optional special notes			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;	
Optional special notes			Selected period 2005-2014	
Optional special notes			None	
Latitude	φw	deg	37,976	-90 to +90
Longitude	λw	deg	23,736	-180 to +180
Elevation (in meters above sea level)	h_w	m	96	-500 to +9000
Time zone	TZ	h	1	-12 to +12





Month	Temperature	Relative humidity	Global radiation horizontal plane	Diffuse radiation horizontal plane	Direct (beam) radiation	Wind speed
	°C	RH %	W	W	W	m/s
JAN	10,50	80,9	92	44	115	5,24
FEB	9,24	82,3	110	58	106	5,41
MAR	13,18	78,9	185	75	187	4,73
APR	13,79	76,3	233	93	216	4,91
MAY	19,47	73,6	294	93	285	4,58
JUN	23,76	65,4	343	84	362	5,44
JUL	26,29	58,4	325	86	344	4,66
AUG	26,23	64,3	307	74	347	4,94
SEP	21,95	77,3	214	81	211	6,53
OCT	19,30	78,4	170	61	206	6,68
NOV	16,86	81,1	108	47	141	5,05
DEC	11,83	81,6	84	38	121	4,85
Max	31,1	99,7	1035	472	994	16,2
Average	17,8	74,8	206	69	221	5,2
Min	-0,3	29,0	0	0	0	-0,2
	Total radiation [kWh/m²]		1.805	608	1.936	

Annex B

List of case studies

The following cased studies have been produced in the context of the service contract.

[1] ENERC32017-437-SI2-785.185, Case study on EN ISO 52000-1, Overarching standard October 31, 2021

[2] ENERC32017-437-SI2-785.185, Case study on EN ISO 52000-1, Overarching standard, simplified spreadsheets, October 31, 2021

[3] ENERC32017-437-SI2-785.185, Case study on EN ISO 52010-1, Climatic data October 31, 2021

[4] ENERC32017-437-SI2-785.185, Case study on EN 15316-1, Heating and domestic hot water systems, general part, October 31, 2021

[5] ENERC32017-437-SI2-785.185, Case study on EN 15316-4-2, Heat pumps October 31, 2021

[6] ENERC32017-437-SI2-785.185, Case study on EN ISO 52016-1, Heating and cooling needs and internal temperatures October 31, 2021

[7] ENERC32017-437-SI2-785.185, Case study on EN ISO 52016-1, Annex F, Solar shading reduction factors October 31, 2021

[8] ENERC32017-437-SI2-785.185, Case study on EN 16798-1, Conditions of use October 31, 2021

[9] ENERC32017-437-SI2-785.185, Case study on EN 16798-7, Natural ventilation October 31, 2021

[10] ENERC32017-437-SI2-785.185, Case study on EN 16798-7 and EN 16798-5-1, Mechanical ventilation October 31, 2021

[11] ENERC32017-437-SI2-785.185, Case study on Single-family House October 31, 2021

[12] ENERC32017-437-SI2-785.185, Case study on Multi-family House October 31, 2021

[13] ENERC32017-437-SI2-785.185, Case study on Office building October 31, 2021

Each case study includes:

- a report
- a power point presentation
- a set of supporting calculation spreadsheets

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

Link: EPB Center support documents

This document has been produced under contract with the European Commission (service contract ENER/C3/2017-437/S12-785.185).