**PUBLIC DOCUMENT**

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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 16798-1 Conditions of use

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Final report

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# Contents

Page

# 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** |
| **MFH** | **Multi-family house** |
| **MS** | **EU Member State(s)** |
| **OFF** | **Office building** |
| **NA (/ND)** | **National Annex or National Datasheet for EPB standards** |
| **NSB** | **National Standards Body of CEN and/or ISO** |
| **RER** | **Renewable energy ratio** |
| **SFH** | **Single family house** |
| **TR** | **Technical report (of CEN and/or ISO)** |
| **XLS** | **Spreadsheet** |

# 1 Introduction

This document is intended to present the case study on EN 16798-1 and shows the effect of choices given in that standard.

EN 16798-1 is focused on the definition of the conditions of use of the building. This includes the following relevant use conditions for EPB purposes:

- thermal conditions;
- hygrometric conditions;
- ventilation rate (outdoor air);
- occupancy;
- internal gains.

Conditions of use for domestic hot water are defined in another standard, EN 12831-3.

Lighting conditions of use (lux levels on the work plane) are defined in EN 16798-1 but this information is not taken into account in EN 15193-1.

EN 16798-1 also specifies other operating conditions which are needed for design purpose, such as:

- acoustics;
- other local comfort requirements.

These do not impact directly on energy performance of buildings and therefore they are not discussed in this case study.

Conditions of use have a deep impact on energy performance. Standardised and realistic conditions of use shall be defined for a fair rating or comparison of buildings (design and asset rating).

The influence is not limited to the desired set-point for temperatures, humidity and other services. It is fairly obvious that if you require a higher indoor temperature, you will increase heating needs. Internal gains, which are linked to the assumed activities ongoing inside the building, also have an impact on needs since they are part of the thermal balance of the building. Internal gains reduce the heating needs during winter and increase the cooling load in summer.

# 2 Executive summary

This case study concerns EN 16798-1, which is the standard that defines operating conditions inside the building.

Standard operating conditions are required to give a reference for the calculation of the energy performance. Any performance evaluation shall be referred to the level of comfort provided.

EN 16798-1 has a direct impact on needs, that is the actual amount of energy to be supplied or extracted from the conditioned space to provide the desired level of service. Technical systems may then require more energy than needs (because of losses and auxiliary energy use) or less energy if heat recovery is possible (cross-flow heat exchangers to reduce ventilation needs).

This case study focuses on the direct impact of EN 16798-1, that is on the energy needs.

The dependency of needs on comfort levels, depending on context, is analysed both with direct indicators, such as heating needs for a test building, and indirect indicators, such as degree-days resulting from a comfort choice.

# 3 The context of the case study

This module and standard (EN 16798-1) sets the conditions of use and comfort objectives, that is the effort level for the building envelope and technical systems. The conditions of use determine the level of comfort. Generally, an increase in comfort requires an additional use of energy. A fair comparison between buildings or between a building and a regulatory requirement requires a well-defined level of comfort.

The transition from monthly to hourly calculation methods requires extra care about the definitions of conditions of use and comfort requirements and their implications on technical systems operation.

A monthly method requires just average or total values for a month. Any concern about actual patterns and schedules is embedded in the averaging or summing method.

An hourly method requires an hourly pattern for each operating condition. This does not mean that 8760 values for each variable have to be defined. Typically, 24 hours pattern will be defined separately for work-days and holidays (holidays meaning Sundays and any special holiday), optionally for Saturdays. Then these profiles are combined into a complete time series for one year (plus the stabilisation period).

This requires decisions like:

- selecting which is the day of the week of the first calculation day;
- if taking into account special holidays, such as school holidays in summer;
- if taking into account a special pattern for Saturdays;
- if taking into account daylight saving time.

In other words, a reference calendar has to be established.

To build something representative, the hourly patterns for the conditions of use of all services shall be coordinated. No one would expect domestic hot water draw-off with no occupancy. The link of all conditions of use to a common basis that is occupancy, is one of the reasons for concentrating the conditions of use for all services in a single module.

Dynamic calculations require that the model be initialised at the beginning of the calculation, basically to set-up heat capacities and other kind of energy or mass (humidity, $CO_2$ concentration) accumulated in the building and systems. This can be done in at least two ways, that is:

- starting with a copy of the last days of the year;
- cycling on the last day of the year until stabilisation for a given number of iterations.

The module shall be able to handle all the above options.

It is also interesting to make some statistics to evaluate the equivalent average impact of a given hourly pattern. This allows understanding the potential impact of default choices and a comparison with the equivalent monthly values in use. An example of such statistical data is the potential for free cooling, expressed in degree-days.

# 4 Coverage of the scope

## 4.1 Introduction

This standard defines the intended level of service and the influence of activities inside the building on the thermal energy balance.

Not all services are covered by this standard (domestic hot water, lighting, …). These are covered in other modules. For the sake of completeness, they will be shortly discussed indeed in this case study.

All space categories and system technologies are inherently covered.

### 4.2 Coverage of technologies

This module has no direct link with any comfort technology.

Even though operation levels schedules are defined (set-back operation), system controls and building automation functions should provide the link between the comfort requirements and the system set-points and operation. This is further analysed in the following.

### 4.3 Coverage of installation and building configurations

For the (CEN and ISO) EPB standards, it is a basic concept that a "space" is a part of a building with uniform operating conditions. In principle, this module has to be applied independently for each space of the building.

It has to be noted that a "space" is not a "room". For a simple building, the entire building may be considered a single "space" whereas for special applications there might be several spaces in a single room. See EN ISO 52000-1 for further details.

For the purpose of the calculations, spaces are aggregated into "thermal zones" for the thermal balance and "service areas" for each technical system. The effect of the definition of thermal zones and service areas is taken into account in the building and technical systems modules, by appropriate aggregation of the results for each space included in the thermal zone or service area.

### 4.4 Coverage of space categories

This module shall define a complete set of conditions of use (i.e. for all services) for each space category.

The set of default profiles given in annex B of EN 16798-1 does not cover the whole set of default space categories defined in EN ISO 52000-1 annex B, table B-7.

This limitation is not in the methodology but just in the limited set of default data input which is provided in the Annex B to EN 16798-1.

### 4.5 Coverage of performance indicators

This module doesn't contribute directly to performance indicators.

This module provides a reference service level for all weighted performance indicators in use.

### 4.6 Coverage of calculation intervals

This module is focused on base values and hourly patterns.

Coherent and justified monthly values can be extracted as monthly averages or totals of hourly values.

## 5 Definition of the cases

### 5.1 Rationale of the selection of cases

This case study will focus on giving some indicators of the potential impact of the choices about service level and assumed internal conditions of use.

The impacts that are evaluated in this case study are:

- effect of comfort level on heating and cooling degree-days;
- effect of comfort level on heating and cooling needs;
- effect of ventilation rate on thermal energy balance;
- effect of internal gains on thermal energy balance.

## 5.2 Comfort categories

The set-point for most services cooling depends on a "comfort category" i.e. on the desired comfort level. Default values provided in annex B of EN 16798-1 are given in table 1.

**Table 1 – Selection of set-points for residential buildings as a function of comfort category**

| Comfort category | Heating | Cooling | Humidif. | Dehumidif. | Ventilation | | |
|---|---|---|---|---|---|---|---|
| | | | | | Building emissions LPB-2 | People emissions Non adapt. | Air exchange rate |
| | *Table B.5* | *Table B.5* | *Table B.16* | *Table B.16* | *Table B.7* | *Table B.11* | *Table B.11* |
| | °C | °C | % RH | % RH | $l/sm^2$ | l/s pers | $h^{-1}$ |
| I | **21** | **25,5** | 30 | 50 | 1,00 | 3,5 | 0,70 |
| II | **20** | **26** | 25 | 60 | 0,70 | 2,5 | 0,60 |
| III | **18** | **27** | 20 | 70 | 0,40 | 1,5 | 0,50 |

Category I is intended as a "high comfort" level.

Category II is intended as a "normal comfort" level.

Category III is intended as a "poor comfort" level.

Category IV is considered "not acceptable" and it is not taken into account in this case study.

The relative impact of comfort level is expected to depend also on climate. A trivial example is cooling: depending on the climate, no cooling may be required for the lower comfort levels whilst some cooling may be required for the highest comfort level.

The values defined as "reduced" in the tables of annex B of EN 16798-1 are not relevant in this context. They should be used as a system set-point if and when no comfort is required, e.g. during set-back operation when there is no occupancy or the comfort requirement may be reduced.

Comfort categories do not impact all services: there is no such distinction for domestic hot water and lighting.

## 5.3 Types of buildings

When relevant, the calculation is done for several types of buildings categories:

- residential;
- office, office room or meeting room;
- kindergarten.

For the residential case, the base case is continuous operation. The option of intermittent heating is explored as well.

The calculation is repeated for typical non-insulated buildings and insulated buildings.

For simplicity, a different space category will be assumed for the same building description.

## 5.4 Technologies

Technology has no direct impact on the definition of conditions of use.

The potential of technologies in mitigating the effect of the choices about operating conditions will be shortly discussed, where relevant (example: heat recovery to mitigate ventilation needs). Technology includes both building envelope solutions (materials, shadings) and technical systems solutions.

## 5.5 Calendar

The calendar is the definition of workdays, holidays, etc. which is a required parameter to combine daily profile into a full year profile.

The default choice is a non-leap year starting on Monday, which is the case for year 2018.

No daylight-saving time is considered.

No special holidays are considered.

## 5.6 List of selected cases and variants

### 5.6.1 Case 1 – Thermal balance

#### 5.6.1.1 Description

The set indoor temperature obviously influences heating and cooling needs.

The impact of the choice of temperature level is influenced by climate and building properties.

This influence is evaluated both as:

- a number of degree-days;
- a change in heating and cooling needs for the single-family house;

depending on the desired comfort level.

#### 5.6.1.2 Estimation of equivalent degree-days

The equivalent degree days for heating are calculated according to the following equation:

$$HDD = \sum_i \frac{max\left[0; \theta_{int;set;H} - \Delta\theta_{gains} - \theta_{ext,i}\right]}{24}$$

The equivalent degree days for cooling are calculated according to the following equation:

$$CDD = \sum_i \frac{max\left[0; \theta_{ext,i} + \Delta\theta_{gains} - \theta_{int;set;C}\right]}{24}$$

where

| | |
|---|---|
| $\theta_{int;set;H}$ | is the internal set temperature for heating, which depends on the comfort category |
| $\theta_{int;set;C}$ | is the internal set temperature for cooling, which depends on the comfort category |
| $\Delta\theta_{gains}$ | is the increase in internal temperature due to gains. |
| $\theta_{ext;i}$ | is the outdoor temperature in the hour i |

Building insulation causes a rise of internal temperature with respect to outdoor temperature. The increase of internal temperature due to gains is assumed to vary:

- from 3 °C (existing residential buildings);
- to 10 °C (special buildings with high insulation and gains).

The temperature difference value is determined by a calculation in free-floating mode, see clause 6.1.3, “Checking temperature rise due to needs” for more details.

These are “rule of thumb values” for a first estimation of the potential influence. The relationship is not straightforward and linear because insulation level also reduces solar gains on opaque elements. Indeed, this gives a first idea of the relative impact of comfort category and climate on energy needs for heating and cooling.

#### 5.6.1.3 Estimation of free cooling potential

If no action is undertaken, the internal temperature in the building will always be higher than external temperature because of internal gains. During the initial and final part of the cooling season, if the outdoor temperature is lower than the internal set-point temperature, ventilative cooling may be used.

The potential for ventilative cooling is estimated as an amount of degree days in the hours that satisfy both the following conditions:

- outdoor temperature is lower than internal set temperature, minus a margin of 3°C (otherwise the cooling effect thanks to air exchange is not worth the effort in case of mechanical ventilative cooling);
- in that hour there would be a positive contribution to cooling degree days.

#### 5.6.1.4 Calculation of needs

The calculation of the heating and cooling needs is performed for the single-family house (SFH) with the same variants as for the calculation of degree-days.

For simplicity no change in the building characteristics is assumed according to climate. Only two levels of insulation are assumed which are the same as for the SFH case study for average climate.

Needs are calculated with infinite power available for heating.

- U value walls: 0,80 W/m$^2$K
- U value roof: 0,60 W/m$^2$K
- U value windows: 1,80 W/m$^2$K
- U value floor: 1,20 W/m$^2$K

Conditions of use: according to EN 16798-1 annex B, single family house, detached with humidification and dehumidification.

For the new building the following properties are assumed:

- U value walls: 0,20 W/m$^2$K
- U value roof: 0,15 W/m$^2$K
- U value windows: 1,20 W/m$^2$K
- U value floor: 0,40 W/m$^2$K

For more details about the building used as a test, see the case study on single family house, base case for existing and new building.

#### 5.6.1.5 Intermittency and building time constants

Intermittency is often considered as a means to reduce heating needs. During off time, the temperature of the building is left free to float.

For heating, the impact depends on the building time constant. Losses during off-time are fed by heat stored in the building structure and they have to be compensated at the beginning of the next on-time (comfort condition recovery after temperature drop for set-back or off-time). For cooling a peak-shaving effect is expected for the same reason.

This is checked by assuming intermittent heating and recalculating needs for the SFH, both new and existing.

### 5.6.2 Case 2 – Ventilation

#### 5.6.2.1 General

The continuous renewal of indoor air is a necessity for survival within a building. Natively, ventilation needs are not an energy quantity but an amount or a flow rate of fresh outdoor air.

This implies two types of energy costs.

- Air treatment energy need.
  This is the energy required to bring outdoor air to indoor conditions. It may imply heating, cooling, humidifying and dehumidifying, depending on the season.
  Air treatment cost can be reduced with heat and/or humidity recovery techniques.
  The sensible heat required for air treatment is included in the heating and cooling needs as $Q_{H;ve}$ and $Q_{C;ve}$. It's value is calculated separately for information.
  The latent heat required for air treatment is calculated as humidification and dehumidification needs.
- Air transport energy use.
  Outside air shall be supplied into the building and extracted indoor air exhausted.
  This requires the use of mechanical energy (energy for fans).
  This energy use depends on the amount of air to be transported and on the characteristics of the ventilation system (required pressure head and fan efficiency).
  It is for free in case of natural ventilation, but with natural ventilation there is no chance to use any heat recovery technique to reduce the air treatment energy needs.
  An estimation of the air transport energy use is provided based on an average value of Wh/m$^3$.

NOTE: when possible, natural ventilation is the optimal option for free cooling.

NOTE: the specific energy use for air transport was taken from data specification of a good quality VMC unit. A reasonable value for single family house is 0,35 Wh/m$^3$ with 100 Pa head losses.

For the sake of determining a potential impact, the pure air treatment energy use is evaluated. Then, there are technologies that allow to reduce energy needs linked to ventilation by means of recovery (heat and/or humidity) techniques.

The ventilation flow rates are defined starting from a reference (maximum) value with full occupancy which is also used for design purpose. There are several criteria available to define it:

- based on flow rate per person;
- based on flow rate per unit floor area;
- based on perceived air quality, which is a combination of the two previous requiring a contribution linked to occupancy (persons) and one linked to the floor area (polluting emission produced by building materials);
- based on an overall air exchange rate;
- based on maximum (target) excess $CO_2$ of internal air compared to outdoor air;
- differentiated for rooms with air supply and air extraction for the residential sector;
- evaluated for non-adapted persons versus adapted persons.

This variety of conventions already in use to define the reference flow rate is a fact, which delayed the standardisation process.

The reference ventilation flow rate may well be specified in a different way depending on the space category in the same building.

For this case study, only the following criteria are used:

- based on an overall air exchange rate for residential buildings;

- based on perceived air quality for non-adapted people, for non-residential buildings.

In principle, the various criteria should all bring to similar flow rates for the same conditions.

#### 5.6.2.2 Occupancy

Ventilation needs are directly linked to occupancy, which is the main parameter. Occupancy is directly linked to the space category.

Technical systems (ventilation system) may be able or not to adjust operation to occupancy. To evaluate this potential, the calculation of theoretical ventilation needs is repeated with:

- full flow rate during comfort requirement time
- flow rate as a function of occupancy.

for the office building.

#### 5.6.2.3 Climate

The air treatment energy needs are directly linked to climate

Calculation of theoretical air treatment needs is repeated for the three selected climates: Athens, Strasbourg and Oslo.

#### 5.6.2.4 Calculation performed

Since the ventilation, humidification and dehumidification needs that have been identified do not depend directly on the building envelope, the calculation is performed for a fictive 1 $m^2$ building of each space category. Figures are all values in kWh/$m^2$year for comparison.

### 5.6.3 Case 3 – Internal gains

#### 5.6.3.1 Description

Internal gains depend on the presence and activity of occupants, on plug loads and on production equipment inside the building.

Metabolism and any use of electricity or other energy carriers (e.g. gas for cooking) within the building turns into heat that contributes to the thermal heat balance, hence influences heating or cooling needs.

The potential impact can be evaluated in terms of kWh/$m^2$year:

- yearly total;
- during the heating and cooling season.

For this rough estimation, heating and cooling season are defined as those hours when there is a non-zero contribution to CDD or CDD.

#### 5.6.3.2 Space category

The space category defines both presence and activity of occupants. It has a direct impact on the internal gains.

Internal gains can be a help (in the heating case) or an additional load (in the cooling case). Climate and insulation level determines which effect is larger.

The calculation of the total internal gains is performed for each space category for which default data is provided.

### 5.6.4 Case 4 – Humidification and dehumidification

The effect on humidification and dehumidification is already discussed under the clause “ventilation”.

## 5.7 Calculation files summary

The naming convention and the list of supporting calculation files are given in annex A.

# 6 Calculation details

## 6.1 Calculation tools

### 6.1.1 Use profiles – EN 16798-1

There was no accompanying spreadsheet for EN 16798-1. The expected output of the application of this module are yearly time series of data, indeed.

To facilitate the use of EN 16798-1, a spreadsheet has been prepared to generate:

- a calendar, to have a means of combining daily profiles for each type of day;
- the time series for each relevant data such as:
    - diversity factors for occupancy and gains;
    - occupancy;
    - internal gains;
    - system set points;
    - comfort requirements.

For a standard calculation (according to standard use and climate conditions, which is the case for regulatory application), this choice is done once for all cases.

For a tailored calculation (according to a specific use of the building, which is the case for e.g. energy audits) this allows to match actual operating conditions.

The spreadsheet also allows to define the operating conditions for technical systems. These should be determined:

- in the general part for each technical system, such as heating, cooling, ventilation, etc.
- taking into account the required comfort conditions and their schedule;
- taking into account the control options.

This is one of the main interactions of BACs: the calculation of the required operating schedule and set-points to optimise system operation and get the comfort conditions in the scheduled time.

This is also an attention point to identify and quantify any failure in getting the required comfort level when scheduled.

The spreadsheet will be available on the EPB-Center website.

The default profiles for the detached house were used for this case study.

The profile selection is shown in figure 1.

**Space category :**

| | | |
|---|---|---|
| **RESIDENTIAL_Det_house** | | **11** |
| Source data sheet | **RES_det_house** | |

| | | |
|---|---|---|
| Space reference area | $m^2$ | 142 |
| Space net internal volume | $m^3$ | 357,4 |
| Comfort category | | II |
| Type of building | | Low polluting |
| Ventilation calculation option | | Method 1 - Perceived IAQ |

*Figure 1 – Operating conditions selection for the single family house*

Data on reference space area and net internal volume are required only if you need absolute values of conditions of use.

Depending on conventions for the data provided, the floor area may be net, gross, net internal.

The volume is used for calculations concerning ventilation and the net internal volume is the most common choice.

See the accompanying video for detailed explanations on this spreadsheet.

### 6.1.2 Climatic data - EN ISO 52010-1

Climatic data are calculated with EN ISO 52010-1 module, using data from the JRC data-base.

The 3 locations used are Athens, Strasbourg and Oslo.

See preparatory work document and case study on EN ISO 52010-1 for further details.

A copy of the 3 files with the climatic data for the three locations in included in the case study material.

### 6.1.3 Checking temperature rise due to gains

The spreadsheet for EN ISO 52016-1 was run with no power of heating and cooling systems. This determines the free-floating indoor temperature which is then compared to external temperature to get $\Delta\theta_{gains}$, that is the temperature increase due to gains.

This was repeated for the single-family house and for:

- the two default insulation levels (existing and new building);
- the three climates (contribution of gains also includes solar gains;

An example of the resulting pattern for indoor and outdoor temperature is given in figure 2. External temperature is continuously changing whilst indoor temperature changes are dampened by insulation and internal heat capacity of the building structures. It is evident that on the average, internal temperature always exceeds external temperatures by an amount given by the temperature drop required to expel all gains through the building envelope.

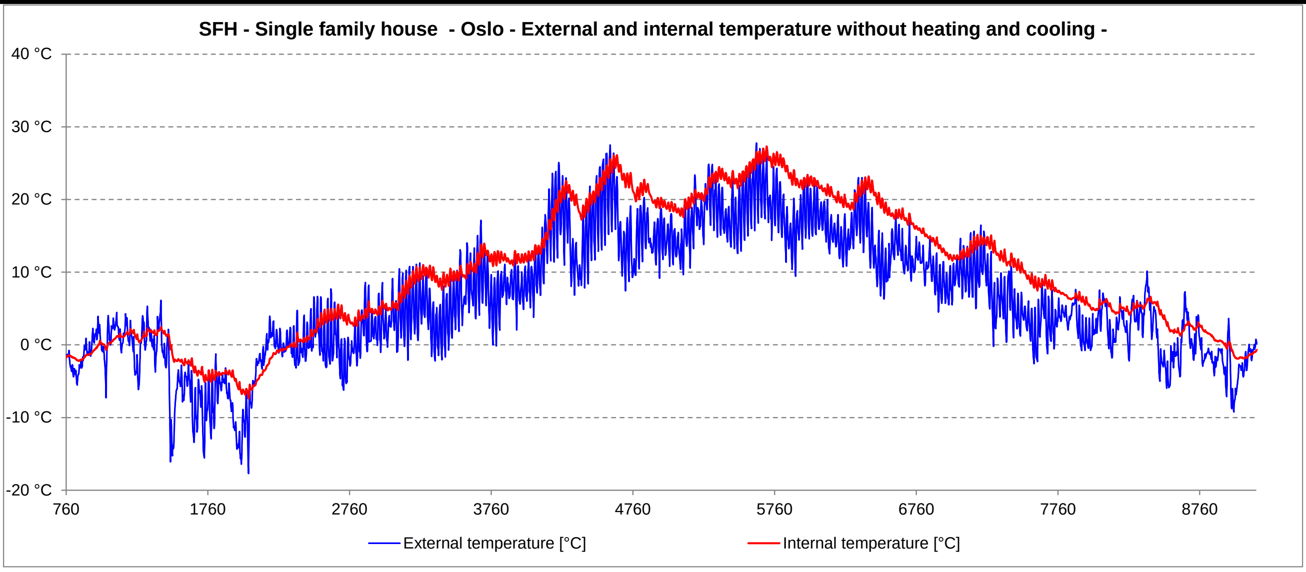


*Figure 2 – Internal and external temperature for the existing SFH in Oslo, without heating and cooling*

The detailed results are given in the following table 2.

**Table 2 – Single family house. Difference between internal and external temperature without heating and cooling $\Delta\theta_{gains}$**

| | Difference between internal and external temperature without heating and cooling $\Delta\theta_{gains}$ [°C]. | | | | | |
|---|---|---|---|---|---|---|
| | New building | | | Existing building | | |
| | Athens | Strasb. | Oslo | Athens | Strasb. | Oslo |
| January | 6,8 | 5,7 | 2,5 | 3,9 | 3,0 | 0,5 |
| February | 6,8 | 4,5 | 7,1 | 4,1 | 2,1 | 3,7 |
| March | 5,9 | 4,7 | 2,2 | 4,0 | 3,4 | 1,3 |
| April | 7,8 | 5,6 | 4,8 | 5,6 | 3,6 | 3,4 |
| May | 5,3 | 4,5 | 4,4 | 4,4 | 3,8 | 3,5 |
| June | 6,5 | 7,2 | 6,9 | 5,6 | 5,4 | 5,4 |
| July | 6,6 | 5,6 | 5,6 | 5,4 | 3,9 | 4,2 |
| August | 8,5 | 6,9 | 8,4 | 6,5 | 4,7 | 5,6 |
| September | 9,7 | 8,6 | 7,4 | 6,3 | 5,4 | 3,9 |
| October | 9,6 | 7,3 | 8,8 | 6,1 | 4,2 | 4,9 |
| November | 8,2 | 6,9 | 5,2 | 4,7 | 3,4 | 2,3 |
| December | 8,3 | 4,1 | 4,6 | 4,6 | 1,8 | 2,0 |
| Year | 7,5 | 6,0 | 5,7 | 5,1 | 3,7 | 3,4 |
| **Average** | **6,4** | | | **4,1** | | |

This rough check confirms the expected range of $\Delta\theta_{gains.}$

The average yearly values of $\Delta\theta_{gains}$ used for this case-study are 3, 6 and 9 °C:

- 3°C is a likely value for an existing residential building;
- 6 °C is a likely value for new residential buildings;
- 9 °C is a very high value for special buildings (very high insulation and/or high internal gains)

NOTE The air exchange rate is rather high (0,6 $h^{-1}$). A higher air exchange rate reduces $\Delta\theta_{gains}$

The exercise of determining the temperature increase because of gains can be repeated for a number of assumptions about the influencing factors, such as:

- building category;
- air exchange rate (a high air exchange rate reduces the temperature difference);
- shadings, fixed or movable, that may help reduce gains in summer and keep them in winter.

### 6.1.4 Energy needs calculation – EN ISO 52016-1

Energy needs calculation were performed with the demo spreadsheet on EN ISO 52016-1.

The spreadsheet provides the following:

- heating and cooling needs (sensible heat)
- humidification and dehumidification needs (latent heat).

The configuration file for each calculation has been saved.

### 6.1.5 Degree-days

The calculation of the degree-days and of the free cooling potential is performed in additional columns of the sheet “ClimDat_t” and summarised in the additional sheet “statistics” of the demo spreadsheet for EN ISO 52016-1.

Degree days do not depend directly on the insulation level of the building.

### 6.1.6 Ventilation needs

The pure ventilation heat losses and gains are calculated in additional columns of the sheet “ClimDat_t” and summarised in the additional sheet “statistics” of the demo spreadsheet for EN ISO 52016-1.

The electric energy that may be used by ventilation fans is calculated in additional columns of the sheet “ClimDat_t” and summarised in the additional sheet “Statistics” of the demo spreadsheet for EN ISO 52016-1.

### 6.1.7 Total gains

The calculation of the total internal gains is included in the special additional sheet “statistics” of the demo spreadsheet for EN ISO 52016-1.

## 6.2 General data

Tables 3 and 4 show the default data defined in annex B of EN 16798-1 for the available space categories.

**Table 3 – Default data per space categories, full occupancy**

| Full occupancy | | Office | | | School | | Comm. | Rest. | Residential | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Single | Land | Meet | Class | Kind | Dep. sto | Restaurant | Apart | Retired | Detached |
| Occupancy | $m^2$/pers | 10,0 | 17,0 | 2,0 | 5,4 | 3,8 | 17,0 | 6,1 | 28,3 | 28,3 | 42,5 |
| Occupants total gains | W/$m^2$ | 11,8 | 7,0 | 59,2 | 21,7 | 33,3 | 9,3 | 19,4 | 4,2 | 4,2 | 2,8 |
| Occupants sensible gains | W/$m^2$ | 8,0 | 4,7 | 40,1 | 13,8 | 20,0 | 4,5 | 13,2 | 2,8 | 2,8 | 1,9 |
| Appliances sensible gains | W/$m^2$ | 12,0 | 12,0 | 12,0 | 8,0 | 4,0 | 1,0 | 4,0 | 3,0 | 3,0 | 2,4 |
| Lighting power | W/$m^2$ | 9,5 | 9,5 | 9,5 | 9,5 | 9,5 | 9,5 | | | | |
| Lighting level | Lux | 500 | 500 | 500 | 500 | 500 | 500 | | | | |
| Moisture production | g/$m^2$h | 6,0 | 3,5 | 30,0 | 11,1 | 15,8 | 3,5 | 9,8 | 2,1 | 2,1 | 1,4 |
| CO2 production | l/$m^2$h | 1,87 | 1,10 | 9,35 | 3,46 | 4,92 | 1,10 | 3,07 | 0,66 | 0,66 | 0,44 |
| ***Comfort category II*** | | | | | | | | | | | |
| Ventilation, base flow rate | l/s$m^2$ | 1,40 | 1,11 | 4,20 | 2,00 | 2,54 | 1,11 | 1,85 | 0,42 | 0,42 | 0,42 |
| CO2 increase (info) | $ppm_{CO2}$ | 371 | 275 | 618 | 481 | 538 | 275 | 462 | 437 | 437 | 291 |
| ***Comfort category I*** | | | | | | | | | | | |
| Ventilation, base flow rate | l/s$m^2$ | 2,00 | 1,59 | 6,00 | 2,85 | 3,63 | 1,59 | 2,64 | 0,49 | 0,49 | 0,49 |
| CO2 increase (info) | $ppm_{CO2}$ | 260 | 192 | 433 | 337 | 376 | 192 | 323 | 375 | 375 | 250 |

**Table 4 – Default data per space categories, weekly average**

| Average, one week | | Office | | | School | | Comm. | Rest. | Residential | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Single | Land | Meet | Class | Kind | Dep. sto | Restaurant | Apart | Retired | Detached |
| Occupancy | $m^2$/pers | 56,0 | 95,2 | 11,2 | 40,3 | 26,1 | 52,5 | 17,6 | 41,9 | 28,3 | 62,9 |
| Occupants total gains | W/$m^2$ | 2,1 | 1,3 | 10,6 | 2,9 | 4,9 | 3,0 | 6,7 | 2,8 | 4,2 | 1,9 |
| Occupants sensible gains | W/$m^2$ | 1,4 | 0,8 | 7,2 | 1,8 | 2,9 | 1,5 | 4,6 | 1,9 | 2,8 | 1,3 |
| Appliances sensible gains | W/$m^2$ | 2,1 | 2,1 | 2,1 | 1,1 | 0,6 | 0,5 | 0,6 | 1,8 | 3,0 | 1,4 |
| Lighting power | W/$m^2$ | 1,7 | 1,7 | 1,7 | 1,3 | 1,4 | 5,1 | | | | |
| Lighting level | Lux | | | | | | | | | | |
| Moisture production | g/$m^2$h | 1,1 | 0,6 | 5,4 | 1,5 | 2,3 | 1,1 | 3,4 | 1,4 | 2,1 | 1,0 |
| CO2 production | l/$m^2$h | 0,33 | 0,20 | 1,67 | 0,46 | 0,72 | 0,36 | 1,06 | 0,45 | 0,66 | 0,30 |
| ***Comfort category II*** | | | | | | | | | | | |
| Ventilation, base flow rate | l/s$m^2$ | 0,50 | 0,40 | 1,50 | 0,59 | 0,98 | 0,65 | 1,46 | 0,42 | 0,42 | 0,42 |
| CO2 increase (info) | $ppm_{CO2}$ | 186 | 137 | 309 | 217 | 203 | 153 | 202 | 296 | 437 | 197 |
| ***Comfort category I*** | | | | | | | | | | | |
| Ventilation, base flow rate | l/s$m^2$ | 0,71 | 0,57 | 2,14 | 0,85 | 1,41 | 0,93 | 2,09 | 0,49 | 0,49 | 0,49 |
| CO2 increase (info) | $ppm_{CO2}$ | 130 | 96 | 216 | 152 | 142 | 107 | 141 | 253 | 375 | 169 |

Default data with full occupancy are relevant for system sizing.

The weekly average is relevant for energy performance because it takes into account the use patterns.

Comfort category influences only ventilation flow rate and thus $CO_2$ increase. Table B.9 of EN 16798-1 indicates:

- 550 ppm $CO_2$ increase for comfort category I;
- 800 ppm $CO_2$ increase for comfort category II.

$CO_2$ increase is the ratio of $CO_2$ production rate in l/$m^2$h to the ventilation flow rate in l/s$m^2$ with the appropriate conversion factor. It is an indicator of the foreseen air quality. In this case, the value to be observed is the full occupancy condition.

The values in the table 3 show that the default ventilation flow rates are safe (rather high) with respect to the IAQ criteria. Lower ventilation rates could be accepted.

## 6.3 Degree-days analysis

### 6.3.1 General

Heating and cooling degree days analysis does not provide a direct estimation of heating and cooling needs. They give an idea of the effect of the different assumptions on the heating and cooling needs for a given building. See clause 5.6.1.2 for the definition of the "equivalent degree days" that are shown here.

They also provide some information and clue on what to do and on some potentials.

### 6.3.2 Degree days for comfort category II

Figures 3 and 4 show the heating and cooling degree days for comfort category II.

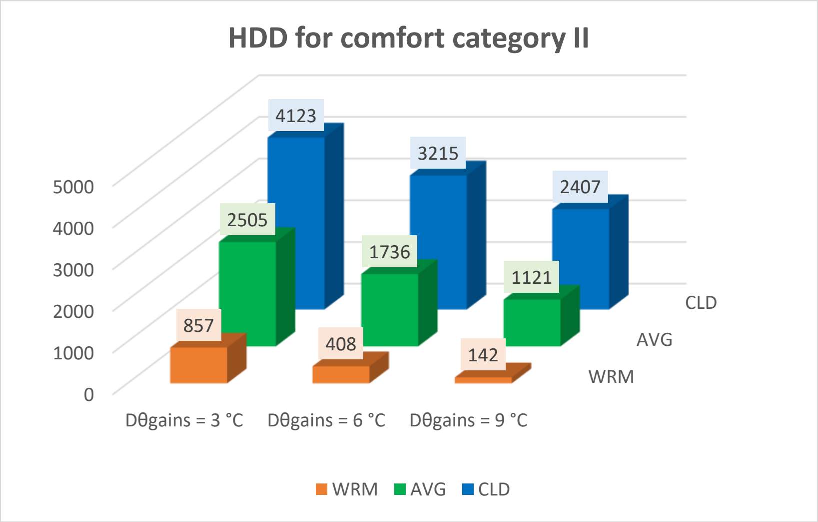


*Figure 3 – Heating degree-days, comfort category II*

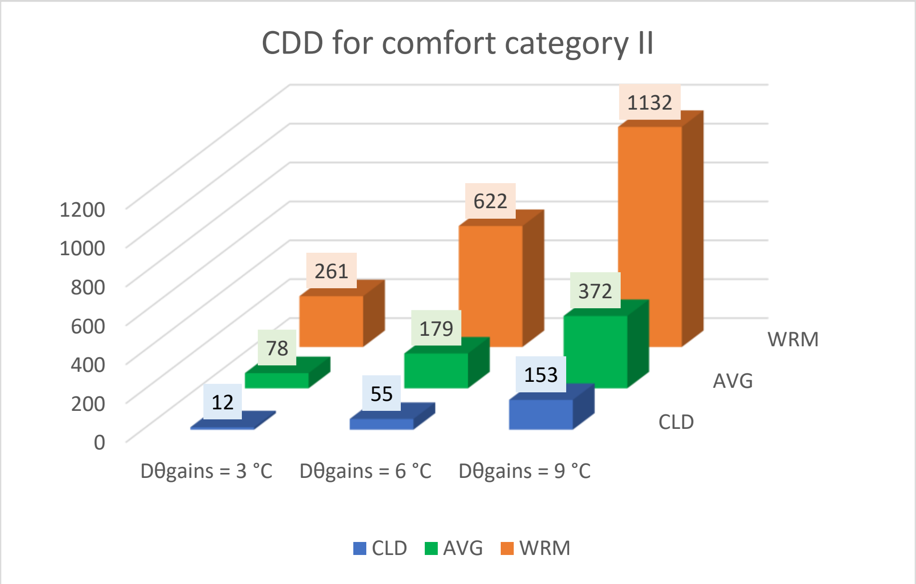


*Figure 4 – Cooling degree-days, comfort category II*

The insulation level of a building (the more insulated, the higher the $\Delta\theta_{gains}$) obviously has a positive effect for the heating degree-days and a negative effect on cooling degree-days.

Under warm climate a significant amount of cooling degree days appears for well insulated buildings and this would be even worse with comfort category I.

Figures 5 and 6 show the heating and cooling degree-days for existing and new buildings depending on climate and comfort level. This shows the potential impact of the selection of the comfort category on heating and cooling needs.

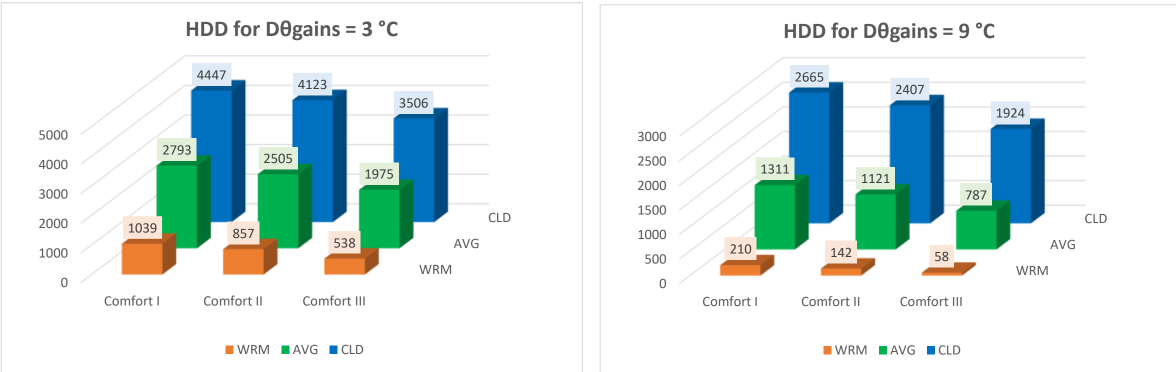


*Figure 5 – Heating degree-days, building with $\Delta\vartheta_{gains}$ = 3°C and 9 °C*

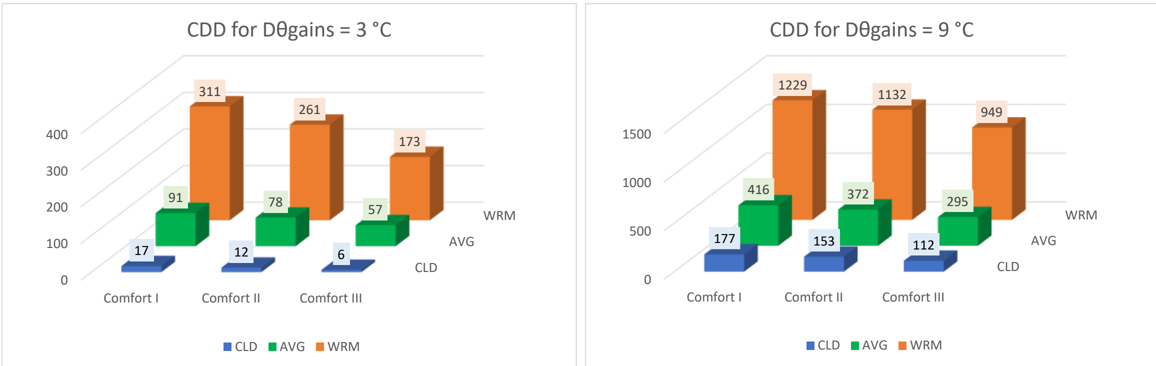


*Figure 6 – Cooling degree-days, buildings with $\Delta\vartheta_{gains}$ = 3°C and 9°C*

To compensate, $\Delta\theta_{gains}$ can be modulated according to the season. This is possible in practice since part of the gains are linked to the solar gains. These can be controlled via movable shadings which play an important role especially in the warm climate for insulated buildings

Another option is to use free cooling in the intermediate season. This opportunity is shown in figures 7 to 9 that show the monthly heating degree days and cooling degree days for comfort category II and for the three typical climates. It is evident there that asking for more insulation reduces the heating degree days but increases the cooling degree days. Additionally, these diagrams display the free cooling potential, also expressed in degree days.

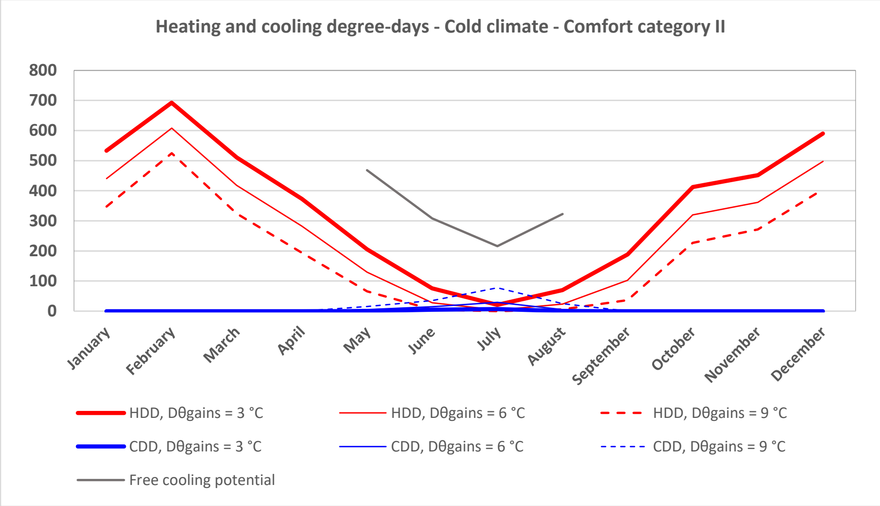


*Figure 7 – Heating and cooling degree-days, cold climate, comfort category II*

With the cold climate, cooling degree days appear only for the buildings with high $\Delta\theta_{gains}$. This can be compensated by shadings or by free cooling.

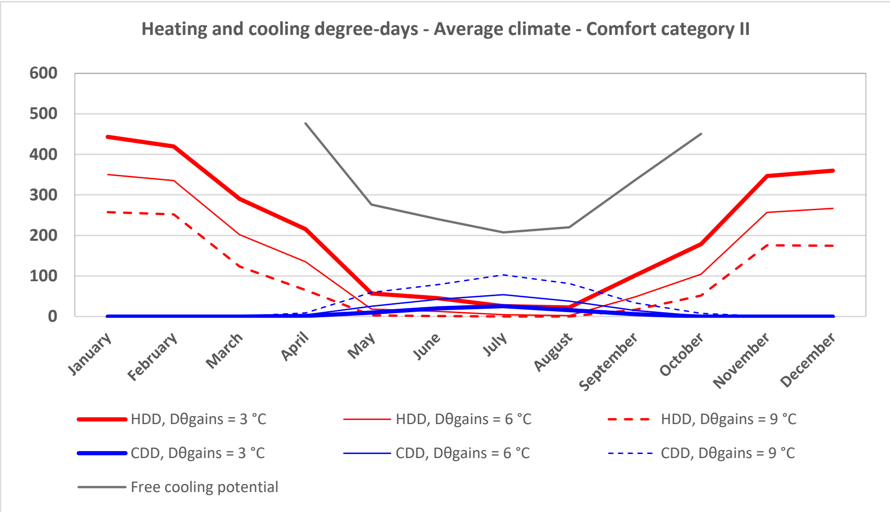


*Figure 8 – Heating and cooling degree-days, average climate, comfort category II*

With the average climate free-cooling may still help.

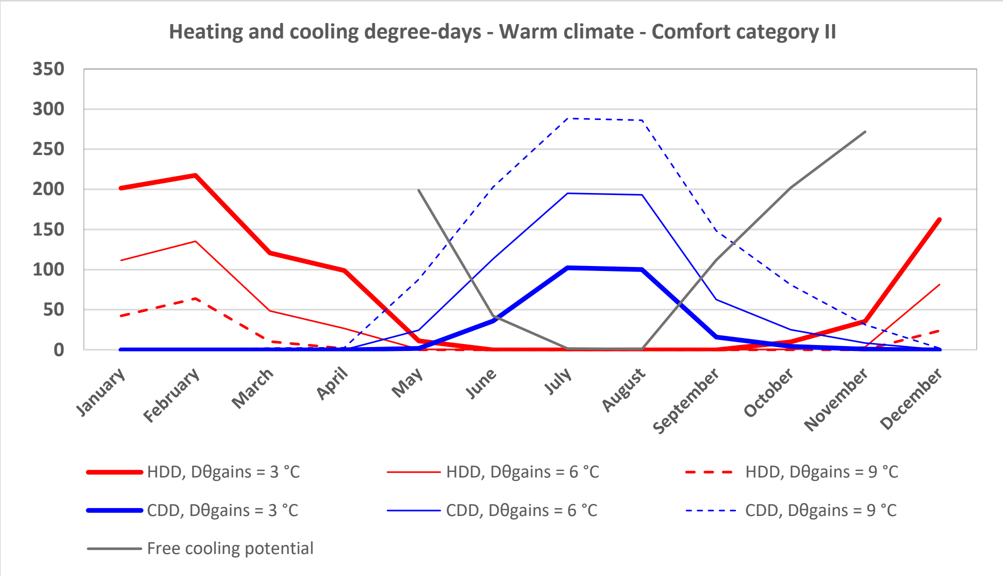


*Figure 9 – Heating and cooling degree-days, warm climate, comfort category II*

With the warm climate, there is virtually no free-cooling potential in the warmest months (a minimum temperature difference of 3 °C was required here, that is the outdoor temperature shall be at least 3 °C below indoor set-point temperature to allow free-cooling). Shadings are very important to limit cooling needs.

The complete set of graphs, for all possible combinations of climate, buildings, comfort categories can be found in the annexed spreadsheets.

### 6.3.3 Heating and cooling needs

The same analysis performed with degree-days can be done by calculating energy needs for heating and cooling. For this, a sample building is required. Two levels of building insulation for a single-family house were selected and their properties are described in clause 5.6.1.4.

Figures 10 and 11 show the heating needs for the existing and new building in the three climates and for three comfort categories.

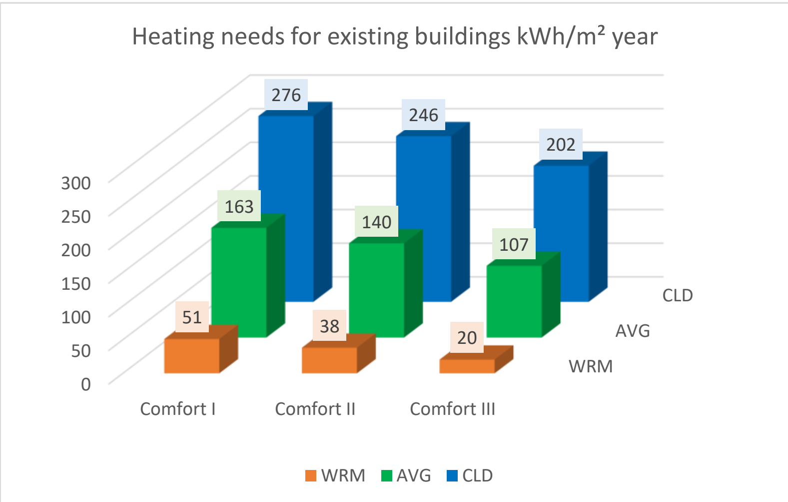


*Figure 10 – Heating needs, "existing" building (low insulation)*

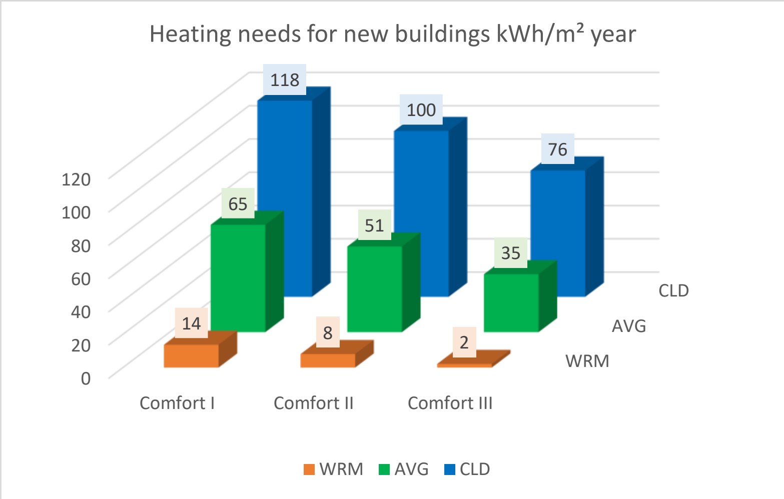


*Figure 11 – Heating needs, "new" building (improved insulation)*

Obviously, the insulation level reduces the needs.

The comfort category has some impact, indeed.

Values shown for the needs (kWh/m² per year) may look high for the cold climate and the "new" building. This is because properties of the building are the same for all three climates, whereas in reality a different level of insulation is expected for an "existing" building according to climate. The properties of the building have been left unchanged on purpose, to see the relative influence of climate and comfort categories without the interference of changing other properties.

Also, a "new building" would probably have transparent surfaces optimised for solar gains in the cold climate. Additionally, the air exchange rate of 0,6 $h^{-1}$ looks high and this increases the needs (no heat recovery assumed here). Values of air exchange rate around 0,3…0,4 $h^{-1}$ are more likely. See next clauses for an evaluation of the impact of choices about ventilation.

For comparison, passive house standard has a target value of 15 kWh/m² year, taking into account ventilation heat recovery. Ventilation at 0,6 $h^{-1}$ without heat recovery adds about 50 kWh/m² year, which explains half of the difference. The remaining is due higher insulation level and optimisation of solar gains.

Figures 12 and 13 show the cooling needs for the existing and new building in the three climates and for three comfort categories.

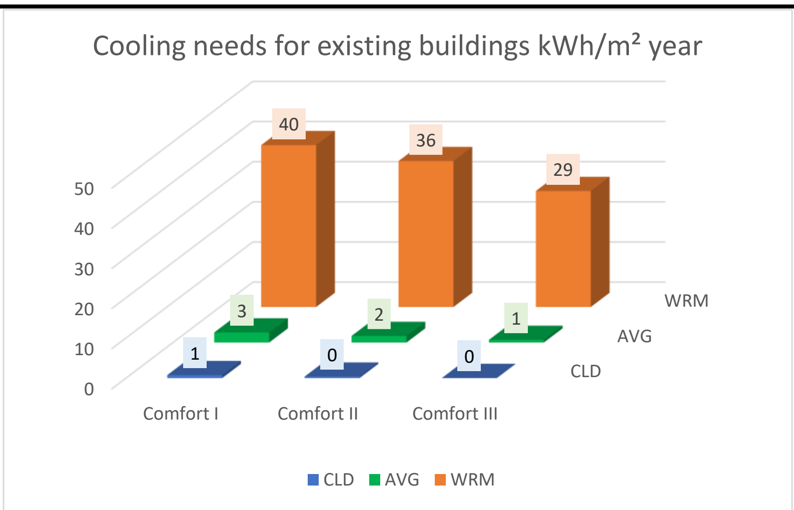


*Figure 12 – Cooling needs, "existing" building (low insulation)*

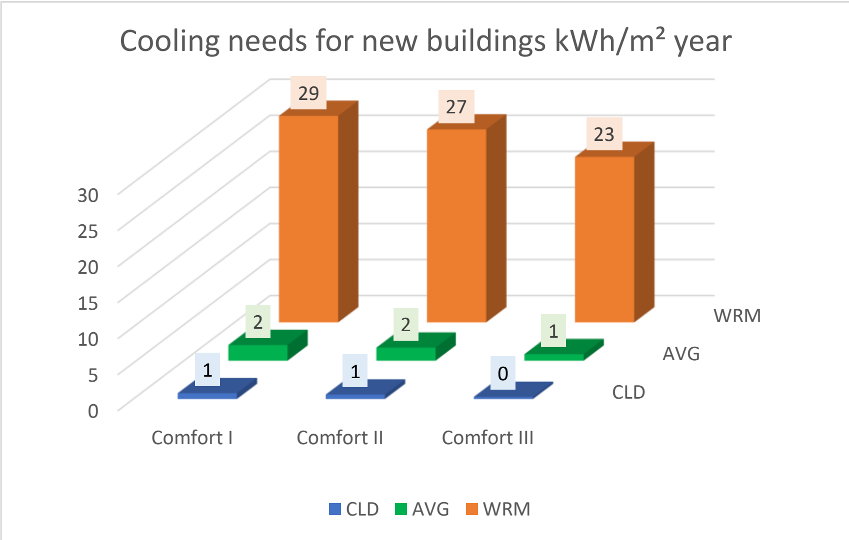


*Figure 13 – Cooling needs, "new" building (improved insulation)*

This example shows some decrease of cooling needs with a higher insulation. The comfort category has some impact as well, indeed.

The effect of the insulation on cooling needs for the warm climate is not easy to predict:

- when the outdoor temperature is lower than the set indoor temperature, the increased insulation "traps" heat gains inside the building, thus increasing cooling needs;
- on the contrary, a higher insulation reduces solar gains through opaque elements, thus reducing cooling needs;
- when outdoor temperature is higher than the set indoor temperature, insulation prevents heat gains by transmission and therefore reduces cooling needs.

Depending on circumstances, one effect may be more relevant.

### 6.3.4 Intermittent operation

One popular question is the impact of intermittent operation on energy needs for heating.

During the night, people are sleeping and blankets create a situation where a lower temperature could be even more comfortable. Hence the idea to lower the room temperature during the night.

This is a possible regulatory and/or operational choice which shall be reflected in the use profiles given in EN 16798-1.

As an example, the calculation of needs is repeated:

- for the average climate;
- for comfort category II;
- for the existing and new single family house;
- for continuous or intermittent operation.

The assumed intermittency pattern for the residential category is a reduction of the heating set-point from 20 °C to 16 °C from 22.00 to 06.00 in the morning.

The results on yearly needs for heating are given in table 5.

**Table 5 – Result of comparison, intermittent versus continuous operation**

| | | New building | | Existing building | |
|---|---|---|---|---|---|
| | | Continuous use | Intermittent use | Continuous use | Intermittent use |
| Heating needs | kWh/year | 7.310 | 7.045 | 19.893 | 18.583 |
| Difference | % | | -3,6% | | -6,6% |
| Results for the 3 coldest days | | | | | |
| Average indoor temperature | °C | 20 | 19,6 | 20 | 18,9 |
| Minimum indoor temperature | °C | 20 | 17,8 | 20 | 16,0 |
| Average power | kW | 2.746 | 2.670 | 6.721 | 6.345 |
| Average power when on | kW | 2.746 | 3.978 | 6.721 | 8.908 |
| Difference | % | | 44,9% | | 32,5% |
| Peak power | kW | 4.467 | 10.507 | 9.546 | 20.000 |
| Difference | % | | 135,2% | | 109,5% |

The reduction of the annual energy need is small: just 3,6% with the new building. There is some more advantage with non-insulated buildings because the temperature drop during the night is higher.

The results for the 3 coldest days show that:

- there is no real "reduced heating" but only ON-OFF operation, because during the night set-back the temperature doesn't reach the new set-point. Actually, it does only for 2 hours during the coldest night for the existing building;
- there are consequences on the system operation (efficiency) and sizing.
    - The average power when the system is on is increased by 45% for the new building and 32,5 % for thew existing building. This means average higher operating temperature, hence higher distribution losses and lower generator efficiency.
    - The peak power is more than doubled if a recovery of indoor temperature is required within one hour. This means higher installation costs.

It has to be noted that this behaviour is observed with an air exchange rate of 0,6 $h^{-1}$. The same calculation with a more likely (0,3…0,4 $h^{-1}$) air exchange rate would result in a reduced temperature drop and less energy saving with intermittency. The same effect is true when ventilation with heat recovery is used: for the thermal balance this is equivalent to a reduced, nearly zero air exchange rate.

Figures 14 and 15 show the operation during the 3 coldest nights for the new and the existing building.

The same scale has been kept to facilitate comparison also between existing and new building.

It is evident that with set-back, the system has to compensate the set-back during the on-time with higher power operation. It's not only the peak when turning on again, during the day operation is at a constantly higher power to reload the heat lost from the thermal mass of the building during the night.

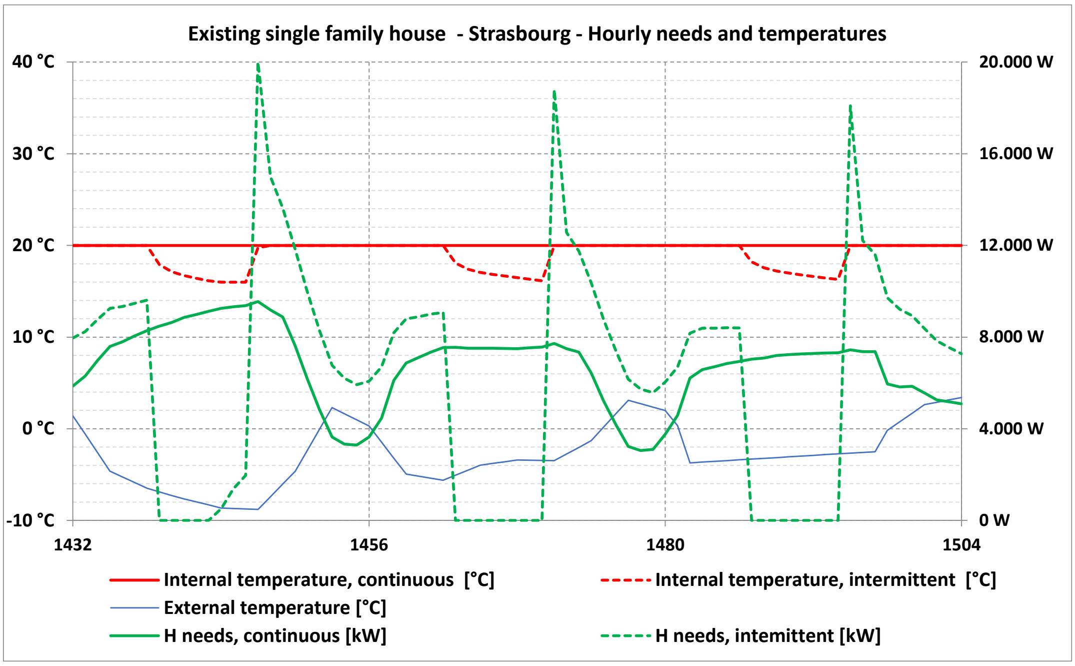


*Figure 14 – "Existing" building – comparison continuous operation / night set-back*

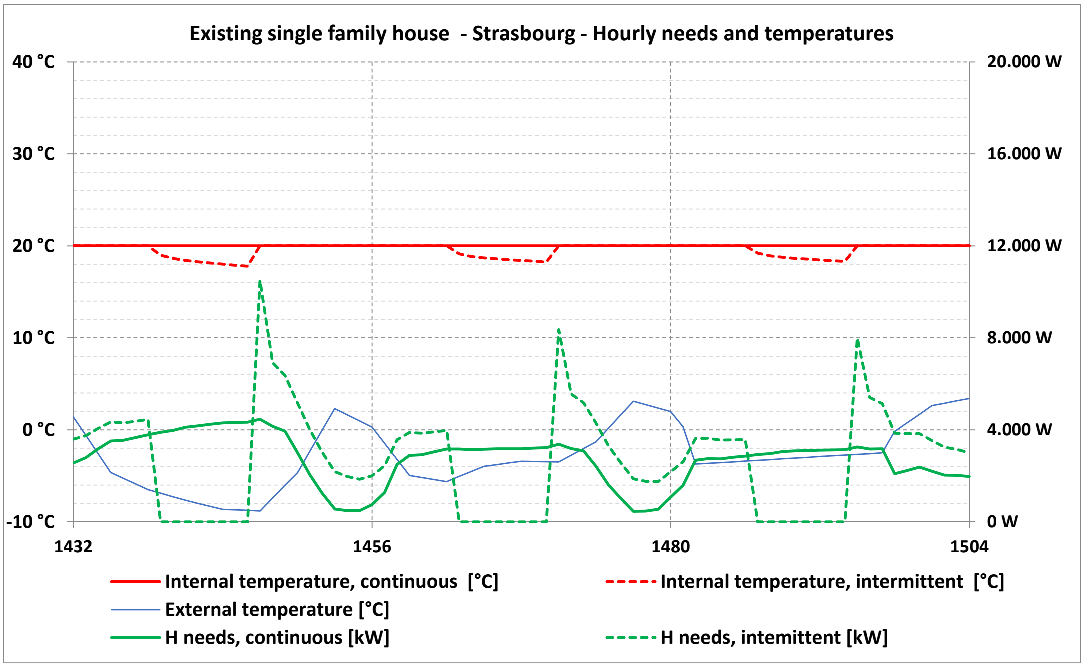


*Figure 15 – "New" building – comparison continuous operation / night set-back*

The effect of intermittency on heating will be significant only if the off-time is a significant fraction of the building time constant. This might be the case during weekends for non-residential building use types such as offices. The time constant of a building may range from 20 hours (light-weight barrack) to some hundreds of hours (massive structures) and this depends also on air exchange rate. Most frequent values are in the range 40 to 200 hours, so a mere night set-back is not expected to have a great impact.

Intermittency on cooling system cannot be proposed because there is no passive defence against overheating.

For other services, such as ventilation and air conditioning (which implies heating, cooling, humidification and dehumidification needs) and lighting, there is no significant time constant and following the load (occupancy) with the systems is an important energy efficiency measure.

## 6.4 Ventilation

### 6.4.1 General

This clause exemplifies the potential impact of ventilation flow rate choice.

The reason for the energy impact of ventilation has been presented in clause 5.6.2.

The following data is presented:

- the heating and cooling losses because of ventilation;
- the humidification and dehumidification needs, which are linked to ventilation;

Looking at table 3, the most interesting categories for the ventilation needs are:

- meeting room;
- kindergarten;
- detached house.

The most likely comfort categories are I and II.

Here the building envelope should play a secondary role, so only the new building assumption is used.

### 6.4.2 Operation schedules

#### 6.4.2.1 Meeting room

Operation schedules for meeting room are shown only for work-days. During week-end the system is off.

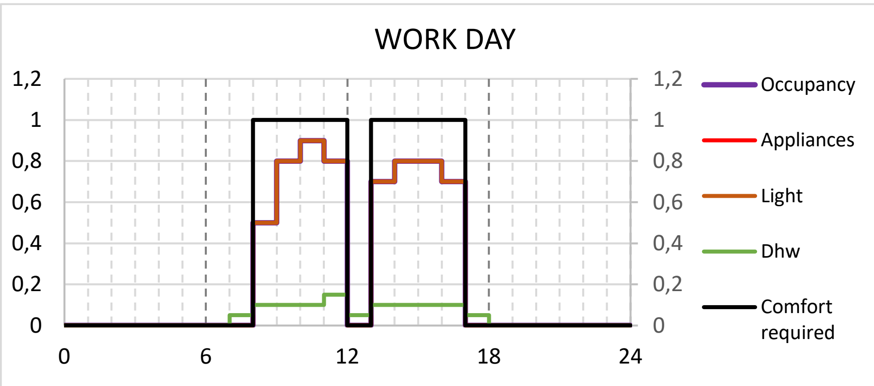


*Figure 16 – Occupancy and other diversity factors for meeting room, work day.*

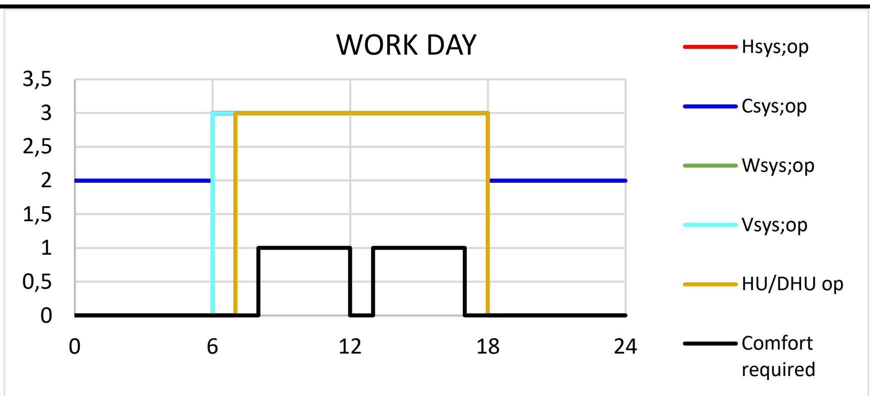


*Figure 17 – Operation levels for meeting room, work day.*

#### 6.4.2.2 Kindergarten

Operation schedules for kindergarten are shown only for work-days. During week-end the system is off.

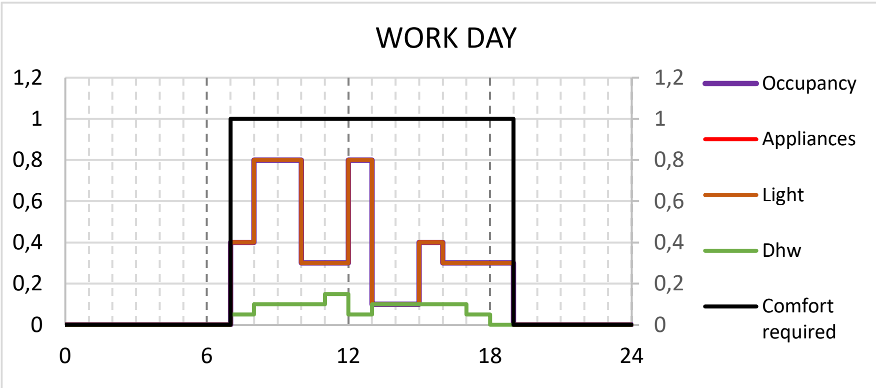


*Figure 18 – Occupancy and other diversity factors for kindergarten, work day.*

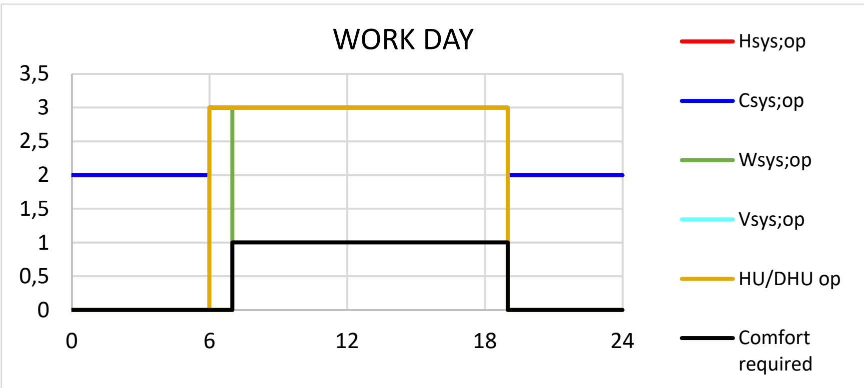


*Figure 19 – Operation levels for kindergarten, work day.*

#### 6.4.2.3 Single family house

Operation schedules for single family house are shown for work-days and week-ends.

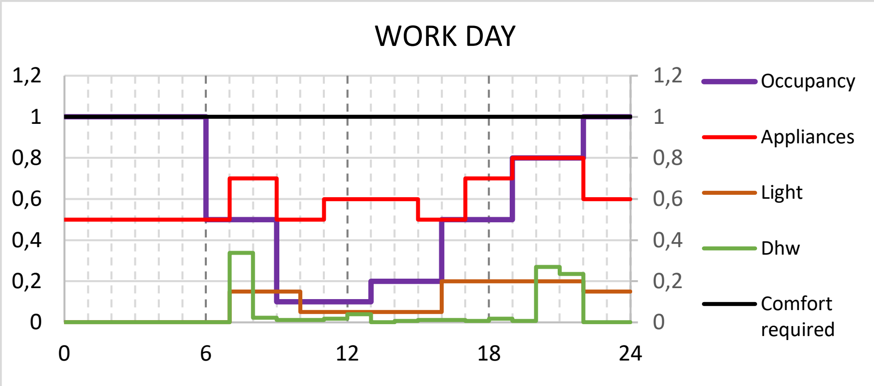


*Figure 20 – Occupancy and other diversity factors for single family house, work day.*

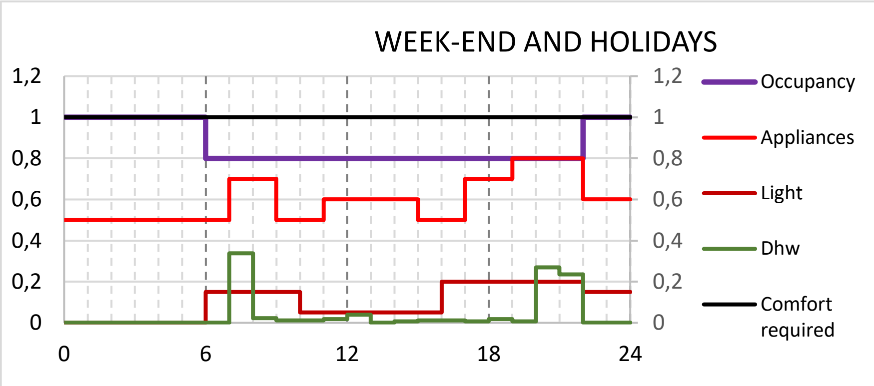


*Figure 21 – Occupancy and other diversity factors for single family house, week-ends.*

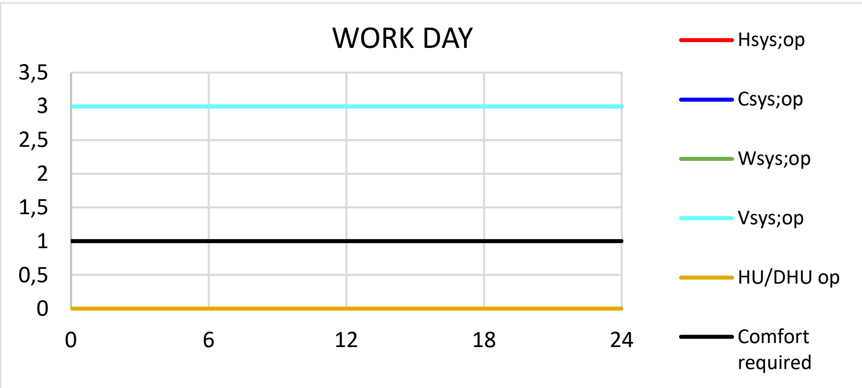


*Figure 22 – Operation levels for single family house, work day.*

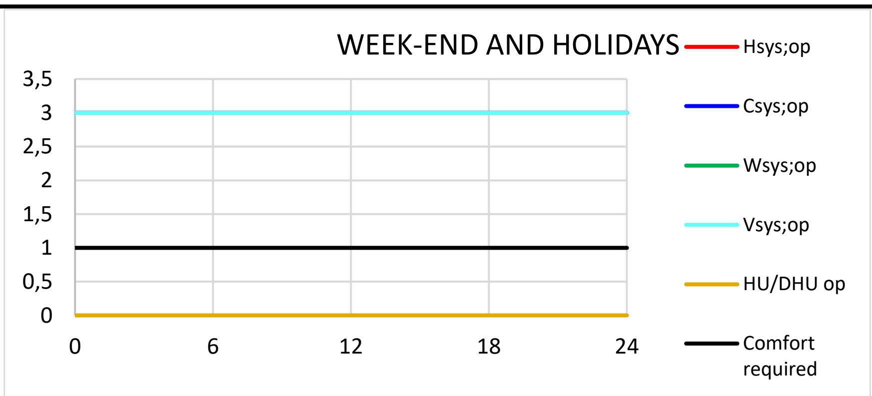


*Figure 23 – Operation levels for single family house, week-end.*

For the single family house systems operate continuously, only occupancy and diversity factors change during the week-end.

### 6.4.3 Results

Figure 24 shows the potential impact on the energy balance of the ventilation losses during winter season for the three considered space categories and for both comfort category I and II.

The figure shown is the sum of the ventilation losses extended to the hour when there is a heating need.

The potential contribution od ventilation losses to the energy balance is evident and quite high.

Climate, occupancy and comfort category all have a high impact.

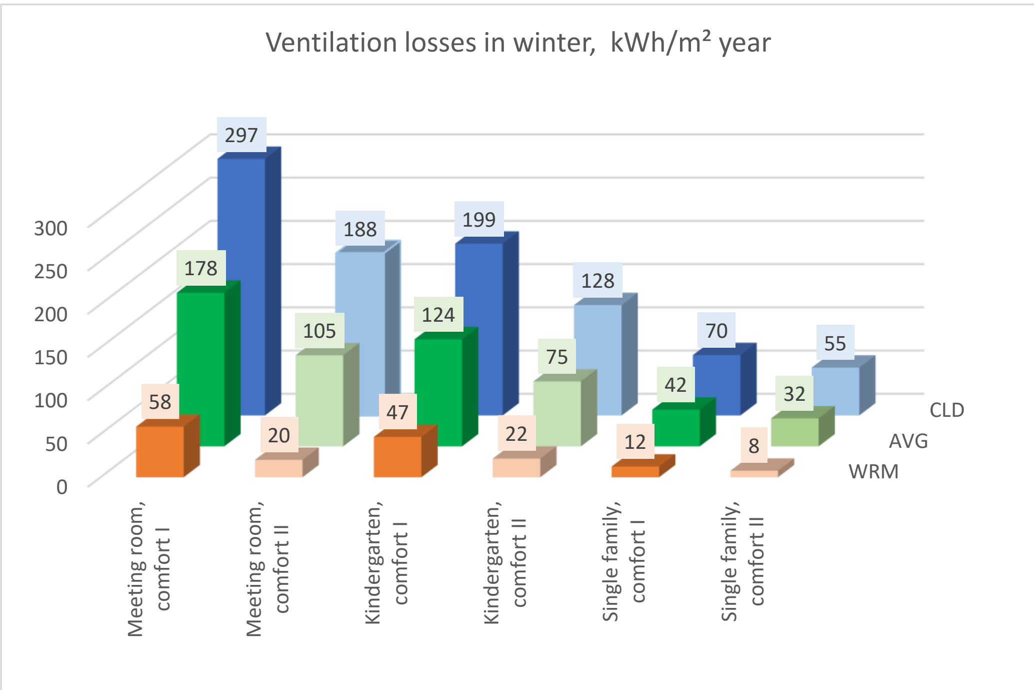


*Figure 24 – Ventilation losses during the heating period*

This impact can be very much reduced by means of heat recovery. However, heat recovery also requires a significant use of electric energy for the fans, which reduces its overall effect. The quality of the system (e.g. reduced head losses of ducts and efficiency of fans) plays an important role in the overall effectiveness of heat recovery.

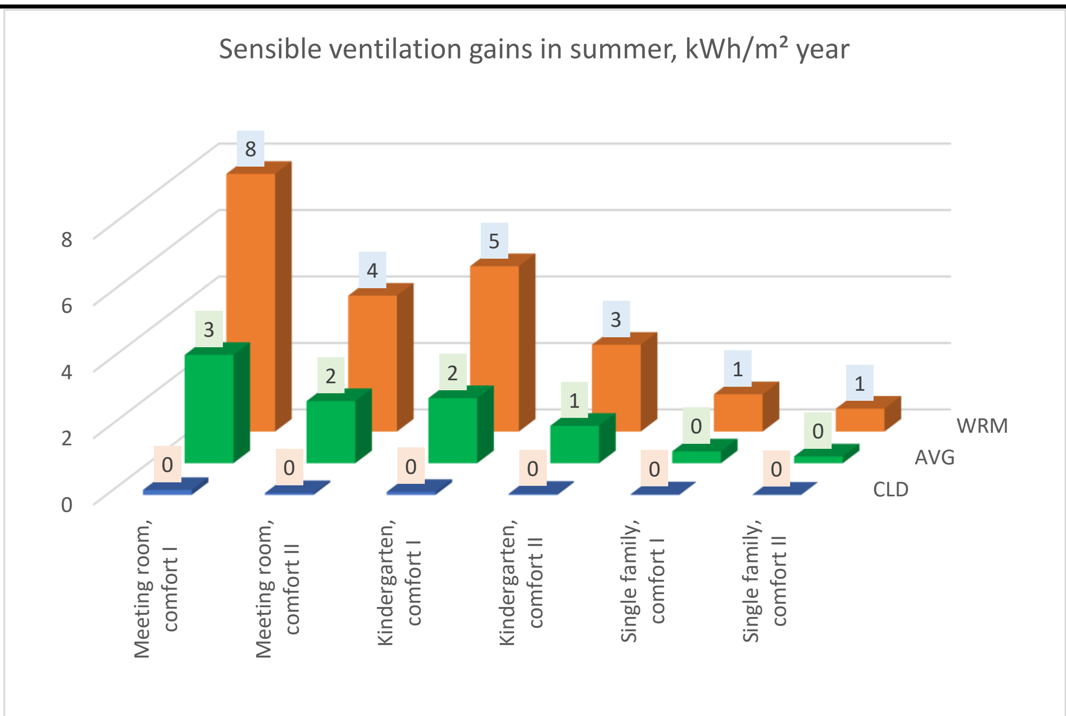


*Figure 25 – Ventilation gains during the cooling period*

For comparison, figure 25 shows potential impact on the energy balance of the ventilation sensible gains during the cooling season for the three considered space categories and for both comfort category I and II figures are quite lower than ventilation losses.

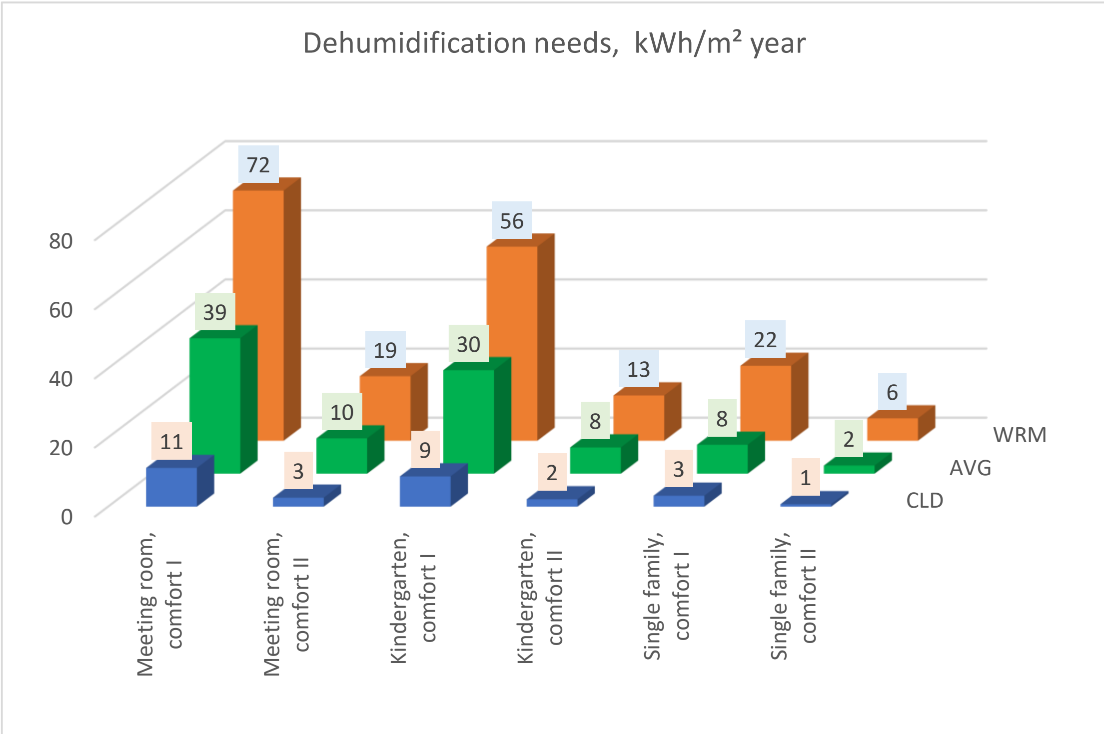


*Figure 26 – Dehumidifcation needs*

Figure 26 shows the dehumidification needs for the three considered space categories and for both comfort category I and II.

Dehumidification needs are higher for the warmer climate and the graph shows the effect of pretending comfort category I. The reduction of the set point from 60%RH (comfort category II) to 50 %RH (comfort category I) multiplies by 3 to 4 the de humification needs. Dehumidification needs appear even in the cold climate with comfort category I. Additionally, in some systems dehumidification may occur unintentionally (e.g. too low temperature set-points of chilled water), causing energy waste.

Figure 27 shows the humidification needs for the three considered space categories and for both comfort category I and II.

Figures are much lower than for dehumidification and they are significant only for comfort category I, cold climate and spaces with high occupancy.

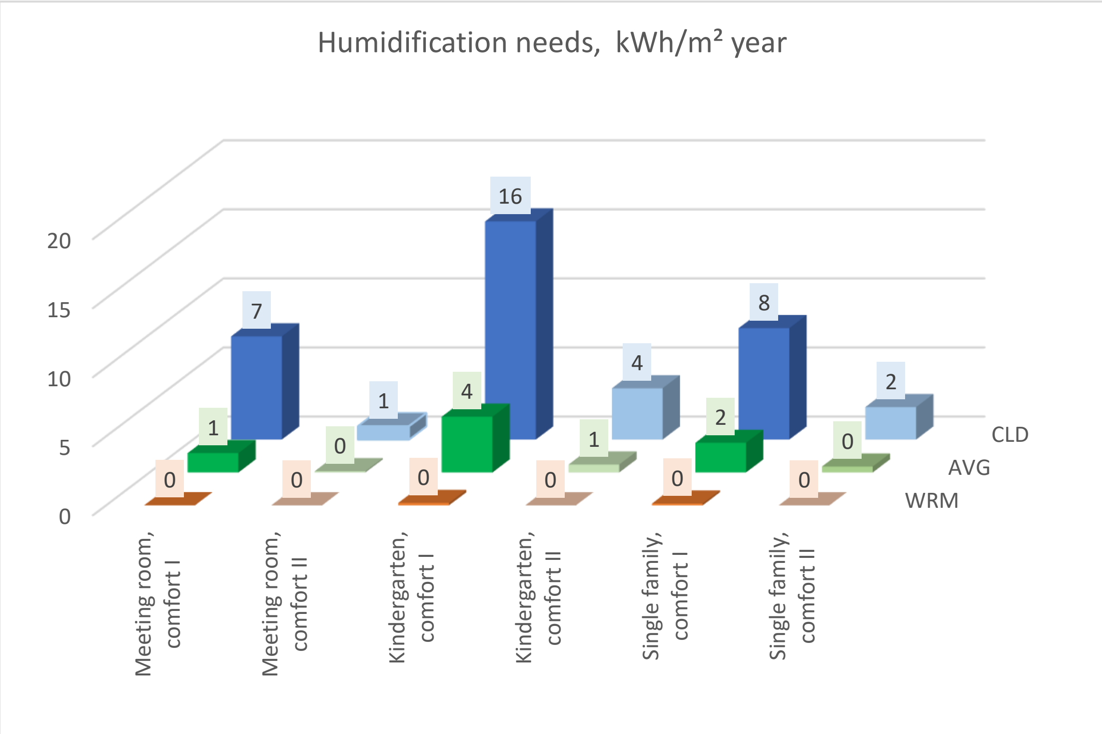


*Figure 27 – Dehumidifcation needs*

The figures shown demonstrate the high energy use of sensible and latent heat for the air treatment: sensible heat for heating in winter and latent heat for dehumidifying in summer.

These figures cannot be reduced acting on the building envelope.

These figures show the high energy cost of air treatment and hence the importance of limiting ventilation to the amount required and when required. There is evidently a high saving potential in adapting the air exchange rate to the actual occupancy.

## 6.5 Internal gains

Table 6 shows the annual value of internal gains defined in annex B of EN 16798-1 for the available space categories.

**Table 6 – Yearly values of internal gains per space categories**

| Average, one year | | Office | | | School | | Comm. | Rest. | Residential | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Single | Land | Meet | Class | Kind | Dep. sto | Restaurant | Apart | Retired | Detached |
| Occupants total gains | kWh/m² | 18,5 | 11,0 | 92,6 | 25,5 | 42,5 | 26,4 | 58,8 | 24,9 | 36,8 | 16,6 |
| Occupants sensible gains | kWh/m² | 12,5 | 7,4 | 62,7 | 16,2 | 25,6 | 12,8 | 40,0 | 16,6 | 24,5 | 11,3 |
| Appliances sensible gains | kWh/m² | 18,8 | 18,8 | 18,8 | 9,4 | 5,1 | 4,7 | 5,4 | 15,7 | 26,3 | 12,5 |
| Lighting power | kWh/m² | 14,8 | 14,8 | 14,8 | 11,1 | 12,1 | 44,9 | | | | |

The results are expressed in kWh/m² per year to allow comparison with other indicators, such as needs and primary energy per service.

Figure 28 shows the total gains per year for the three categories of spaces considered in the previous clause about ventilation.

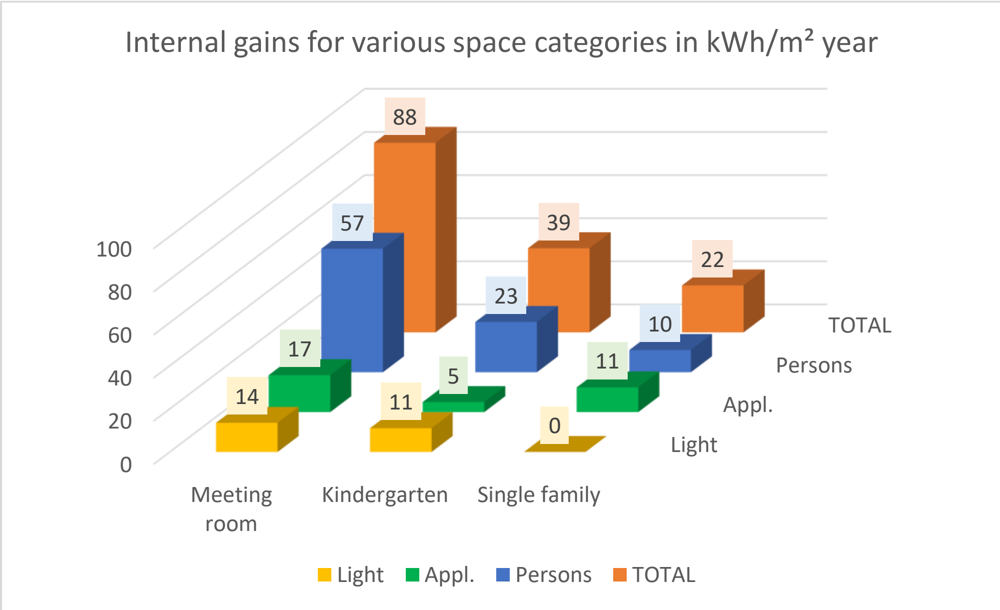


*Figure 28 – Internal sensible gains for three categories of spaces*

Occupants and appliance gains are relevant for most categories, most important for meeting rooms. They have no direct influence on the energy performance (i.e. no energy carrier amount is accounted for them, even if appliances mostly use electricity) but they contribute to satisfy heating needs and they add to cooling needs.

Lighting power is estimated assuming a full size fluorescent lamp technology. It may be a significant item in the energy performance because:

- lighting power is converted into heat in the building. This contributes to satisfy heating needs and adds to cooling needs;
- lighting power is electrical and therefore usually has a high weighting factor, so the primary energy use for lighting is higher than the recovered energy. Unless it is fed by PV or other renewable electricity, lighting is a significant energy use.

Lighting power estimation may be reduced (approximately cut by half) with high performance LEDs.

# 7 Analysis

## 7.1 Completeness

The module provides conditions of use for heating, cooling, ventilation, humidification and dehumidification. This module also provides a definition of the maximum allowable range of temperature in the absence of cooling or heating.

The space categories listed in the tables in annex B to EN 16798-1 do not include all the space categories defined in table B.7 of annex B to EN ISO 52000-1.

Domestic hot water conditions of use are defined in EN 12831-3. The needs are defined for most categories, tapping profiles are missing for non-residential buildings.

Some parameters are provided for lighting but they are not connected with EN 15193-1.

## 7.2 Functionality

This standard provides the expected results.

The standard does not include a full chain of equations to implement the method described. This is done with the new spreadsheet that has been developed to help interested parties to use EN 16798-1.

See clause 8, conclusion and recommendations, for further details.

## 7.3 Sensitivity

Obviously, conditions of use influence the energy performance. Standard energy performance of buildings cannot be compared without taking into account and neutralising the effect of different conditions of use.

## 7.4 Usability

The input required to the assessor for a standard or a design assessment (checking energy performance for a building permit or issuing an EPC) is minimal: just select in a series of lists:

- the space category;
- the comfort category;
- the method to determine the reference ventilation flow rate;
- a few well known dimension data (net floor area and net volume);

as shown in figure 29, to get the whole yearly profile for all operating conditions.

**Space category :**

| | | |
|---|---|---|
| **RESIDENTIAL_Det_house_with_HUDU** | | **12** |
| Source data sheet | **RES_det_house_HUDU** | |
| Space area | $m^2$ | 142 |
| Space volume | $m^3$ | 357,4 |
| Comfort category | | II |
| Type of building | | Low polluting |
| Ventilation calculation option | | Method 3 - Air exchange rate |

*Figure 29 – Operating conditions selection interface*

Use profiles are usually given as a base (reference) value and an hourly pattern of the relative value, all resulting from the previous choice. Figures 30 and 31 are some statistics and a sample graph of relative values.

| **BASE PARAMETERS** | **Value** | **Unit** | **Values per person** | | **Space total** | | **Average, one week** | |
|---|---|---|---|---|---|---|---|---|
| Occupancy | 42,5 | m²/pers | | | 3,34 | p | 62,9 | m²/pers |
| Occupants total gains | 2,8 | W/m² | 119,0 | W/pers | 397,6 | W | 1,89 | W/m² |
| Occupants sensible gains | 1,9 | W/m² | 80,8 | W/pers | 269,8 | W | 1,28 | W/m² |
| Appliances sensible gains | 2,4 | W/m² | | | 340,8 | W | 1,43 | W/m² |
| Lighting | 1,8 | W/m² | | | 250 | W | | |
| Lighting | 0 | Lux | | | | | | |
| Moisture production | 1,4 | g/m²h | 59,9 | g/h pers | 200,22 | g/h | 59,9 | g/pers h |
| CO2 production | 0,44 | l/m²h | 18,7 | l/h pers | 62,48 | l/h | 18,7 | l/pers h |
| Ventilation, base flow rate | 0,42 | l/sm² | 17,8 | l/s pers | 59,6 | l/s | 0,42 | l/sm² |

*Figure 30 – Statistics on the use profile for residential, detached house*

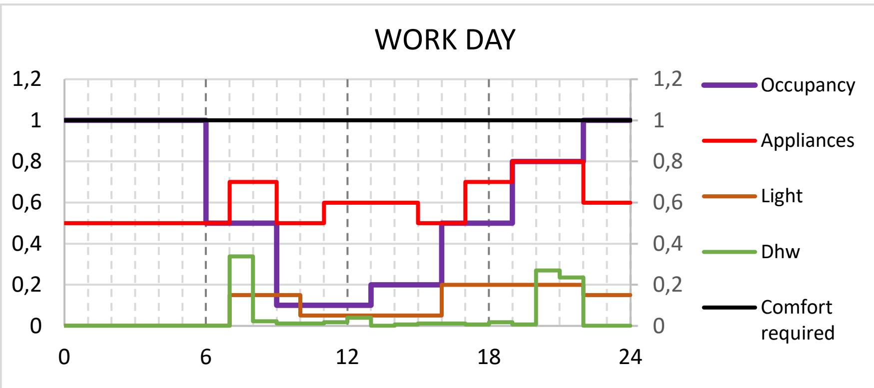


*Figure 31 – Example of hourly patterns, detached house, work day*

Full details on the use profiles can be seen in the demo spreadsheet for EN 16798-1.

A more detailed input is required only for a tailored assessment (energy audits). For that purpose, use profiles should match actual use and have to be tailored.

## 8 Conclusions and recommendations

The current version of the standard covers the topic in principle. There are some issues, indeed.

- There is a number of hidden choices and the required calculations are not fully spelled into equations. There is no equation in the standard to obtain the yearly time series from the daily patterns. The calendar functions in the new spreadsheet provides a solution and the analysis to draft the required equations.
- The set of default profiles in annex B is not complete: it does not cover all the space categories defined in table B.7 of EN ISO 52000-1. The same is true for EN 12831-3, which should provide daily domestic hot water needs and daily tapping patterns for all space categories. Also, tapping patterns of EN 12831-3 should be made consistent with occupancy factors in EN 16798-1.
- Clarification and review are needed about the calculation of ventilation flow rates. There are several methods and it should be clear which to use for each space category.

This case study and the accompanying spreadsheet made them explicit and provide suggestions for their solution.

# Annex A

# List of calculation files

## A.1 File name coding

The files are identified with a code which is built in the following way:

**NN - STANDARD-BBB-X-CLI-C-INT_CALC.XLSM**

where

- **NN** is a progressive number identifying the calculation order
- **STANDARD** is the standard code
  - EN 12831-3 domestic hot water needs
  - EN_16798-1 Use profiles
  - ISO_52016-1 Heating, cooling, humidification and dehumidification needs
- **BBB** is the building type
  - **SFH** for Single family house
  - **OFF** for office
  - **KND** for kindergarten
  - **MET** for meeting room
- **X** can be:
  - E for existing building
  - N for new building
- CLI is the climate code
  - AVG for average climate
  - CLD for cold climate
  - WRM for warm climate
- C indicates the comfort category
  - I / II / III
- INT indicates operation type of heating
  - CNT for continuous
  - INT for intermittent (night set back)
- OTH indicates other information

Climatic data files are coded:

**NN - STANDARD_ TMY_Location_Orientations.XLSM**

where

- **NN** is a progressive number identifying the calculation order
- **STANDARD** is the standard code
  - ISO_52010-1 climatic data

- **TMY** for true meteorological year
    - **Location** is the location
    - **Orientations** an info on the orientations included for solar radiations on exposed planes

## A.2 File clusters

This case study is supported by three file clusters:

- files for free-floating temperature evaluation;
- files for degree-days and energy needs evaluation;
- files for ventilation and air treatment energy cost evaluation.

## A.3 Free floating check

00 - ISO_52010-1_TMY_Athens_8_planes.xlsx

00 - ISO_52010-1_TMY_Oslo_8_planes.xlsx

00 - ISO_52010-1_TMY_Strasbourg_8_planes.xlsx

10 - EN_16798-1_RES_det_HUDU.xlsm

20 - ISO_52016-1_SFH_EX_base_2021-08-18_DESC_FF.xlsx

20 - ISO_52016-1_SFH_NW_base_2021-08-18_DESC_FF.xlsx

21 - ISO_52016-1_SFH_EX_base_2021-08-18_CALC_Free_floating - Athens.xlsm

21 - ISO_52016-1_SFH_EX_base_2021-08-18_CALC_Free_floating - Oslo.xlsm

21 - ISO_52016-1_SFH_EX_base_2021-08-18_CALC_Free_floating - Strasbourg.xlsm

21 - ISO_52016-1_SFH_NW_base_2021-08-18_CALC_Free_floating - Athens.xlsm

21 - ISO_52016-1_SFH_NW_base_2021-08-18_CALC_Free_floating - Oslo.xlsm

21 - ISO_52016-1_SFH_NW_base_2021-08-18_CALC_Free_floating - Strasbourg.xlsm

99 - Summary of Free floating - 2021-08-18.xlsx

## A.4 Degree-days and energy needs evaluation

00 - ISO_52010-1_TMY_Athens_8_planes.xlsx

00 - ISO_52010-1_TMY_Oslo_8_planes.xlsx

00 - ISO_52010-1_TMY_Strasbourg_8_planes.xlsx

10 - EN 12831-3 - DHW_needs_SFH.xlsx

10 - EN_16798-1_SFH-X-AVG-I-CNT_HUDU.xlsm

10 - EN_16798-1_SFH-X-AVG-II-CNT_HUDU-dhw.xlsm

10 - EN_16798-1_SFH-X-AVG-II-CNT_HUDU.xlsm

10 - EN_16798-1_SFH-X-AVG-II-INT_HUDU.xlsm

10 - EN_16798-1_SFH-X-AVG-III-CNT_HUDU.xlsm

10 - EN_16798-1_SFH-X-CLD-II-CNT_HUDU.xlsm

10 - EN_16798-1_SFH-X-WRM-II-CNT_HUDU.xlsm

10 - EN_16798-1_XXX-X-YYY-Z-WWW_HUDU.xlsm

20 - ISO_52016-1_SFH_E_YYY-I-CNT_DESC.xlsx

20 - ISO_52016-1_SFH_E_YYY-II-CNT_DESC.xlsx

20 - ISO_52016-1_SFH_E_YYY-II-INT_DESC.xlsx

20 - ISO_52016-1_SFH_E_YYY-III-CNT_DESC.xlsx

20 - ISO_52016-1_SFH_N_YYY-I-CNT_DESC.xlsx

20 - ISO_52016-1_SFH_N_YYY-II-CNT_DESC.xlsx

20 - ISO_52016-1_SFH_N_YYY-II-INT_DESC.xlsx

20 - ISO_52016-1_SFH_N_YYY-III-CNT_DESC.xlsx

21 - ISO_52016-1_SFH_E_AVG-I-CNT_CALC.xlsm

21 - ISO_52016-1_SFH_E_AVG-II-CNT_CALC.xlsm

21 - ISO_52016-1_SFH_E_AVG-II-INT_CALC.xlsm

21 - ISO_52016-1_SFH_E_AVG-III-CNT_CALC.xlsm

21 - ISO_52016-1_SFH_E_CLD-I-CNT_CALC.xlsm

21 - ISO_52016-1_SFH_E_CLD-II-CNT_CALC.xlsm

21 - ISO_52016-1_SFH_E_CLD-III-CNT_CALC.xlsm

21 - ISO_52016-1_SFH_E_WRM-I-CNT_CALC.xlsm

21 - ISO_52016-1_SFH_E_WRM-II-CNT_CALC.xlsm

21 - ISO_52016-1_SFH_E_WRM-III-CNT_CALC.xlsm

21 - ISO_52016-1_SFH_N_AVG-I-CNT_CALC.xlsm

21 - ISO_52016-1_SFH_N_AVG-II-CNT_CALC-0_3ach.xlsm

21 - ISO_52016-1_SFH_N_AVG-II-CNT_CALC.xlsm

21 - ISO_52016-1_SFH_N_AVG-II-INT_CALC.xlsm

21 - ISO_52016-1_SFH_N_AVG-III-CNT_CALC.xlsm

21 - ISO_52016-1_SFH_N_CLD-I-CNT_CALC.xlsm

21 - ISO_52016-1_SFH_N_CLD-II-CNT_CALC.xlsm

21 - ISO_52016-1_SFH_N_CLD-III-CNT_CALC.xlsm

21 - ISO_52016-1_SFH_N_WRM-I-CNT_CALC.xlsm

21 - ISO_52016-1_SFH_N_WRM-II-CNT_CALC.xlsm

21 - ISO_52016-1_SFH_N_WRM-III-CNT_CALC.xlsm

## A.5 Ventilation and air treatment energy cost evaluation

00 - ISO_52010-1_TMY_Athens_8_planes.xlsx

00 - ISO_52010-1_TMY_Oslo_8_planes.xlsx

00 - ISO_52010-1_TMY_Strasbourg_8_planes.xlsx

10 - EN 12831-3 - DHW_needs_KND.xlsx

10 - EN 12831-3 - DHW_needs_OFF.xlsx

10 - EN 12831-3 - DHW_needs_SFH.xlsx

10 - EN_16798-1_KND-X-AVG-I-INT.xlsm

10 - EN_16798-1_KND-X-AVG-II-INT.xlsm

10 - EN_16798-1_MET-X-AVG-I-INT.xlsm

10 - EN_16798-1_MET-X-AVG-II-INT.xlsm

10 - EN_16798-1_SFH-X-AVG-I-CNT.xlsm

10 - EN_16798-1_SFH-X-AVG-II-CNT.xlsm

20 - ISO_52016-1_KND_N_YYY-I-INT_DESC.xlsx

20 - ISO_52016-1_KND_N_YYY-II-INT_DESC.xlsx

20 - ISO_52016-1_MET_N_YYY-I-INT_DESC.xlsx

20 - ISO_52016-1_MET_N_YYY-II-INT_DESC.xlsx

20 - ISO_52016-1_SFH_N_YYY-I-CNT_DESC.xlsx

20 - ISO_52016-1_SFH_N_YYY-II-CNT_DESC.xlsx

21 - ISO_52016-1_KND_N_AVG-I-INT_CALC.xlsm

21 - ISO_52016-1_KND_N_AVG-II-INT_CALC.xlsm

21 - ISO_52016-1_KND_N_CLD-I-CNT_CALC.xlsm

21 - ISO_52016-1_KND_N_CLD-II-INT_CALC.xlsm

21 - ISO_52016-1_KND_N_WRM-I-INT_CALC.xlsm

21 - ISO_52016-1_KND_N_WRM-II-INT_CALC.xlsm

21 - ISO_52016-1_MET_N_AVG-I-INT_CALC.xlsm

21 - ISO_52016-1_MET_N_AVG-II-INT_CALC.xlsm

21 - ISO_52016-1_MET_N_CLD-I-INT_CALC.xlsm

21 - ISO_52016-1_MET_N_CLD-II-INT_CALC.xlsm

21 - ISO_52016-1_MET_N_WRM-I-INT_CALC.xlsm

21 - ISO_52016-1_MET_N_WRM-II-INT_CALC.xlsm

21 - ISO_52016-1_SFH_N_AVG-I-CNT_CALC.xlsm

21 - ISO_52016-1_SFH_N_AVG-II-CNT_CALC.xlsm

21 - ISO_52016-1_SFH_N_CLD-I-CNT_CALC.xlsm

21 - ISO_52016-1_SFH_N_CLD-II-CNT_CALC.xlsm

21 - ISO_52016-1_SFH_N_WRM-I-CNT_CALC.xlsm

21 - ISO_52016-1_SFH_N_WRM-II-CNT_CALC.xlsm

10 - EN_16798-1_OFF_S-X-AVG-I-INT_HUDU.xlsm

10 - EN_16798-1_OFF_S-X-AVG-II-INT_HUDU.xlsm

20 - ISO_52016-1_OFF_S_E_YYY-I-CNT_DESC.xlsx

20 - ISO_52016-1_OFF_S_E_YYY-II-CNT_DESC.xlsx

21 - ISO_52016-1_OFF_S_E_AVG-I-INT_CALC.xlsm

21 - ISO_52016-1_OFF_S_E_AVG-II-INT_CALC.xlsm

21 - ISO_52016-1_SFH_E_AVG-I-CNT_CALC.xlsm

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

Link: EPB Center support documents

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