CEN EPBD STANDARDS - THE NEW GENERATION; AN OVERVIEW WITH EMPHASIS ON VENTILATION AND COOLING RELATED STANDARDS

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ABSTRACT

In the frame of a multi-year EU project, the set of European Standards from 2006/7 to support the European Energy Performance of Buildings Directive (EPBD) is undergoing a revision. The majority of the standards describe calculation methods. Based on the experience with the first generation of the standards and on a EU research project investigating the application of the standards in the Member States, a rigorous set of requirements has been set up. This includes issues like unambiguity and software proofness. The new standards have been developed in a modular structure and supported by accompanying technical reports and spreadsheets.

INTRODUCTION

A set of European standards was developed during the years 2005 to 2007 in order to support the implementation of the European Energy Performance of Buildings Directive (EPBD, 2002), as reported in (Zweifel, 2007).

The EPBD was revised in 2010, referred to as "recast" (EPBD, 2010). New requirements are set out in this directive, leading to the need of changes and additions in the standards. This was one of the reasons for the need of a revision of the standards.

Another reason was the experience with the first generation of standards and the fact that they were not used to the expected extent by the Member States for the implementation. This was investigated in the frame of a European research project (van Kampen, 2010) which lead to new findings about the reasons. One part of these reasons being on the political side and having nothing to do with the standards themselves, another part was due to some shortcomings in the standards:

- They did not really form a comprehensive set;
- they did not always fit together;
- they were sometimes ambiguous and not always formulated in a software-proof way.

A new two-phase project was finally launched for the revision of the set of standards.

PHASE 1 RESULTS

In phase 1, a rigorous set of requirements for the standards has been set up and documented in two Technical Specifications, setting out the basic principles (CEN TS 16628) and the detailed technical rules (CEN TS 16629). The basic principles include issues like

- the standardization process, including collaborations and consultations;
- the application range of the standards;
- common general organisation of each standard and the national implementation;
- the overarching structure for the energy performance assessment;
- common model(s) and editorial rules for each standard;
- common quality aspects for each standard.

The detailed technical rules require that each EPB standard is accompanied by

- an informative Technical Report, containing the informative documentation and justification, including worked examples;
- an accompanying spreadsheet.

All standards are required to follow a common terminology, as set out in the "Overarching Standard" (OAS). This document is the other result of phase 1. It sets out the procedure for the overall building energy calculation. It is the former EN 15603, now to be published as EN ISO 52000-1.

In the OAS, a modular structure is defined as shown in Table 1, in which all the standards of phase 2 are supposed to fit. One standard may cover more than one module, but the modules covered shall always be indicated. This allows a step-by-step implementation.

Although many countries still want to rely on monthly calculation methods, an hourly approach is developed as equally valid.

Each EPB calculation standard shall contain only unambiguous procedures, but there is a need for flexibility, to take into account differences due to national or regional building traditions, building use and regulatory context. Therefore, in each EPB standard, a template is given in an Annex A, to specify in a transparent way the choices with regard to the methods and the required input data or input data sources. A set of informative default choices (using the Annex A template) are provided in Annex B.

Table 1
Modular structure of the CEN EPBD standards

OVERARCHING		BUILDING (AS SUCH)		TECHNICAL BUILDING SYSTEMS										
	DESCRIPTIONS		DESCRIPTIONS		DESCRIPTIONS	HEATING	COOLING	VENTILATION	HUMIDIFI CATION	DEHUMIDIFICATION	DOMESTIC HOT WATER	LIGHTING	BUILDING AUTOMATION & CONTROL	PV, WIND, ..
SUB1	M1	SUB1	M2	SUB1		M3	M4	M5	M6	M7	M8	M9	M10	M11
1	General	1	General	1	General									
2	Common terms and definitions; symbols, units and subscripts	2	Building Energy Needs	2	Needs									
3	Applications	3	(Free) Indoor Conditions without Systems	3	Maximum Load and Power									
4	Ways to Express Energy Performance	4	Ways to Express Energy Performance	4	Ways to Express Energy Performance									
5	Building Functions and Building Boundaries	5	Heat Transfer by Transmission	5	Emission & control									
6	Building Occupancy and Operating Conditions	6	Heat Transfer by Infiltration and Ventilation	6	Distribution & control									
7	Aggregation of Energy Services and Energy Carriers	7	Internal Heat Gains	7	Storage & control									
8	Building Partitioning	8	Solar Heat Gains	8	Generation & control									
9	Calculated Energy Performance	9	Building Dynamics (thermal mass)	9	Load dispatching and operating conditions									
10	Measured Energy Performance	10	Measured Energy Performance	10	Measured Energy Performance									
11	Inspection	11	Inspection	11	Inspection									
12	Ways to Express Indoor Comfort	12	--	12	BMS									
13	External Environment Conditions													
14	Economic Calculation													

A few Member States accept commercial building simulation software for the purpose of the mandatory energy performance calculation. However, this is not foreseen in the current OAS, the main reason being that it is not possible to provide a comprehensive validation scheme (including systems calculations).

Countries will continue to use their scheme, deviating from the standard in this point.

Another key element of the OAS is the overall balance for those energy carriers, which can include on-site generation with export and redelivery, especially electricity. It is visualised in Figure 1. For the energy indicator, which is defined on the level of weighted delivered energy, the method offers full flexibility to use different weighting factors (primary energy, greenhouse gas emission etc.) for the different flows, even time dependent. Any simplifycation is, however, possible by using equal weighting factors for the different flows. A two step approach with a steering parameter offers the possibility to decide on the national level on the consideration of properties from outside the building (the supply chain).

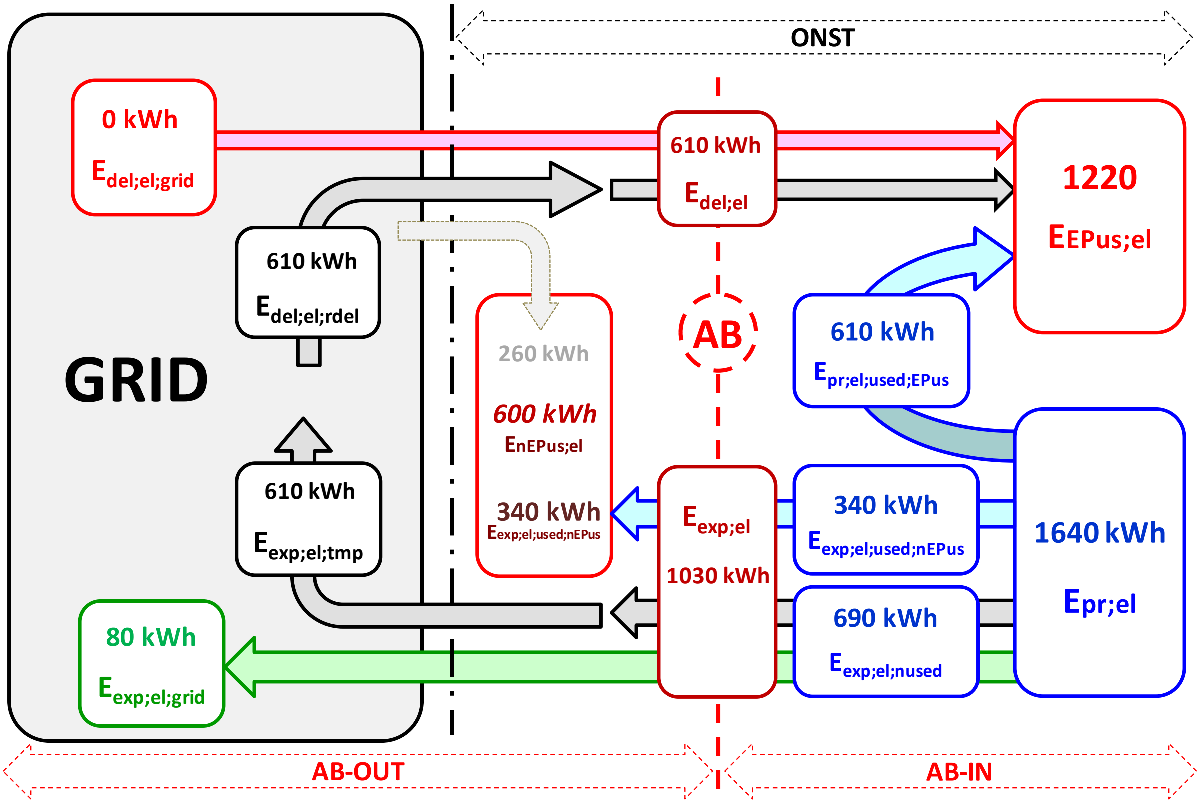


Figure 1 Reference diagram for the energy balance of electric energy in the OAS

Key to Figure 1:

AB	Assessment boundary
AB-IN	Inside the assessment boundary
AB-OUT	Outside the assessment boundary
GRID	Grid

$E_{\mathrm{pr,el},t}$: electricity produced on-site and inside the assessment boundary in calculation step t;

$E_{\mathrm{EPus,el},t}$: electricity used by technical systems for EPB services in calculation step t;

$E_{\mathrm{nEPus,el},t}$: electricity used in the building for non EPB services in calculation step t;

$E_{\mathrm{pr,el,used,EPus},t}$: part of produced electricity $E_{\mathrm{pr,el},t}$ used by technical systems for EPB services in calculation step t. Minimum of $E_{\mathrm{pr,el},t}$ and $E_{\mathrm{EPus,el},t}$.

$E_{\mathrm{exp,el},t}$: part of the produced electricity $E_{\mathrm{pr,el},t}$ in excess of that used by technical systems for EPB services in calculation step t. Exits the assessment boundary during calculation step t;

$E_{\mathrm{exp,el,used,nEPus},t}$: part of the exported electricity $E_{\mathrm{exp,el},t}$ used for non-EPB services in the building in calculation step t;

$E_{\mathrm{exp,el,nused},t}$: part of the exported electricity $E_{\mathrm{exp,el},t}$ that is not used for any service in the building (neither EPB nor non-EPB) in calculation step t;

$E_{\mathrm{del,el},t}$: energy delivered by the grid during calculation step t;

$E_{\mathrm{exp,el,tmp,an}} = E_{\mathrm{del,el,rdel,an}}$: part of the annual electric energy exported to the grid that will be redelivered to the building in a different calculation interval;

$E_{\mathrm{exp,el,tmp},t}$: electric energy exported to the grid during calculation interval t that will be redelivered to the building for EPB uses in a different calculation interval.

$E_{\mathrm{del,el,rdel},t}$: temporary exported electric energy that is redelivered to the building for EPB uses during calculation step t.

$E_{\mathrm{exp,el,grid},t}$: electric energy that is exported to the grid and will never be redelivered to the building for EPB uses.

$E_{\mathrm{del,el,grid},t}$: net energy delivered by the grid during calculation interval t, excluding the redelivered energy.

PHASE 2 RESULTS

All the subsequent standards are being revised in phase 2 according to the phase 1 requirements. They are developed in the following technical committees (TC's), coordinated by TC 371, which is also responsible for the above-mentioned phase 1 documents:

- TC 89 Thermal performance of buildings and building components
- TC 156 Ventilation for buildings (including air conditioning and cooling)
- TC 169 Light and Lighting
- TC 228 Heating systems and water based cooling systems in buildings (including domestic hot water production)
- TC 247 Building Automation, Controls and Building Management

The standards have been out for public enquiry between autumn 2014 and summer 2015. They will be finished until the end of 2015 and published in spring 2016.

Several EPB standards are being prepared or revised as combined EN ISO standards under the so-called Vienna Agreement between CEN and ISO. This is in particular the case for the standards from TC 89. The intention is to come (eventually) to a complete and consistent set of EN ISO standards on the Energy Performance of Buildings (EPB). A systematic set of numbers, the 52000-series has been reserved for this, the standards gradually moving into this system.

One key standard of this set is prEN ISO 52016-1, the successor of EN ISO 13790. It provides both an hourly and a monthly calculation interval method for the energy needs for heating and cooling, and a major point is to show that – apart from higher time resolutions for the climatic data (and possibly space use data, however with additional benefit) – no additional input data are needed.

There are a small number of standards dealing with issues like inspection and economic evaluation. The vast majority, however, deals with calculation methods for the energy performance. One key standard is prEN 16798-1, the revision of EN 15251, providing input data on indoor environment parameters and space use.

In the following sections, the emphasis is put on the standards on ventilation, air conditioning and cooling. A schematic overview is given in Figure 2.This figure illustrates the areas which are covered by the different standards and that there is a comprehensive set with no gaps. Ventilation related parts are indicated in green, cooling related parts in blue and heating related parts in red.

Two of the standards shown in Figure 2 are developed in TC 228: prEN 15316-2 and -3 deal with the emission and the distribution of water based systems, covering both heating and cooling.

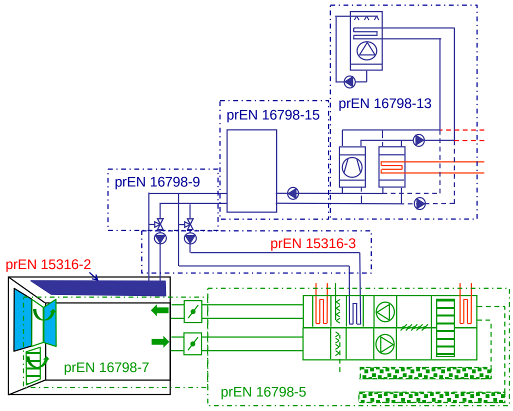


Figure 2 System schematic with the covered areas of the different standards

Also, there are links shown in Figure 2, where (potential) energy flows are transferred to heating related standards. These include heating input to the ventilation system, heating input to absorption chillers, but also heat rejected from the chillers for potential recovery, e.g. for domestic hot water preheating.

STANDARDS ON VENTILATION AND AIR CONDITIONING

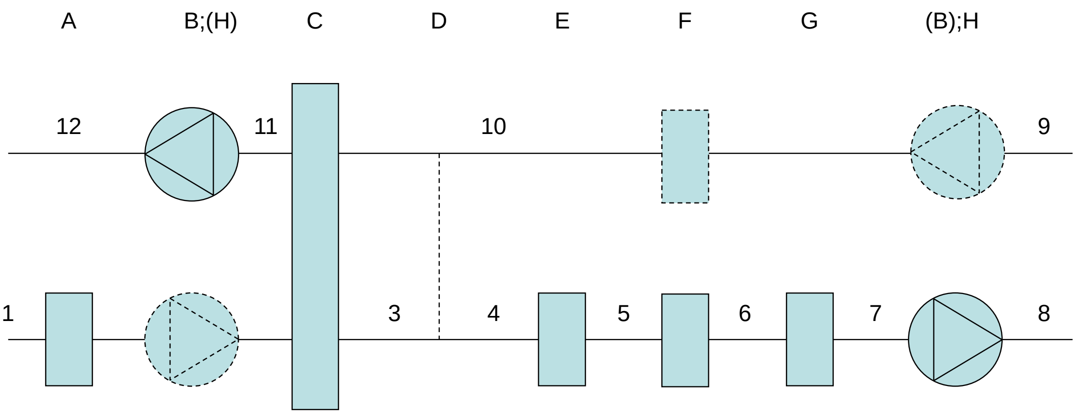
The ventilation related systems and standards are indicated in green in Figure 2. The start of the calculation of ventilation systems is in the occupied space and is described in prEN 16798-7, the former EN 15242. This standard was changed to fully cover module M5-5 “emission”. For this, it was extended to include

- the calculation of air flow rates also for mechanical ventilation system, including VAV systems;
- the required conditions of the supply air (depending on system type and control).

For required air flow rates there is a reference to prEN 16798-1 (EN 15251 rev.) and for the definition of the ventilation effectiveness to prEN 16798-3 (EN 13779 rev.). The parts on the leakage of distribution systems were moved to prEN 16798-5.

prEN 16798-5 is intended to cover a number of modules in the areas of distribution, i.e. the duct system, and "generation", which for the ventilation and air conditioning service is meant to be the air handling unit (AHU), including humidification and dehumidification. In the course of development it was decided to divide the work item into two separate documents because the scope of the two calculation methods is different:

- Part 5-1 describes a detailed method for ventilation and air conditioning systems and uses an hourly calculation step. It is a comprehensive calculation of all aspects of air conditioning systems.



General	A	B	C	D	E	F	G	H
Volume flow rates	Frost protection / ground preheating/-coo-ling	Exhaust air fan	Heat recovery	Recirculation	Cooling / dehumidification	Humidification	Heating	Supply fan
Detailed								
Air handling unit localosation	Ground air preheating and -cooling	localisation	Heat recovery type			Humidifier type		Fan motor localisation
NC	else	DOWN_HR	ROT_SORBT	yes		CONTACT		OUTS_AIR
Supply air temperature control	Frost protection type		only for FLAT_PLATE and ROT_HYG	Recirculation control		humidifier control		System type for variable air volume flow rate fan energy calculation
ODA_COMP	PREH		-	VARIABLE		SPEED		SINGLE_ZONE
Control of the volume flow rate	Control of the frost protection		Control of the heat recovery device			Adiabatic cooling		Control of the fan
VARIABLE	INDIRECT		SPEED					DIRECT
								localisation
								DOWN_HR

Figure 3 Ventilation/AC-system scheme and technology choice options in prEN 16798-5-1

- Part 5-2 is a simplified method for compact systems. It uses a monthly calculation step and includes heat generation (like air-to-air heat pumps) and domestic hot water heating. It does, on the other hand, not cover the full range of technologies which are contained in part 5-1. Although it is primarily dedicated to residential systems, the scope is intentionally not restricted to these, since there are many non-residential applications with smaller units of this type.

Part 5-1 has a lot of options to be chosen. Figure 3 shows the scheme used for the explanation of the nomenclature in the standard, also used in the accompanying spreadsheet. The latter is fully functional and covers all options offered in the standard. In order to ease its use, the options choices are given in drop down menus as shown in Figure 3.

Many of the options are control options, addressed by identifiers, with a link to the building automation:

- Different air flow control types
- Supply air temperature and humidity control types
- Different types of heat recovery:
  - Flat plate;
  - rotary (with different coatings);
  - pumped circuit.

  including the aspects of
  - control;
  - frost protection;
  - auxiliary energy consumption.
- Recirculation control
- Fan control: Several options, based on an input from CEN TC 247; experience showed that this has a big impact on the fan energy consumption and was too optimistic in the current version of EN 15241.
- Ground preheating / -cooling
- Adiabatic cooling by humidification of extract air and heat recovery.

The fan energy being considered the main energy consumption for the service of ventilation, there are also auxiliary energies calculated: for the rotary and pumped circuit heat recovery drives, for the extra pressure difference of the heat recovery, for the circulation pump of the humidifier, for the frost protection by electric preheating and for the controls.

In some areas, the methods go to a level, which is beyond what is implemented in many of today's commercial simulation tools. Two modelling aspects are described in more detail in the following sections.

Heat recovery

For the heat recovery, an empirical model based on detailed laboratory measurements is used. The heat recovery efficiency is calculated with equation (1).

$$\eta_{hr} = \eta_{hr;nom} \cdot f_q \cdot f_v \cdot f_n \qquad (1)$$

The nominal heat recovery efficiency is an input from tests at rated conditions according to product related standards. The factors f_q, f_v and f_n are correction factors for the dependency of the ratio between outdoor and exhaust air mass flows, the air velocity and the rotation speed in case of rotary heat exchangers. Details are given in (Stettler, 2014).

For the latter, there is a similar, slightly more complex model for the humidity recovery efficiency. There is an additional correction factor $f_{\Delta x;x}$ for the condensation potential, which depends on the type of the heat exchanger coating (non-hygroscopic, hygroscopic, sorbtive) and of the outdoor air moisture content and its saturation moisture content.

Fan Energy Consumption

The fan energy consumption depends strongly on the control. The method considers several options, based on an input provided by CEN TC 247 (Tödtli, 2014). The details are explained in the accompanying Technical Report (prCEN TR 16798-6-1).

The principal difference to make is between single zone and multi zone systems. In case of uncontrolled fans, the two are the same: the flow rate is controlled by dampers, and the pressure difference varies along the fan characteristics.

In case of the control of the fan speed they are different. For a single zone system (or a system with a control zone, which is treated the same way) the control can act directly to the fan to adjust the flow rate, whereas in multi zone system the flow rate is controlled on zone level by dampers od VAV boxes, and the fan controller needs to react on this.

There are two options considered for this, representing a solution often used in practise, called "constant pressure control" and a solution closer to the ideal situation, called "minimum pressure control". With constant pressure control, the pressure in the supply duct is controlled to a constant value and the effect on the fan energy consumption is weak. With minimum pressure control, feedback signals from the zone dampers are needed. The effect on the fan energy consumption depends on the proportion of the whole pressure difference controlled to be constant (ideally small, the pressure difference over the dampers), which is an input parameter.

COOLING STANDARDS

General

The core of the cooling related calculation standards is prEN 16798-9, the "general" part. Similar to the general part of the heating and DHW calculation standards, part 9 connects the calculation pieces of the other standards for emission, distribution, storage and generation to a complete system, considering the flow rate and temperature control of the distribution branches and the load dispatching in case of insufficient energy supplied by the generation system. It follows (as the other parts do) the principle, that a subsequent energy using module reports the required energy supply per calculation interval to the delivering module, and this in turn reports the energy really delivered, based on its operational conditions, back to the using module.

Figure 4 shows the schematic representation of a (non-exhaustive) water based system from the standard, illustrating the boundaries of the involved modules and the nomenclature used in the standard.

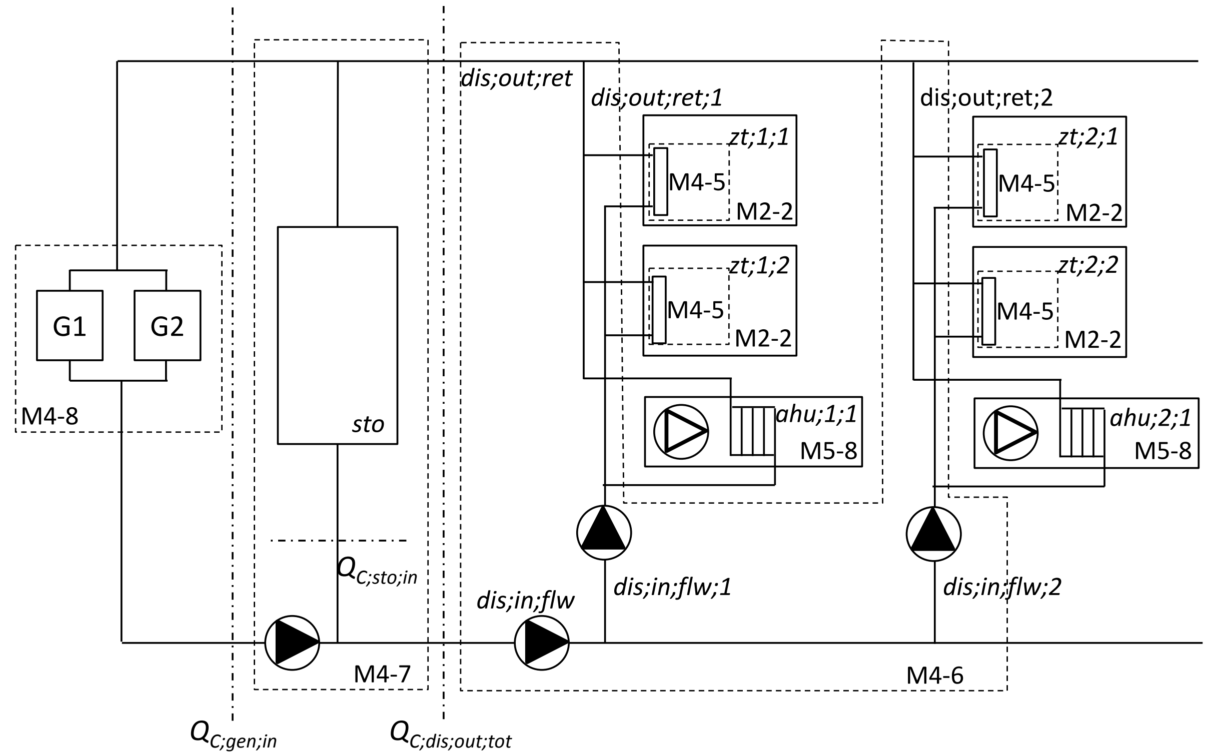


Figure 4 Cooling system scheme with module boundaries and nomenclature given in prEN 16798-9

The system shown in Figure 4 with a generation, a storage and two distribution branches, each serving two thermal zones and one air handling unit, is exactly represented in the spreadsheet going along with the standard. A full annual data set of hourly values is implemented to test the calculation of the partial performance indicator given in the standard.

The standard also addresses direct expansion (DX) systems, where the calculation becomes generally simpler. A schematic representation is given in the Technical Report prCEN TR 16798-10.

Generation

prEN 16798-13 is a new standard for the cooling generation calculation, which was until now covered only in an informative annex of EN 15243. It contains 2 Methods:

- Method A for an hourly calculation step;
- Method B for a monthly calculation step.

The technologies covered in both methods are

- Compression and absorption chillers;
- A place holder for "other" type of generator, being used e.g. for direct use of boreholes, ground or surface water;
- Multiple generators handling;
- “Free cooling” control option, i.e. direct cooling via heat rejection device;
- Different Heat rejection types:
  - air cooled condensers;
  - dry, wet and hybrid heat recovery devices;
  - control options for the heat rejection (e.g. switch between dry and wet operation for hybrid heat rejecters);

The model for compression chillers used in method A is the one described in (Zweifel, 2009). There is a connection to product standards: A performance map is used, which is generated on the base of the measurement points from tests according to EN 14511, which are used in EN 14825 for the calculation of the seasonal energy efficiency ratio SEER. However, the 4 measurement points are not sufficient; a fifth point outside the range of the four is needed. Discussions with manufacturers have shown that there is willingness in the industry that more data shall be made available.

The difference between the required input data for the two methods documents the fact, that in systems calculations, an hourly calculation interval often leads to a simplification, since a large set factors for the consideration of the effect on averaging of climatic variations and control influences, to be derived from pre-calculations and often restricted to specific climates and operational conditions, can be avoided.

Storage

A new standard prEN 16798-15 was developed for the calculation of cooling storage systems. This was done in close collaboration with TC 228, to ensure the same philosophy as for heating and DHW storage calculation. The method is applicable to any calculation interval and covers different storage types:

- Water tanks
- Ice storage
- Phase change materials (PCM)

The calculation of the storage charging circuit is included in the standard, as shown in Figure 4. There is an accompanying TR and a spreadsheet for PCM devices available.

INPLEMENTATION AND FUTURE DEVELOPMENT

The implementation in the EU Member states will be on a step-by-step basis. This means, the member states are given the possibility to continue using their own methods for some of the modules (which are not always set down in standards, but sometimes in regulatory documents).

Experience has shown, that the goal of one single unified calculation method for whole Europe cannot be reached in a short time. The new set of standards is an important step in this direction. But more time will be needed until the value of some of the developments is fully recognised.

CONCLUSION

The new set of standards for the energy performance of buildings calculations are, thanks to a rigorous set of requirements, a modular structure and a common format of presentation, more unambiguous, more flexible and more applicable. The restriction of the standards to the equation based method description, the accompanying Technical Reports for explanations and the spreadsheets makes them software-proof.

In some areas of the system calculations, there are model approaches, which can also be used in commercial simulation software and would in some cases increase their capabilities.

ACKNOWLEDGEMENT

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Part 2: Test conditions
Part 3: Test methods
Part 4: Operating requirements, marking and instructions

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