ENPER-EXIST

Applying the EPBD to improve the Energy Performance Requirements to Existing Buildings – ENPER-EXIST

WP1: Detailed calculations

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ENPER-EXIST project information

The ENPER-EXIST project was initiated and is coordinated by the Centre Scientifique et Technique du Bâtiment (CSTB) in the frame of the Intelligent Energy Europe (EIE) programme in the part SAVE of the European Commission, DG TREN. It involves partners from 7 countries on the topic of energy performance standardization and regulation. Contract EIE/04/096/S07.38645. Duration: 01/01/2005 - 30/07/2007.

The Energy Performance of Building Directive (EPBD) sets a series of requirements specifically dedicated to existing buildings but the member states are facing difficulties to implement quickly these requirements. The main goal of the ENPER-EXIST project is to support the take off of the Energy performance of building directive (EPBD) in the field of existing buildings.

ENPER-EXIST has 4 main objectives:

1. To de-fragment technical work performed on existing buildings. Indeed actions already launched in CEN to apply the EPBD are de-fragmented but mainly focus on new buildings. On the other hand different projects on certification procedures are going on at the European level but are not coordinated.
2. To de-fragment work on legal, economical and organisational problems such as the analysis of certification on the market, the human capital and the national administrations.
3. To achieve a better knowledge of the European building stock.
4. To define a roadmap for future actions regarding existing buildings.

ENPER-EXIST uses an intensive networking of existing national and international projects to reinforce efforts to solve these issues. It works in close coordination with the Concerted Action set up by Member States to support the application of EPBD. The work program is split in 4 technical work packages in addition to dissemination and management activities.

WP1: Tools application
WP1 analyses how existing buildings are taken into account in technical tools such as CEN standards, national calculation procedures. Recommendations on how to improve the consideration of existing building are be defined.

WP2: Legal economical and organisational impact
WP2 analyses the impact of the certification procedures and regulations of existing buildings on the market, on the human capital and on the national administration. Surveys are carried out in the different member states and recommendations are drawn up.

WP3: Building stock knowledge
WP3 analyses the level of information available in each country regarding the existing building stock. A procedure enabling to refine this information and ways to use the certification procedure as a tool to collect data regarding this stock is developed.

WP4: Roadmap
An overview of possible legal measures for existing buildings is written. Indications are given about alternative strategies to improve on a wide scale the energy efficiency of existing buildings. Possibilities (including pro's and cons) to widen the scope of the EPBD in case of a future revision of the requirements of the directive are described.

A website, newsletters and workshops enable a strong interaction between ENPER-EXIST and different interest groups and a wide dissemination of ENPER-EXIST results. The workshops are organised with the different actors involved in the application of the EPBD.More information on the project website: www.enper-exist.com

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Executive summary

The CEN working groups have done a tremendous job to deliver a huge amount of EPBD CEN standards to guide the implementation of the EPBD in the member states. Because of lack of time and priority it has been inevitable that most of the working groups had more focus on new than on existing buildings. ENPER Exist has jumped into this gap and has provided assistance to the EPBD CEN standards.

Within ENPER Exist various courses have been taken to provide this assistance:

- The expert knowledge of the participants of the project is used to analyse the most important CEN standards. This has been a desk research.
- The usability of the CEN standards on existing buildings has also been tested in practice in a pilot test which focussed on the gathering of the input data.
- The third practical test has been the performance of some detailed calculations with the CEN standards.
- The knowledge of the developers of existing EP methods for existing buildings (on national level and on EU level) is used to find alternative solutions for gaps which were found in the previous tasks.

This document provides the knowledge gained by the performance of detailed calculations with the CEN standards. Together with the pilot study on data acquisition this is the ultimate test of the usability of the standards in practice. In the scope of this study calculations are performed related to the hourly heating and cooling need, the ventilation flow, energy use for lighting and the generation efficiency of boilers. For the same subjects, calculations are performed with a national or other alternative method, to see if both methods are in line or cross-pollination is possible.

Hourly heating and cooling need

Calculation of energy use for space heating and cooling using the hourly calculation method of ISO/DIS 13790 standard can be used to existing building only in the case the inspection of the buildings allows to gather the most important necessary data or default values are available.

More guidance to define default values according to the observations will make the method more useful. When using defaults, the results might not be very precise, but will give a good idea of the energy demand. The problem arises when it is difficult to define values for calculation method inputs. We saw according to results presented in this report that for example the air flows of ventilation have a very strong influence on the results; this parameter is very difficult to estimate for existing buildings especially in the case of no ventilation system. A fixed default might be a solution here.

Ventilation flow

The calculation of ventilation air flow supply according prEN 15242 depends strongly on the input data: air tightness of the building envelop and air flow rate of the ventilation system. These two parameters are very difficult to estimate for existing buildings. There influence is very high on the calculation of heating energy needs.

So for existing buildings the liability of the EP calculation increases when standard conditions for the ventilation flow are used, in stead of using the calculation of ventilation air flow supply according prEN 15242.

Energy use for lighting

The study shows for an office type building more than 100 % higher lighting energy demands for the provided simple method compared to the comprehensive method. The big differences can be mainly attributed to conservative default values for the installed power density of the artificial lighting system and to an underestimation of daylighting benefits.

The simple method in general represents a good framework for a quick estimation procedure. Nevertheless the default values as currently contained in the draft prEN 15193 seem to be not suited to provide realistic and reliable lighting energy demands. A more detailed and refined set of default parameters might in future provide more realistic scenarios Therefore, for the moment, the comprehensive method should be applied in analyzing an optimizing lighting energy demands. Since also the comprehensive method comprises several new approaches testing and validation of both methods against metered consumptions is essential.

Generation efficiency of boilers

This study shows that it is possible to use the case specific method to develop a table method for the efficiency of boilers for existing buildings. An aspect which is especially important for existing buildings, namely the distinction between a boiler in a heated or unheated room, can be made with this method.

The method is suitable for room thermostat controlled systems. For heating curve controlled systems an additional study on the proper operating conditions/ correction factor is required. Such a study can be performed on national level.

The outcome of the alternative calculation, which has been performed for the Dutch situation, leads up to a similar type of results. Both methods are in line. This supports the usability of the CEN typology method.

1. Introduction

Part of the study on the usability of the CEN standards on existing buildings (WP 1) is the performance of calculations with these standards. Together with the pilot study on data acquisition this is the ultimate test of the usability of the standards in practice. The following calculations are performed in the scope of this study:

- Energy use for lighting (detailed method)
- Generation efficiency of boilers
- Ventilation flow
- Hourly heating and cooling need

Why these detailed calculations and no general energy performance calculations?

- Calculations of the complete energy performance of existing buildings are preferred but have not been possible given the development of the standards: no calculation software is available for the standards yet and developing software is not an objective within the Enper Exist project.
- Enper Exist has been working closely together with SAVE project EPA-NR. This project does have the objective of developing software for the calculation of the complete energy performance of buildings conform the CEN standards and testing it by performing pilot calculations. Because not all the published draft CEN standards contain completely evolved and usable methods it has not been possible for EPA-NR to make software for the energy performance calculation of buildings based on the CEN standards totally. That is why EPA-NR focuses on the heating and cooling need calculation and on the overall standards (certificate/total energy use/general procedures). Detailed methods on systems have been entered into the software in simplified ways in order not to delay the project too much.
- Enper Exist has focused on the performance of calculations on such topics that the work is complementary to the work done within EPA-NR:
    - EPA-NR chose to focus on the monthly method for heating and cooling needs. To see if the hourly method can be used for exiting buildings as well, Enper Exist has performed calculations with the **hourly method for heating and cooling need**. See chapter 2;
    - EPA-NR has managed the methods on systems in a simplified way. For the same reason Enper Exist has tested the most important system standards by performing pilot studies on the data acquisition in stead of doing calculations;
    - Specific topics have been tested within Enper Exist by doing calculations. This is done for the situations where calculations deliver complementary results to the data acquisition pilot study:
        - **Energy use for lighting**: The simplified method for lighting seems to be easy usable for existing buildings. This method has been tested within the Enper Exist pilot study on data acquisition. The problem with the simplified method is that it does only slightly take into account the effect of daylight. Since this can be interesting for existing buildings as well, Enper Exist has performed some calculations on the comprehensive method described in the lighting standard. See chapter 3;

- **Ventilation flow**: The calculation of energy use for ventilation presumes the ventilation flow in the building is known. Enper Exist has tested the calculation method on the estimation on the ventilation flow by performing some calculations with the standard on ventilation air flow rates. The case study is described in chapter 2 (together with the case study on the hourly method);
- **Generation efficiency of boilers**: The CEN standard on generation efficiency of boilers describes among others a method with which it is possible for Member States to develop easy tables with generation efficiencies of specific or typical boilers. The aim of the calculations performed in Enper Exist has been to see if and how this method works in practice. See chapter 4.

2. Hourly method for heating and cooling need and ventilation flow

2.1 Introduction

This chapter contains a case study were two of the CEN Standards are used in practice, namely the hourly method calculation of energy demand (part of the EN/ISO 13790) and the calculation of the ventilation flow (EN 15242), which is an input for the energy demand calculation. As a case study, an application of both standards is made to an existing primary school in Paris.

2.2 General aspects of the calculation

At CSTB, we have developed a calculation method for energy performance of buildings, this method is based on:

- WI 14, ISO/DIS 13790 Energy performance of buildings –Calculation of energy use for space heating and cooling : hourly calculation method
- prEN 15242 : calculation of volume air flow rate by ventilation and infiltration : simplified method
- hourly calculation of gains due to lighting and energy consumption of lighting
- Simplified approach that take into account heating and cooling systems by energy efficiency

The model used for calculation of energy demand is based on an equivalent R C model. It runs on an hourly basis and all building and system input data can be modified each hour using schedule tables (in general on a weekly basis). Compared to some other simplified models, this one makes a distinction between the internal air and mean radiant temperature. This enables to use it for thermal comfort checks and increases the accuracy for taking into account the radiative and convective par of solar, lighting, and internal gains.

This calculation method was implemented on an excel sheet, which makes it very easy to use.
It gives the energy performance of the building: energy use (energy consumption) of the building in kWh/m².

The main parts for the input data are:

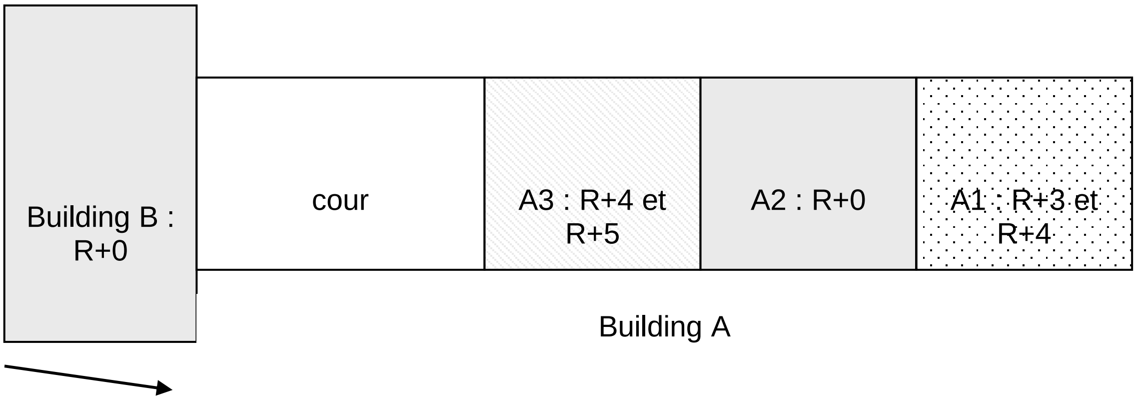
- One part for a general description of the building
- One part for description of opaque and transparent components
- One part for ventilation flow
- One part for lighting
- One part for heating and cooling systems

This calculation method was applied into practice to an existing primary school located in Paris. To calculate only the heating energy needs, the efficiency of heating system is put to 1. The calculation is made using the indoor temperature set points that not take into account the variation due to control and quality of emission.

***General aspects of the building*:**

The building for witch the calculation method was applied is a primary school located in Paris, 28 rue Cambon, 75001 Paris. The necessary data for the calculation is provided from the inspection of the building. In the case of no available data, estimations and default values were used. No drawings of the school were available.

The geometrical description of the School is depicted on the next picture: (note: the arrow point to the north).



The most part of the buildings are composed by class rooms.

The calculations were performed for building A.

2.3 Input parameters and results:

The user input parameters of the model are the following terms :

1. Building description parameters:

- Climate data (hourly) : climate of Paris
- Floor area (m²) : 980 m²
- the high (m) of the inspected zone (for stack effect calculation) = 17.2m
- H value for windows (W/°C)

$$H_{window} = \sum_{Windows} U_{window} * S_{window}$$

According the type of windows (inspection of the building), default U values are considered

					Number of windows			
Window type	L (m)	H (m)	S_{window} (m²)	U_{window}(W/m²K)	South	North	West	Est
FE1	2.3	2.8	6.44	3.2	4	10	0	0
FE2	2.3	2.8	6.44	2.4	0	2	0	0
FE3	1.45	1.6	2.32	3.2	0	4	0	0
FE4	2.3	0.5	1.15	3.2	0	2	0	0
FE5	1.1	2.3	2.53	2.4	0	2	0	0

Hwindow	368.624	W/K

- H value of the exposed opaque area (W/K)

This coefficient relates to the opaque walls and the cold bridges. The opaque walls are defined as the external opaque walls, not glazed part of the external doors, floor and ceiling

$$H_{opaque} = \sum_{opaquewalls} U_{opaque\ wall} * S_{opaque\ wall} + \text{Cold bridges.}$$

For this existing school we consider a fixed value of cold bridges : 10% of U values

$$H_{opaque} = \left(\sum_{opaquewalls} U_{opaque\ wall} * S_{opaque\ wall} \right) * 1.1$$

Default U values and g values are considered according the type of walls (inspection of the building)

			South	North	West	Est	$U_{opaquewall}$	g
	Type	% glazing	$S_{\text{opaque wall}}$ (m²)				(W/m²K)	-
External walls	PA1	-	102.2	201.3	60	60	1.8	0.047
	PA2	-	0	0	184.04	0	1.8	0.047
	PA3	-	0	0	0	135.89	1.8	0.047
	PA4	-	22.8	22.8	16.5	16.5	2.4	0.063
	PA5	-	189.2	94.9	47.5	85.5	1.8	0.047
External doors	PE1	0.3	0	8.17	0	0	2.7	0.07
	PE2	0.7	32.25	0	0	0	3.2	0.083
Roof+floor	-	0	750				1.2	0.047
H_{opaque}	3224	W/K						

- Inertia class

The classification of inertia is 1: very light to 5: very heavy. This classification was done depending on the heat capacity of each building element.

The classification of inertia for this school is estimated to be class 3

- Air infiltrations :Q4Pa : air tightness of the zone (airflow in m3/h under 4 Pa)

For this existing school, this parameter was estimated according default values

Q4Pa = 1.7 * $S_{\text{external walls (vertical+roofl)}}$

External elements	South	North	West	Est	S_{total}
	S (m²)	S (m²)	S (m²)	S (m²)	(m²)
Walls	314.2	319	297.89	297.89	1228.98
Windows	25.76	93.92	0	0	119.68
Doors	32.25	8.17	0	0	40.42
Roof					375
				Total	1764.08
				Q4PA =	2998.936

- Solar apertures per orientation without and with moveable shadings (m²)

In the general form this term are calculated by:

$S_{sol} = \Sigma g_i$ Si where g_i is the solar factor and the Si is the opaque and transparent i surface.

In case of moveable solar shading, the solar aperture is given with and without solar shading, and the value to be applied is calculated taking into account the solar shading use ratio.

The solar factors for the transparent and opaque surfaces are given in the next table:

	Glazing surface	Opaque surface
Solar aperture without moveable shadings	0.4	Vertical a=0.6
Solar aperture with moveable shadings	0.1	Horizontal a=0.9

The solar factor for the opaque surfaces is calculated using

Solar factor=a*U/23

Where a is the radiation absorption coefficient.

Solar aperture				
South	North	West	Est	H
S (m²)	S (m²)	S (m²)	S (m²)	S (m²)
35.25	54.29	14.72	14.25	35.22
Solar aperture with moveable shading				
South	North	West	Est	H
S (m²)	S (m²)	S (m²)	S (m²)	S (m²)
20.75	25.38	14.72	14.25	35.22

2. Ventilation system:

- Air flows during occupancy and unoccupancy periods (m^3/h)

There is no ventilation system in this school, the fresh air is assumed by opening the windows and by the infiltration through the envelop

For the calculation, three cases of air flows during occupancy and inoccuppancy were considered, and three calculations were performed using these three cases

The first case one assumes a fixed amount of air flows for each square meter (about 8m^3/h/m²). The two others cases assume 1 ach and 0.5 ach. An investigation was conducted on the influence of absence of the air flow during to the innocupancy periods.

	Case 1	Case 2	Case 3
	8m3/h/m²	1 ach	0.5 ach
Air flow rate during occupancy period (m3/h)	7783.6	16734.74	8367.4

- Ratio between supply and exhaust (-)
- Temperature of air preheating (°C)

No preheating

- Heat exchanger efficiency (0 to 1)

No exchanger

3. Heat and cool emissions:

- Internal gains: occupancy and various contributions (W)

The internal gains are composed of the free contributions by to the occupants. These terms are evaluated by two different ways. The first one assumes a fixed amount of internal gains for each square meter (about 4W/m²). The second estimate a fixed amount of internal gains for each occupant of the building (about 90W/m²). These two ways was employed by several French standards.

Internal gains	**Case 1** : 90W/person				
	Students	Teachers	Others	gain/person	
Occupation	135	10	5	90	
Innoccupation	0	0	0	0	
				Total	13500 W
Internal gains	**Case 2** : 4W/m²				
				Total	3892W

- Indoor temperature set points for heating and cooling. The variations of the emission efficiency attributed to the control (regulation) strategy and to type of emitter are not taken into account.

Set point heating	
Occupation	19°C
Inoccupation	15°C
Control and emission	
dt in space	0
dt in time	0

4. Lighting:

- Area naturally lighted (m²)

  It is the share of the building which profits from the natural light. It is considered that this surface is equal to the length of the external wall having a window multiplied by 4m.

Area naturally lighted					
	South	North	West	Est	Total
Wall with windows (m²)	250	263.6	0	128.4	642

- Natural light apertures per orientation without and with moveable shadings (m²). These terms are calculated in the same manner as the solar aperture, replacing the solar factor by the light transmittance factor. The light transmittance for glazing surfaces are exposed in the following table :

	Transmittance (-)
Natural light aperture without moveable shadings	0.3
Natural light aperture with moveable shadings	0

Natural light aperture			
South	North	West	Est
S (m²)	S (m²)	S (m²)	S (m²)
7.728	28.176	0	0
Natural light aperture with moveable shading			
South	North	West	Est
S (m²)	S (m²)	S (m²)	S (m²)
0	0	0	0

- Electrical lighting power (W)

  This term is estimated assuming a 15W/m² installed loads which is associated to a lighting level about 300-400 lux.

Electrical lighting power	
Power/m²	15 W/m²
Total	14594 W

5. heating and cooling equipment:

The school is not cooled; the heating system is composed by a gas boiler and radiators

The characteristics of heating system are not taken into account to calculate the heating energy needs

2.4 Calculation results

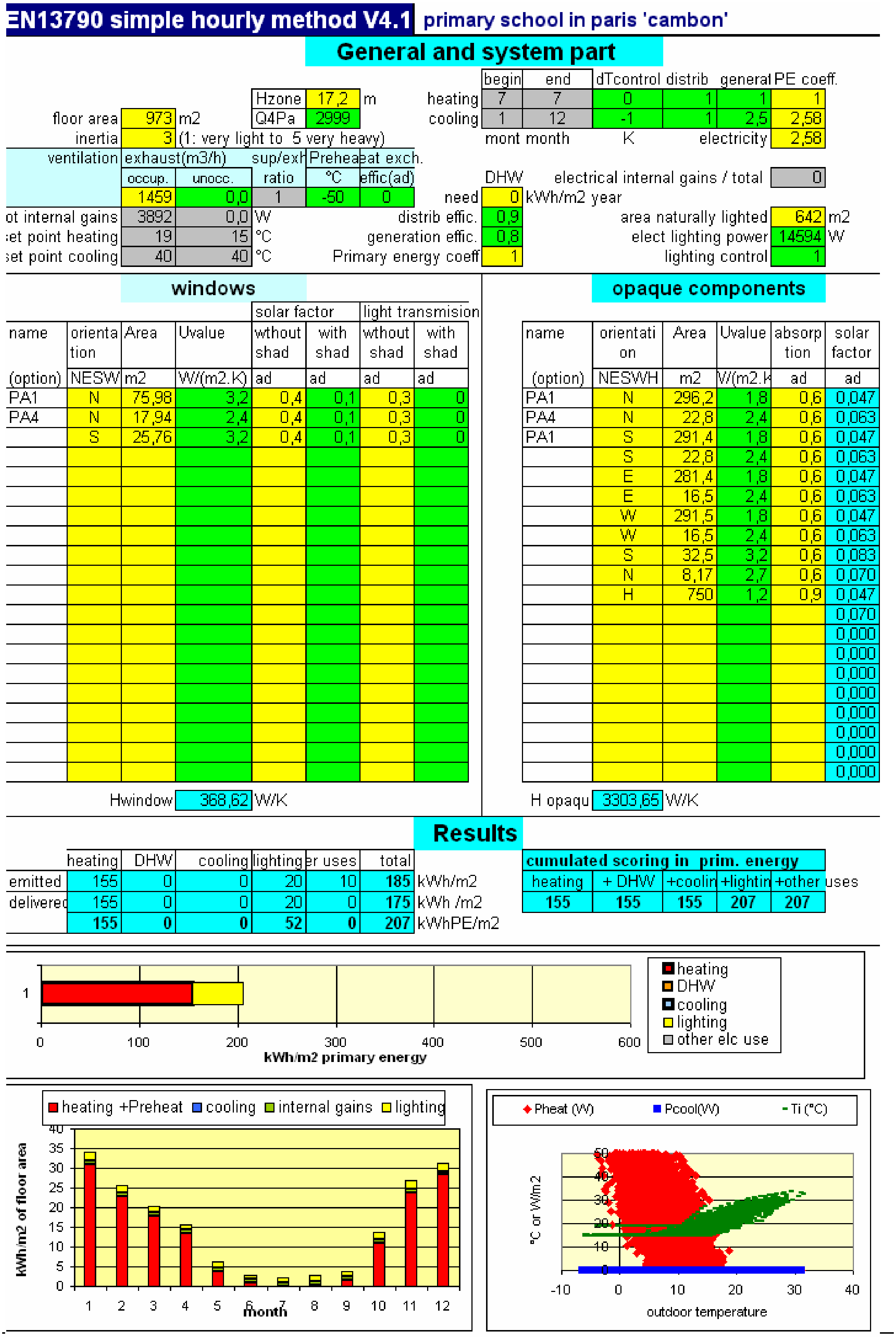
Several calculations were performed according different values of ventilation flow rates and internal gains

		ventilation flow rate					
		occ and inoc 8m^3/h/m²	occ and inoc: 1ach	occ and inoc : 0,5ach	occ : 8m3/h/m² inoc : 0	occ : 1ach inoc : 0	occ : 0,5ach inoc : 0
internal gains	occ : 4W/m² inoc : 0W	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6
	occ : 90W/person inoc : 0W	Case 7	Case 8	Case 9	Case 10	Case 11	Case 12

Occ = occupation period : from 9h-18h

Inoc = inoccupation period : from 18h to 9h

In the following figures of excel sheet : input data and main results :



ΞN13790 simple hourly method V4.1 primary school in paris 'cambon'

General and system part

floor area	973	m2	
inertia	3	(1: very light to 5 very heavy)	
Hzone	17,2	m	
Q4Pa	2999		

	begin	end	dTcontrol	distrib	general	PE coeff.
heating	7	7	0	1	1	1
cooling	1	12	-1	1	2,5	2,58
	mont	month	K		electricity	2,58

ventilation	exhaust(m3/h) occup.	exhaust(m3/h) unocc.	sup/exh ratio	Preheat °C	heat exch. effic(ad)
	1459	0,0	1	-50	0
ot internal gains	3892	0,0	W		
ɛet point heating	19	15	°C		
ɛet point cooling	40	40	°C		

DHW need	0	kWh/m2 year
distrib effic.	0,9	
generation effic.	0,8	
Primary energy coeff	1	
electrical internal gains / total	0	
area naturally lighted	642	m2
elect lighting power	14594	W
lighting control	1	

windows

name	orientation	Area	Uvalue	solar factor wthout shad	solar factor with shad	light transmision wthout shad	light transmision with shad
(option)	NESW	m2	W/(m2.K)	ad	ad	ad	ad
PA1	N	75,98	3,2	0,4	0,1	0,3	0
PA4	N	17,94	2,4	0,4	0,1	0,3	0
	S	25,76	3,2	0,4	0,1	0,3	0

Hwindow 368,62 W/K

opaque components

name	orientation	Area	Uvalue	absorption	solar factor
(option)	NESWH	m2	W/(m2.K	ad	ad
PA1	N	296,2	1,8	0,6	0,047
PA4	N	22,8	2,4	0,6	0,063
PA1	S	291,4	1,8	0,6	0,047
	S	22,8	2,4	0,6	0,063
	E	281,4	1,8	0,6	0,047
	E	16,5	2,4	0,6	0,063
	W	291,5	1,8	0,6	0,047
	W	16,5	2,4	0,6	0,063
	S	32,5	3,2	0,6	0,083
	N	8,17	2,7	0,6	0,070
	H	750	1,2	0,9	0,047
					0,070
					0,000
					0,000
					0,000
					0,000
					0,000
					0,000
					0,000
					0,000

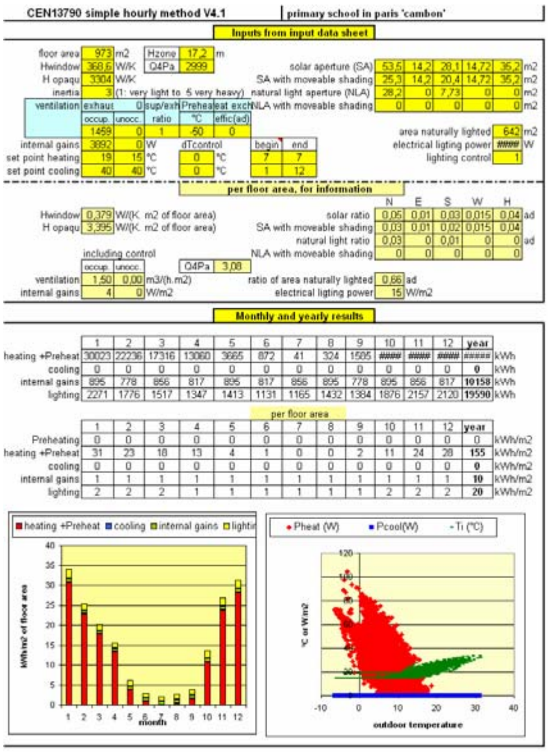
H opaqu 3303,65 W/K

Results

	heating	DHW	cooling	lighting	other uses	total	
emitted	155	0	0	20	10	185	kWh/m2
delivered	155	0	0	20	0	175	kWh /m2
	155	0	0	52	0	207	kWhPE/m2

cumulated scoring in prim. energy

heating	+ DHW	+cooling	+lighting	+other uses
155	155	155	207	207



CEN13790 simple hourly method V4.1 | **primary school in paris 'cambon'**

Inputs from input data sheet

floor area 973 m2 Hzone 17,2 m
Hwindow 368,6 W/K Q4Pa 2999
H opaqu 3304 W/K
inertia 3 (1: very light to 5 very heavy)

ventilation	exhaus	0	sup/exh	Prehea	eat exch
	occup.	unocc.	ratio	°C	effic(ad)
	1459	0	1	-50	0

				dTcontrol		begin	end
internal gains	3892	0	W				
set point heating	19	15	°C	0	°C	7	7
set point cooling	40	40	°C	0	°C	1	12

solar aperture (SA)	53,5	14,2	28,1	14,72	35,2	m2
SA with moveable shading	25,3	14,2	20,4	14,72	35,2	m2
natural light aperture (NLA)	28,2	0	7,73	0	0	m2
NLA with moveable shading	0	0	0	0	0	m2

area naturally lighted 642 m2
electrical ligting power #### W
lighting control 1

per floor area, for information

Hwindow 0,379 W/(K. m2 of floor area)
H opaqu 3,395 W/(K. m2 of floor area)

	N	E	S	W	H	
solar ratio	0,05	0,01	0,03	0,015	0,04	ad
SA with moveable shading	0,03	0,01	0,02	0,015	0,04	
natural light ratio	0,03	0	0,01	0	0	ad
NLA with moveable shading	0	0	0	0	0	

including control

	occup.	unocc.	
ventilation	1,50	0,00	m3/(h.m2)
internal gains	4	0	W/m2

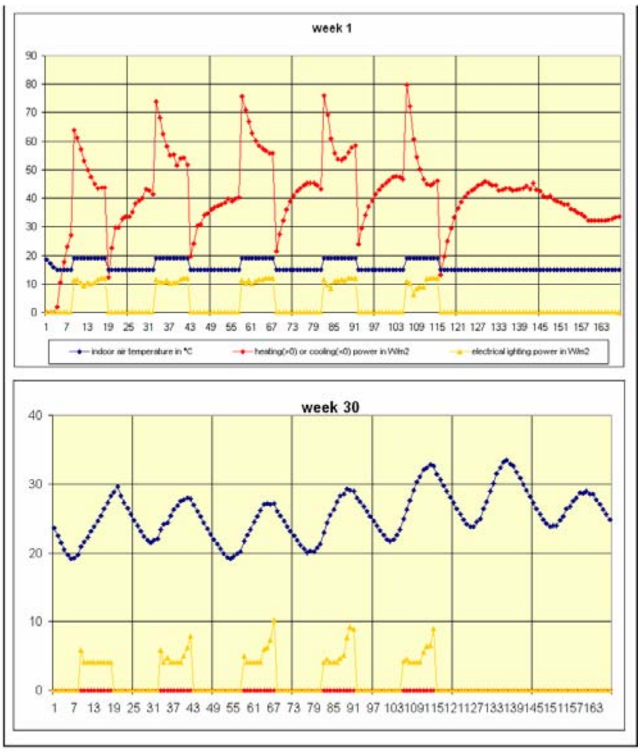
Q4Pa 3,08
ratio of area naturally lighted 0,66 ad
electrical ligting power 15 W/m2

Monthly and yearly results

	1	2	3	4	5	6	7	8	9	10	11	12	year	
heating +Preheat	30023	22236	17316	13060	3665	872	41	324	1505	####	####	####	#####	kWh
cooling	0	0	0	0	0	0	0	0	0	0	0	0	**0**	kWh
internal gains	895	778	856	817	895	817	856	895	778	895	856	817	**10158**	kWh
lighting	2271	1776	1517	1347	1413	1131	1165	1432	1384	1876	2157	2120	**19590**	kWh

per floor area

	1	2	3	4	5	6	7	8	9	10	11	12	year	
Preheating	0	0	0	0	0	0	0	0	0	0	0	0	0	kWh/m2
heating +Preheat	31	23	18	13	4	1	0	0	2	11	24	28	**155**	kWh/m2
cooling	0	0	0	0	0	0	0	0	0	0	0	0	**0**	kWh/m2
internal gains	1	1	1	1	1	1	1	1	1	1	1	1	**10**	kWh/m2
lighting	2	2	2	1	1	1	1	1	1	2	2	2	**20**	kWh/m2



- Heating energy needs calculated using the ISO/DIS 13790 standard (hourly calculation method

In the following table energy needs for heating is given in for all cases in kWh/m²

		ventilation flow rate					
		occ and inoc 8m^3/h/m²	occ and inoc: 1ach	occ and inoc : 0,5ach	occ : 8m3/h/m² inoc : 0	occ : 1ach inoc : 0	occ : 0,5ach inoc : 0
internal gains	occ : 4W/m² inoc : 0W	299	202	174	197	164	155
	occ : 90W/person inoc : 0W	283	188	160	182	150	141

The results highly depend on the two parameters: flow rate of ventilation and internal gains, the influence of the flow rate of ventilation during the occupation period and the presence or not of ventilation in inoccupation is very strong.

The tables below show the influence of each parameter on heating primary energy consumption.

		ventilation flow rate					
		occ and inoc 8m^3/h/m²	occ and inoc: 1ach	occ and inoc : 0,5ach	occ : 8m3/h/m² inoc : 0	occ : 1ach inoc : 0	occ : 0,5ach inoc : 0
internal gains	occ : 4W/m² inoc : 0W	0,0%	-32,4%	-41,8%	-34,1%	-45,2%	-48,2%
	occ : 90W/person inoc : 0W	-5,4%	-37,1%	-46,5%	-39,1%	-49,8%	-52,8%
		variation of heating energy needs comparison to the worst case: continuous ventilation, high flow rate of ventilation and lower internal gains					

The variation of heating energy needs between the “worst” and the “best “ case could be more than 50%.

		ventilation flow rate					
		occ and inoc 8m^3/h/m²	occ : 8m3/h/m² inoc : 0	occ and inoc: 1ach	occ : 1ach inoc : 0	occ and inoc : 0,5ach	occ : 0,5ach inoc : 0
internal gains	occ : 4W/m² inoc : 0W		-34,1%		-18,8%		-10,9%
	occ : 90W/person inoc : 0W		-35,7%		-20,2%		-11,9%

influence of ventilation flow rate in inoccupation
variation of heating energy needs between the case where ventilation is stopped the night and the case where it is not stopped

The influence of ventilation flow rate during inoccupation period is very high.

		ventilation flow rate					
		occ and inoc 8m^3/h/m²	occ and inoc: 1ach	occ and inoc : 0,5ach	occ : 8m3/h/m² inoc : 0	occ : 1ach inoc : 0	occ : 0,5ach inoc : 0
internal gains	occ : 4W/m² inoc : 0W						
	occ : 90W/person inoc : 0W	-5,4%	-6,9%	-8,0%	-7,6%	-8,5%	-9,0%

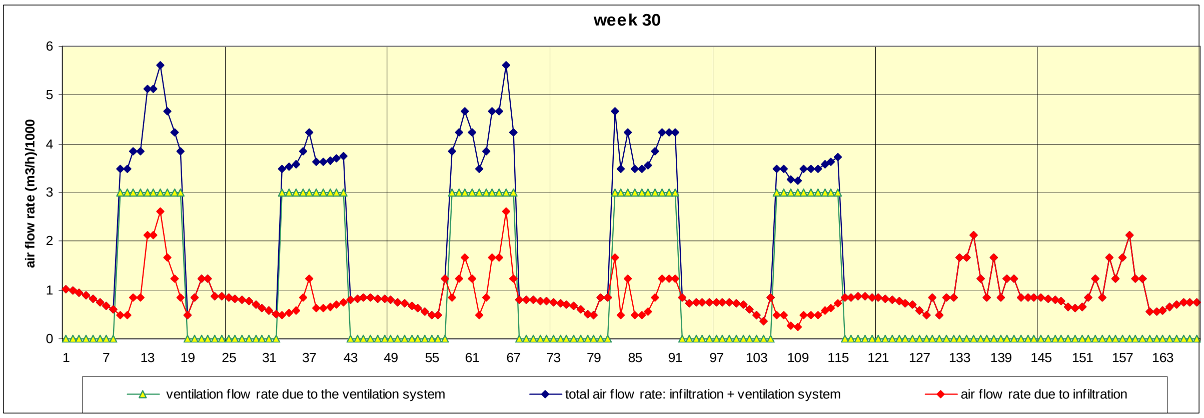
influence of internal gains
variation of heating energy needs between the case where internal gains = 90W/person and internal gains=4W/m²

The influence of internal gain is less than 10%.

In existing buildings it’s very difficult to estimate the ventilation flow rate, however the impact of this parameter on energy consumption is very high.

- prEN 15242 : calculation of volume air flow rate by ventilation and infiltration : simplified method

The following figure shows the results obtained for case 1, it gives the air flow rate due to infiltration and total the air flow rate due to infiltration and the ventilation system. These flow rates are calculated according the simplified method of PrEN 15242.



The air flow rate due to infiltration depends on air tightness of the zone (airflow in m3/h under 4 Pa), this value is very difficult to estimate especially for existing building

The part of air flow rate due to infiltration on the total air flow supply for the building is important and it’s influence on energy consumption is not negligible. Attention and guidance should be made determine the input value: air flow rate under 4Pa!

2.5 Calculation experiences:

Calculation time:

- Time to enter inputs it into the spreadsheet: 2 hours, however time to gather all necessary input data for an existing building is very high. In the case of this school, it was necessary to measure the geometrical data during the inspection of the building and to estimate many inputs. Many default values were used.
- time to perform the calculation itself (including running variations and solving errors): about two hours ; the spreadsheet of calculation method is very easy to use
- time to interpret the outputs : about one hour10 minutes

The most difficult problem in order to perform calculation is the time to gather the inputs. The method provides a good description of the results (different type of plots).

2.6 Alternative calculation:

The comparison with a national alternative method has focused on ventilation. A problem with the CEN methodology is that the method does not give a usable recipe to derive the amount of ventilation rate. The ventilation rate is an input of the method. In existing building practice it is a problem what value is realistic. Although it is probably hard to come up with realistic default values, it is important that guidance is given to avoid that every advisor gives his own interpretation.

We have compared this with the method used in the Dutch EPA (energy performance assessment for existing non-residential buildings) and calculated the ventilation rate for the above described school building.

The ventilation rate is divided in 3 parts: an infiltration part, a natural ventilation part and a mechanical ventilation part.

The infiltration part is based on:

- Year of construction: <1995
- Building height: 10 – 12 m

This results in an infiltration amount of 0,38 dm^3/s.m^2 floor area (with 10 Pa pressure difference). With the floor area being 980 m^2 the amount of infiltration in the building is determined at 1341 m^3/h.

There is no mechanical ventilation present. The natural ventilation is based on:

- The minimal required ventilation (this is a fixed amount based on the function of the building, being an educational building in this case): 3.5 dm^3/s.m^2 floor area
- The fraction of the time the building is used (this is a fixed fraction based on the function of the building, being an educational building in this case): 0.3

This results in a ventilation amount of 0,84 dm^3/s.m^2 floor area. With the floor area being 980 m^2 the amount of infiltration in the building is determined at 2964 m^3/h.

Compared with the rates in the CEN methods these values are much lower. Regarding the ventilation rate this is due to the fact that for the Dutch method this rate is averaged over the occupied and the unoccupied period as for the CEN method the rate is for the occupied period only. Taking that into account, the value determined with the Dutch method is more or less equal with the first and third estimation of the CEN method (8m^3/hm^2 respectively 0,5 ACH)

Conclusion: The order of the determination of the ventilation rate is the same for the Dutch method and the values estimated for the CEN calculations. The difference is that for the Dutch method these values are determined via objective criteria, where the estimation of the values for the CEN method are based on the expertise of the advisor. The latter is more flexible and can be good in specific cases, but is not preferred because in this way no objective assessment of the energy use of the building is possible.

2.7 Conclusion:

Calculation of energy use for space heating and cooling using the hourly calculation method of ISO/DIS 13790 standard could be used to existing building only in the case the inspection of the buildings allows to gather the most important necessary data and default values are available according some observations.

The method can be used for the existing buildings but a considerable effort must be carried out to gather the data of the building. The geometrical data can always be estimated with good precise details even if drawings are not available because measurements could be done on site. It is however difficult to apprehend the characteristics of components of the building: they are often inaccessible.

The method can be especially used if the expert who inspects the building has guidance, which makes it possible to define default values according to the observations. The results might not be very precise, but will give a good idea of the energy demand. The problem arises when it is difficult to define values of calculation method inputs. We saw according to results presented above that for example the air flows of ventilation have a very strong influence on the results; this parameter is very difficult to estimate for existing buildings especially in the case of no ventilation system.

The calculation of ventilation air flow supply according prEN 15242 depends strongly on the input data: air tightness of the building envelop and air flow rate of the ventilation system. These two parameters are very difficult to estimate for existing buildings. There influence is very high on the calculation of heating energy needs.

For existing buildings, calculation of energy demand of heating or cooling in standard conditions increases the liability of the results.

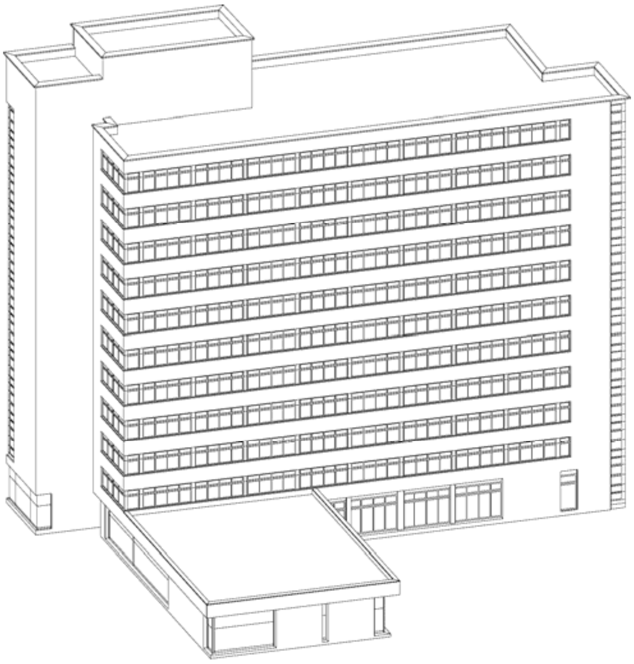
3. Energy use for lighting

EN 15193 offers a simple and a comprehensive method to calculate the lighting energy demand of non residential buildings. Aside demand calculation, metering of the lighting energy comsumption is accounted for. The simple method is described to deliver higher energy consumption demands than the comprehensive method; more detailed planning is therefore rewarded. This chapter compares the two methods. Measured values have not been taken into account, since no building with circuit separation allowing the distinct determination of lighting energy consumption was available.

As the simple method is only applicable to a building category as a whole (e.g. an office building) the comparison is performed on building level instead of room or building zone level.

Building description

The office building is comprised of a basement, a ground floor level with a lobby and a cantina and 10 floors with office spaces. The total floor area is 6270 m².



Simple method

The default values according to Annex E ,F , and G of prEN 15193 are used. For the building type “offices” the set of default values is shown in table 3_1. For the lighting design criteria class, quality level “**” according to table F.2 associated with an installed powers P_N of 20 W/m² is assumed.

The lighting energy demand according to the simple method results in a “LENI” value of 40,95 kWh/(m²a) without considering parasitic power consumption and 46,95 kWh/(m²a) considering parasitic effects. The overall demand for the whole building is 256,8 MWh/a without and 294,4 MWh/a with parasitic effects.

Parameter		**Value**
Name	**Description**	
A	Floor area of building	6270 m²
P_N	for "design criteria class **"	20 W/m²ariticial
F_C	No constant illuminance factor	1
F_O	Automatic	0,9
F_D	Automatic, i.e. daylight dependent ariticial lighting control	0,9
t_D	Operating hour at day time	2250 h
t_N	Operating hour at night time	250 h
P_{RM}	Parasitic Power, Emergency Lighting	1 kWh/(m²a)
P_{PC}	Parasitic Power, Lighting Control	5 kWh/(m²a)

Table 3-1. Input parameters to the simple method according to prEN 15193.

Comprehensive method

Application of the comprehensive method is based on a segmentation of the building into different zones with corresponding user profiles. Since prEN 15193 offers no means for determing the installed power, the determination of the installed power in the different zones has been performed with a utilization factor based method. The average installed power of the lighting system is 13,1 W/m². With a direct/indirect lighting system in mayor parts of the building (among others in all office spaces) – fulfilling EN 12464 requirements - the requirements of the lighting design criteria class "**" are generally met. Daylight is accounted for by a detailed evaluation of the different zones according to prEN 15193 Annex C. The building is located in Germany. In parts –where meaningful -automatic controls have been employed.

The lighting energy demand is 15,1 KWh/(m²a) without considering parasitic power consumption and 21,1 kWh/(m²a) considering these effects. The overall demand for the whole building is 94,7 MWh/a without and 132,3 MWh/a with parasitic effects.

Alternative method

The same example is used to perform a calculation with an alternative method: the Dutch calculation method for existing non-residential buildings. The methodology used in this method is almost the same as the methodology used in the method developed in the European project EPA-NR.

This alternative method is also a simplified method compared to the CEN method. The Dutch method uses comparable input as the simplified CEN method:

Parameter		**Value**
Name	**Description**	
A	Floor area of building	6270 m^2
P_N	Installed lighting power	20 W/m^{2}ariticial
F_O	Occupancy detection present	0,8 (default value when occ. detection is present)
$F_{D,day}$	Daylight dependent lighting control present.	0,6 (default factor to take into account daylighting control in the daylight area)
$F_{D,artificial}$	Daylight dependent lighting control present.	0,8 (idem in the artificial light area)
f_{day}	Fraction of area where daylight can be used	0,2 (default value for office buildings)
t	Total operating hour	2400 h

Table 3-2. Input parameters to the Dutch method

This method does not take into account parasitic power. Nevertheless the energy use for lighting calculated with this method is much higher than with the simplified method of CEN, namely: 29,2 kWh/m^{2}a.

Comparison of results and conclusion

The results obtained by applying the simple method are more than twice as high as the values obtained by using the comprehensive method. The main reasons for the deviation are:

- Installed power: 20 W/m^2 for a “**” rated lighting system as average for a whole building used for the simple method seems very high. The more detailed analysis in the comprehensive method provides a value of 13,1 W/m^2. In the considered building, office type spaces, which require the highest lighting levels (maintained illuminance:

500 lx), encompass less than 60% of the total floor area. Good lighting concepts (rated "**") in these spaces can in practice be realized with lower installed power densities than 20 W/m². In addition spaces like hallways require lower illuminance values (maintained illuminance: down to 100 lx) and therefore lower installed power densities. Therefore the default values for the installed power seems to be way quite high. It may be argued, that a distinction between old and new lighting systems has to made. Such a distinction should then be included in a revision of the standard, providing more realistic values for new installations.

- Daylight supply: In big parts the building has a good daylight supply. This effect is accounted for in the comprehensive method, but almost completely neglected in the simple method. The default value of $F_D = 1$ for control type "manual" and $F_D = 0,9$ for control type "automatic" indicate no or only little benefit from daylight in an office type building at all.

In addition it should be mentioned, that the simple method currently does not distinguish between different climates and sites in Europe. In general the assumptions for parasitic power seem to be quite high.

The simple method in general represents a good framework for a quick estimation procedure. Nevertheless the default values as currently contained in the draft prEN 15193 seem to be not suited to provide realistic and reliable lighting energy demands. A more detailed and refined set of default parameters might in future provide more realistic scenarios Therefore, for the moment, the comprehensive method should be applied in analyzing an optimizing lighting energy demands. Since also the comprehensive method comprises several new approaches and models testing and validation of both methods against metered consumptions is essential.

The simplified CEN method can be compared with the alternative national method which has been assessed as a comparison, as well on input complexity as on order of the results. This result suggests that despite its drawbacks the simplified CEN method can function within existing buildings.

4. Generation efficiency of boilers

4.1 Introduction

Objective

The CEN standard on generation efficiency of boiler (prEN15316-4-1:2006) describes among others a method with which it is possible for member states to develop easy tables with generation efficiencies of specific or typical boilers. The aim of the calculations performed in Enper Exist is to see if and how this method works in practise.

Approach

In this chapter the following items are discussed:

- calculation methods
- input parameters and variables of the case specific method
- validity of the case specific method
- an example of the use of the case specific method to obtain table method data

4.2 Calculation methods

The CEN standard on generation efficiency of boiler gives three methods:

- Typology method
- Case specific method
- Boiler cycling method

The *typology method* allows countries to develop tables with boiler annual efficiencies, depending on boiler type, installation design and operation, etc. An example of the British SEDBUK method is shown in annex A of prEN15316-4-1:2006.

The *case specific method* offers a boiler part load model to calculate boiler efficiency for a given set of operating conditions.

The required boiler data are full load, part load and standby performance data. For modern boilers this data is available from boiler tests according to CEN standards. For existing boilers default values are given in annex B of prEN15316-4-1:2006.

Temperature influence on efficiency is given by correction factors (default values in annex B of prEN15316-4-1:2006). Modulation influence on efficiency is not treated.

The operating conditions may be given on quite different time scales, ranging from one hour to the whole year.

The *boiler cycling method* offers a boiler part load model to calculate boiler efficiency for a given set of operating conditions.

In this memo the use of the case specific method is worked out for thermal losses and efficiency. Auxiliary power consumption is not worked out.

4.3 Inputs parameters and variables of the case specific method

Two types of inputs are required:

- Boiler input parameters, describing the boiler characteristics. Below the input parameters of the case specific method are listed with the data of a typical boiler. The marked input parameters are not in the input list in the standard but prove to be necessary.
- Operating conditions, to be used in the boiler model to determine the boiler performance. The required input variables are listed in Table 4-2. The input variables may be given on quite different time scales, ranging from one hour to the whole year. So the boiler model may be used with one operating condition representing the average annual operating condition. But it may also be fed with hourly data to calculate the boiler performance hour by hour.

Table 4-1. Input parameters of the case specific boiler model.

Input parameter	**Unit**	**Description**	***Boiler HW.B04 from BoilSim project***	
Boiler type		Condensing / non condensing (1/0)	1	
		Full load		
PPn	W	Generator output	21080	
Rgn,Pn	-	Generator efficiency	0.983	
Tgn,test,Pn	C	Average water temp at test cond.	70	
	C	Return water temp at test cond.	60	
fcor,Pn	-	Corr factor (from table)	0.002	
		Intermediate load		part load test
Ppint	W	Generator output	7010	
Rgn,Pint	-	Generator efficiency	1.092	
Tgn,test,Pint	C	Average water temp at test cond.	35	
	C	Return water temp at test cond.	30	
fcor,Pint	-	Corr factor (from table)	0.002	
		Stand-by		
Pgn,l,P0	W	Generator stand-by heat loss	203	
dTgn,test	C	Temp. difference	50	
		Aux		
Paux,gn,Pn	W	Aux. power consumption at full load	160	pump and ventilator
Paux,gn,Pint	W	Aux. power consumption at int. load		unknown
Paux,gn,P0	W	Aux. power consumption at stand-by		unknown
Tgn,min	C	Min boiler temp.	20	

Table 4-2. Input variables of the operating conditions of the case specific boiler model.

Input parameter	Unit	Description
Qg,out	MJ	Net heat output
Tgn,w,av	C	Boiler average water temp
Tgn,w,r	C	Boiler return temp
Ti,gn	C	Boiler room temp
tgn	s	total time of generator operation

4.4 Validity of the case specific method

To show validity of the method data of three boilers tested in the SAVE BoilSim projects are used. The main characteristics of the boilers are listed below. Only the heating function is considered.

Table 4-3. Boiler specs

Boiler code	3.	4.	16
Boiler Function	Heating and hot water function.	Heating and hot water function.	Heating function only
Year of construction	1999	1999	?
Boiler type	Non-condensing	Condensing	Condensing
Fan assisted boiler	Yes	Yes	-
Air supply	Closed	Closed	-
Ignition type	Pilot flame	Electric	Electric
Pilot flame net heat input [W]	99	-	-
Nominal net heat input [W]	25800	21600	26000
Nominal useful output [W]	23300	21200	25200
Burner control	modulating	modulating	Modulating
Minimum heat input [W]	11500	6700	8800
Pump power consumption [W]	113	115	100
Pump after run time [sec]	360	180	900
Fan power [W]	59	44	0
Standby losses NF	188	203	299
Full load effciency	90.3	98.3	96.5
Part load effciency	86.0	109.2	98.1

The validation procedure consisted of:

– Use measured data for the boiler parameters.
  For the intermediate load both test data at minimum load and part load may be used; the latter is in general available from boiler testing according to CEN standards.

- Calculate the resulting part load efficiency for all operating conditions with test data available:
  - Nom load at 60/80
  - Nom load at 40/60
  - Nom load at 30/50 – only available for condensing boilers
  - Min load at 60/80
  - Part load at 30%
- Compare the results with measured part load efficiencies.

The temperature correction factors stem from table values in the standard:

Boiler type	Boiler average water temperature at full load [°C]	Correction factor fcor,Pn [%/°C]	Boiler average water temperature at intermediate load [°C]	Correction factor fcor,Pint [%/°C]
Standard boiler	70	0.04	50	0.05
Gas condensing boiler	70	0.20	30 (return temp)	0.20

The results are shown in the figures below. It can be seen that:

- The results fit perfectly for he conditions used as an input parameter for the model.
- For the non-condensing boiler (3) temperature effect at nominal load is simulated well. Using part load data for the intermediate load input parameters results in an overestimation of the efficiency at minimum load with 5%.
- For the condensing boiler (4 and 16) temperature effect at nominal load is simulated with an error less than 2 %.
  Using part load data for the intermediate load input parameters results in an overestimation of the efficiency at minimum load with 5% (boiler 4) or an underestimation with 2 % (boiler 16).

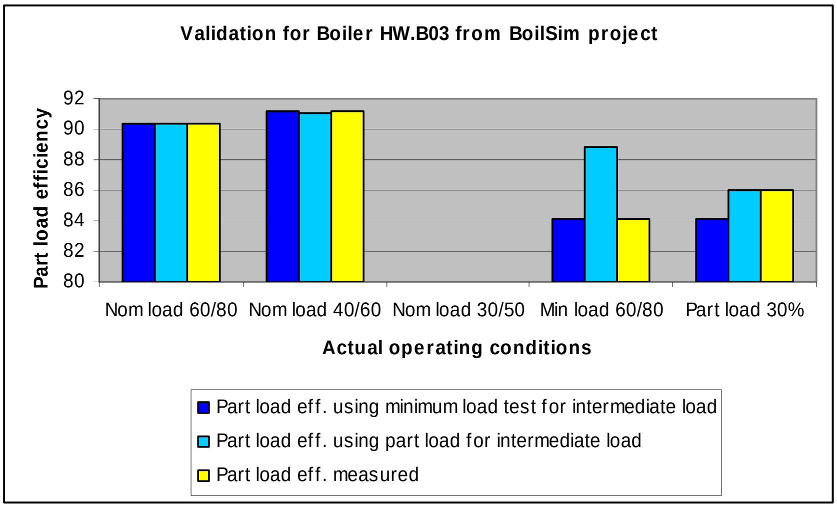


Figure 4-1: Validation of the case specific method (two types of intermediate load) with measured data.

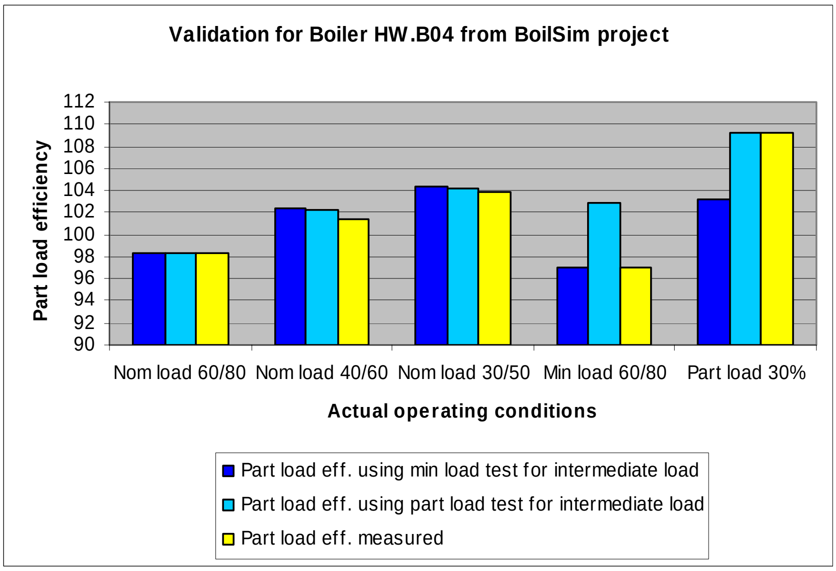


Figure 4-2: Validation of the case specific method (two types of intermediate load) with measured data.

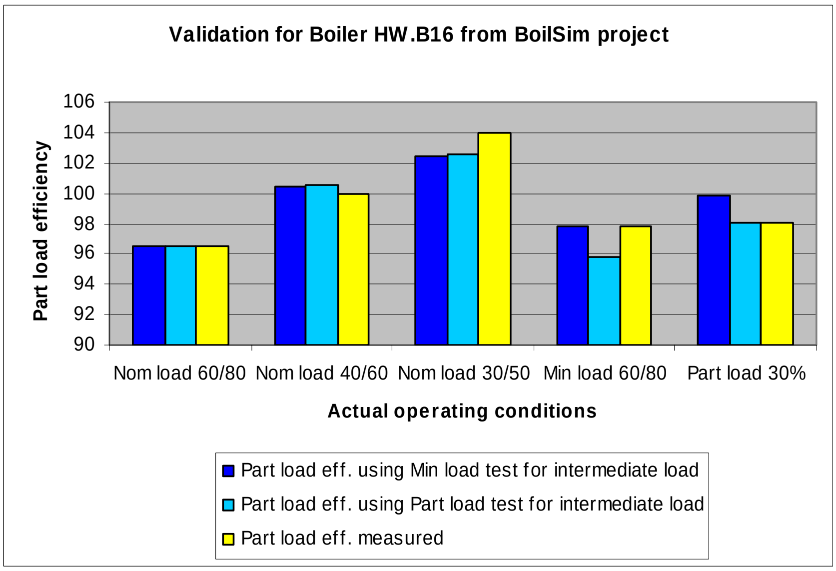


Figure 4-3: Validation of the case specific method (two types of intermediate load) with measured data.

The conclusions are:

- Thermal effect on efficiency is covered quite well using the correction factors, except for the low temperature (30/50) situation of boiler nr. 16..
- Modulating effect on efficiency is not simulated with great accuracy. This is not unexpected since the structure of the model does not deal with this effect.

For more accurate results a more detailed model is required but this requires also test data at minimum load that are not general available.

4.5 The use of the case specific method to obtain table method data

In general table methods are used to give annual efficiency values for specific boiler types, depending on installation specifications like system design temperatures, control type and boiler room temperature. One aspect to be dealt with is the sensitivity of annual efficiency for differences in these installation specifications. If these aspects don't influence annual efficiency in a meaningful way it makes table methods easy to use, since no distinction needs to be made for these aspects.

Calculation methods, like the case specific method, can be used to determine table values using data of (typical) boilers. Here an example is given of a way to obtain this type of data using the case specific method in a simple way.

For three typical boilers annual efficiency is calculated for different installation design specifications. Installation design is here characterized with "annual average" operating condition. The standard gives the rules and additional data to do this.

The only problem is the determination of the correction factor for heating curve controlled systems. The standard is not clear on that issue, so here two guessed values, 0.7 and 0.8, are used to determine sensitivity for it. An overview of the installation design input variables (marked yellow) and other variables used in the calculation of the required boiler water temperatures is given below.

Table 4-4. Installation design input variables in annual efficiency calculation

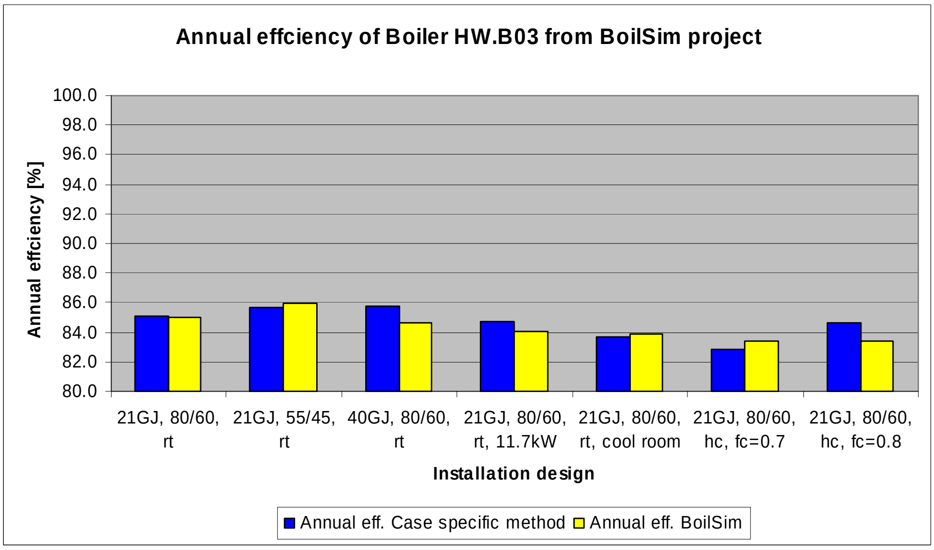
		21GJ, 80/60, rt	**21GJ, 55/45, rt**	**40GJ, 80/60, rt**	**21GJ, 80/60, rt, cool room**	**21GJ, 80/60, hc, fc=0.7**	**40GJ, 80/60, hc, fc=0.7**
Net heat output	MJ	21611	21611	40000	21611	21611	40000
Boiler room temp	°C	15	15	15	10	15	15
Control type: room therm (0) / heating curve (1)		0	0	0	0	1	1
Nom. temp diff emitter return-flow	°C	20	10	20	20	20	20
Average power of emitter	kW	0.685	0.685	1.268	0.685	0.685	1.268
For room thermostat (rt)							
Internal temperature of heated space	°C	20	20	20	20		
Nom emitter power	kW	15.300	15.300	15.300	15.300		
Nom. temp diff emitter - air	°C	50	30	50	50		
Emitter exponent (from table)	-	1.3	1.3	1.3	1.3		
For heating curve (hc)							
Sizing temp (avg nom temp)	C					70	70
Correction factor (0<=fc<=1)	-					0.7	0.7

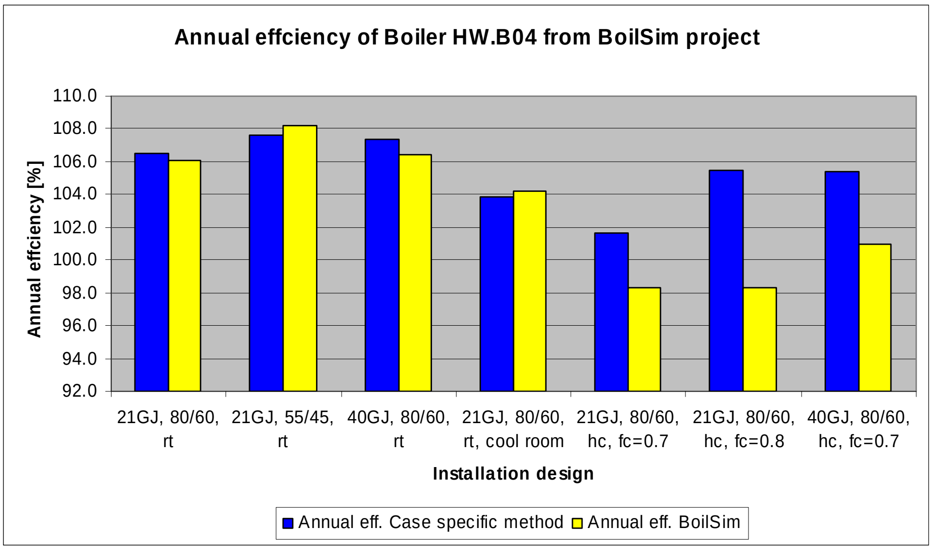
Resulting temperatures							
Boiler average water temp	°C	19.6	17.8	22.4	19.6	31.5	31.5
Boiler return temp	°C	18.7	17.3	20.7	18.7	30.8	30.3

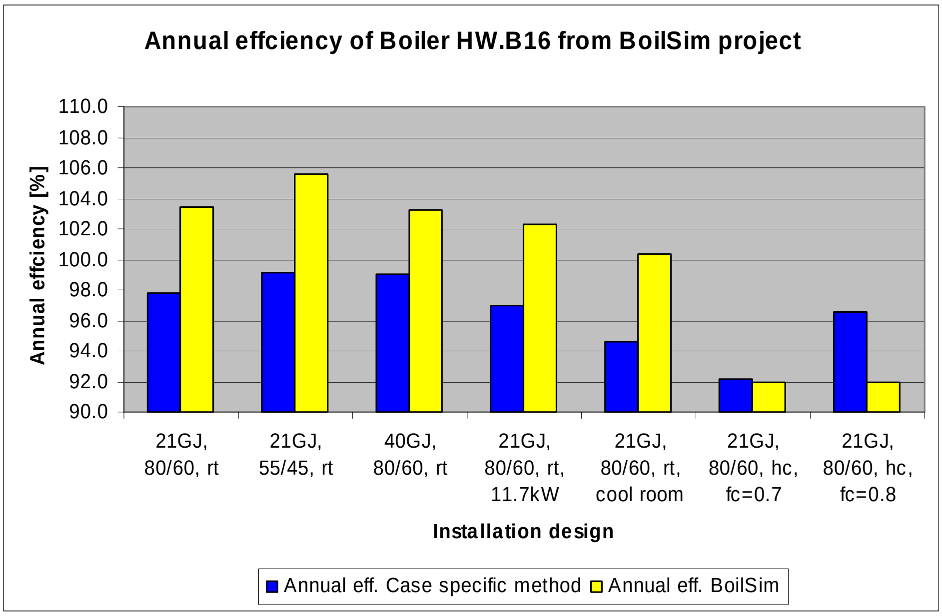
The results are given below in figures, showing also the efficiencies calculated with the BoilSim program using a monthly degree-day approach. Comparison with BoilSim results shows for *room thermostat* controlled systems:

- For the non-condensing boiler (3) efficiencies are within a range of 2%.
- For the condensing boiler 4 efficiencies of the case specific method are within a range of 1%.
- For the condensing boiler 16 efficiencies of the case specific method are 4-6% lower than with the BoilSim method.
- The Case specific method has the same sensitivity for boiler room temperature as the BoilSim model.
- The BoilSim results show more sensitivity for the design temperature than the Case specific method results.

For *heating curve* controlled systems the value of the correction factor fc and the heat demand have a large influence (>4% for condensing boilers when changing fc from 0.7 to 0.8) on annual efficiency. So the fc factor needs full attention; not only to create table values but also in case the case specific method is used directly.







Using only the results of the case specific method (Table 4-5) we find:

- Small effect of the installation specs heat demand, design temperature and design power on the annual efficiency using a room thermostat. So if we create a table for room thermostat controlled boilers, no distinction for these aspects is required.
  Even for condensing boilers design temperature seems to have little impact on annual efficiency. Please note that previous studies in the Netherlands using the BoilSim model show a subtle larger influence of design temperatures on annual efficiency than the less detailed case specific method.
- Significant effect of the boiler room temperature (from 15 to 10°C) on the annual efficiency (1.4 – 3.2%) using a room thermostat. So if we create a table for room thermostat controlled boilers, distinction for boiler room temperature (heated – unheated) is possible.
- Average efficiencies using a room thermostat is within a 1 – 2.5% range of the part load efficiency (for heated boiler room at average 15°C). So if we create a table for room

thermostat controlled boilers, a link between part load efficiency and annual efficiency seems is obvious.

- For heating curve controlled systems the value of the correction factor fc and the heat demand have a large influence (>4% for condensing boilers) on annual efficiency. So the fc factor needs full attention; not only to create table values but also in case the case specific method is used directly.

Table 4-5. Results of annual efficiency calcultion using the case specific method for diferent installation specs.

				Boiler code.	**3**	**4**	**16**
				Full load efficiency	90.3	98.3	96.5
				Part load efficiency	86	109.2	98.1
Installation specs							
Heat demand [GJ]	Design temperature	Design power [kW]	Control type	Temp. boiler room			
21	80/60	15,3	rt	15	85.1	106.5	97.8
21	55/45	15,3	rt	15	85.7	107.6	99.2
40	80/60	15,3	rt	15	85.8	107.4	99.0
21	80/60	11,7	rt	15	84.8		97.0
Average annual efficiency with room thermostat control in heated boiler room of 15 ℃					*85.4*	*107.2*	*98.3*
21	80/60	15,3	rt	10	83.7	103.9	94.6
21	80/60	15,3	hc, fc=0.7	15	82.8	101.6	92.2
21	80/60	15,3	hc, fc=0.8	15	84.6	105.5	96.6
40	80/60	15,3	hc, fc=0.7	15		105.4	

Note: rt = room thermostat; hc = heating curve; fc = correction factor (in heating curve calculation)

4.6 Conclusions

- This study shows that it is possible to use the case specific method to develop a table method for various boiler types.
- The case specific method is easy to use for room thermostat controlled systems. First results suggest that,
  - Annual efficiency is equal to the part load efficiency when the boiler room is heated (15°C average).
  - Annual efficiency is significant (2.5%) lower when the boiler room is not heated (10°C average).
  - Annual efficiency is not significant higher for low temperature systems – however
- The case specific method requires additional information / calculation on the proper operating conditions / correction factor before the method can be used for heating curve controlled systems.
- The validity of the Case specific method is not tested extensive for this document. The first conclusions of some test are:
  - Water temperature effect on efficiency is covered quite well using the correction factors, except for the low temperature (30/50) situation of boiler nr. 16. This is also

    seen more extreme for annual efficiencies where BoilSim results for boiler 16 are 5% higher than Case specific results

  - Modulating effect on efficiency is not simulated with great accuracy. This is not unexpected since the structure of the model does not deal with this effect.

As an example of how this method can work, Annex B gives the result of the Dutch method to derive gross seasonal boiler efficiency. These results are obtained using the BoilSim program and are used in the Dutch method for existing and new buildings. The type of results of this alternative method are in line with what can be expected from the CEN method described above. This supports the usability of the CEN typology method.

5. Conclusions

By performing detailed calculations we have put a selection of CEN standards to the ultimate test of the usability of the standards in practice. We have tested the following methods:

- Hourly heating and cooling need
- Ventilation flow
- Energy use for lighting (detailed method)
- Generation efficiency of boilers

The main conclusions are:

Hourly heating and cooling need

Calculation of energy use for space heating and cooling using the hourly calculation method of ISO/DIS 13790 standard could be used to existing building only in the case the inspection of the buildings allows to gather the most important necessary data or default values are available.

More guidance to define default values according to the observations will make the method more useful. When using defaults, the results might not be very precise, but will give a good idea of the energy demand. The problem arises when it is difficult to define values for calculation method inputs. We saw according to results presented in this report that for example the air flows of ventilation have a very strong influence on the results; this parameter is very difficult to estimate for existing buildings especially in the case of no ventilation system. A fixed default might be a solution here.

Ventilation flow

The calculation of ventilation air flow supply according prEN 15242 depends strongly on the input data: air tightness of the building envelop and air flow rate of the ventilation system. These two parameters are very difficult to estimate for existing buildings. There influence is very high on the calculation of heating energy needs.

So for existing buildings the liability of the EP calculation increases when standard conditions for the ventilation flow are used, in stead of using the calculation of ventilation air flow supply according prEN 15242.

Energy use for lighting

The study shows for an office type building more than 100 % higher lighting energy demands for the provided simple method compared to the comprehensive method. The big differences can be mainly attributed to conservative default values for the installed power density of the artifial lighting system and to an underestimation of daylighting benefits.

The simple method in general represents a good framework for a quick estimation procedure. Nevertheless the default values as currently contained in the draft prEN 15193 seem to be not suited to provide realistic and reliable lighting energy demands. A more detailed and refined set of default parameters might in future provide more realistic scenarios Therefore, for the moment, the comprehensive method should be applied in analyzing an optimizing lighting energy demands. Since also the comprehensive method comprises several new approaches testing and validation of both methods against metered consumptions is essential.

Comparison with a national approach shows that the simplified CEN method is functional in existing buildings.

Generation efficiency of boilers

This study shows that it is possible to use the case specific method to develop a table method for the efficiency of boilers for existing buildings. An aspect which is especially important for existing buildings, namely the distinction between a boiler in a heated or unheated room, can be made with this method.
The method is suitable for room thermostat controlled systems. For heating curve controlled systems an additional study on the proper operating conditions/ correction factor is required. Such a study can be performed on national level.

Annex A: XXX

Annex B: Boiler efficiency - Example of Dutch table method

The Dutch table method for gas or oil fired water heaters is given below.

Boiler type	**Gross seasonal boiler efficiency ($\eta_{b;i}$)**	
Oil fired boiler for a single dwelling, *within* the heated space or Oil fired boiler for a non residential building with a “user surface” <= 500 m^2, *within* the heated space. Efficiency excl. pilot flame.	75 %	
Oil fired boiler for a single dwelling *outside* the heated space or Oil fired boiler boiler in a collective heating installation for more dwellings or Oil fired boiler for a non residential building with a “user surface” > 500 m^2 or with the boiler *outside* the heated space. All efficiencies excl. pilot flame.	70 %	
	$\theta_{flow,design}$ <= 55°C	**$\theta_{flow,design}$ > 55°C**
Gas fired boiler for a single dwelling, *within* the heated space or Gas fired boiler for a non residential building with a “user surface” <= 500 m^2, *within* the heated space. All efficiencies excl. pilot flame.		
– no test data	75 %	75 %
– full load net efficiency >= 88.5 %	80 %	80 %
– part load net efficiency >= 100 %	92.5 %	90 %
– part load net efficiency >= 104 %	95 %	92.5 %
– part load net efficiency >= 107 %	97.5 %	95 %
Gas fired boiler for a single dwelling *outside* the heated space or Gas fired boiler boiler in a collective heating installation for more dwellings or Gas fired boiler for a non residential building with a “user surface” > 500 m^2 or with the boiler *outside* the heated space. All efficiencies excl. pilot flame.		
– no test data	70 %	70 %
– full load net efficiency >= 88.5 %	75 %	75 %
– part load net efficiency >= 100 %	87.5 %	85 %
– part load net efficiency >= 104 %	90 %	87.5 %
– part load net efficiency >= 107 %	92.5 %	90 %