EPBD and Ventilation Requirements: Uneven Inputs and Results in European Countries

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ABSTRACT

Since the 2002/91/CE EPBD was published, all European countries should making efforts in harmonizing local standards, imposing the assessment of building energy and environmental impact through a common certification procedure. Generally speaking, as a matter of fact, beside the main problem of different methods and tools adopted for evaluating the building energy balance, ventilation is still one of the controversial issues, since each country refers to different local requirements regarding the air-change rate values to be used when performing the calculation.
In the framework of a wider research carried out in Politecnico di Milano regarding certification procedures used in several European countries, the same case-study building has been analyzed by adopting the different calculation methods and verifying the differences among the provided input data. The role of ventilation in the energy balance has been also tested and reported in this paper.

KEYWORDS

EPBD, Building energy simulation, Air change rate among EU.

INTRODUCTION

The European Directive on the Energy Performance of Buildings (EPBD) was published in the framework of a common European approach regarding energy savings in buildings. The Directive proposes different objectives including the provision of a common European procedure for the building energy performance calculation.
The common procedure has not been arranged yet, but the European method for evaluating building energy performance proposed by CEN in the EN ISO 13790 standard is implemented in most countries. Based on this standard, there are three different approaches to calculate the energy demand for heating and cooling: a simplified seasonal or monthly method, a simplified hourly method and a dynamic simulation method. At national level, the countries have implemented specific certification procedures, choosing if applying the EN ISO 13790 (and in what extent) or other calculation methods, and have setting local references to be considered for assessing the building energy performance input parameters.
The variety in the adopted methods and in the building parameters implies non-homogeneous results concerning the assessment of the building energy performance.

VENTILATION IN BUILDING ENERGY PERFORMANCE

The heat exchanges due to ventilation are central in both the heating and cooling demand calculation, and consist in a combination of air flows due to air infiltration, natural ventilation through window operation and/or mechanical ventilation. The air change rate due to infiltration depends on the air tightness of the building, which can be calculated in detail on the base of measurements or, usually, selected among local standard values.

According to the EN ISO 13790 simplified methods the ventilation heat transfer coefficient is based on the time-average airflow rate, expressed in m^3/s, which is calculated according to Eqn. 1.

$$q_{ve,mn} = f_{ve,t} \cdot q_{ve} \tag{1}$$

Where:

q_{ve}	air flow rate, determined in accordance to local standards
$f_{ve,t}$	time fraction of operation, calculated as fraction of the hours per day

The EN ISO 13790 standard includes also a calculation procedure to take into account the cooling effect of extra flow rate and night-time ventilation, expressed by Eqn.2.

$$q_{ve,extra,mn} = c_{ve,eff,extra} \cdot f_{ve,t,extra} \cdot q_{ve,extra} \tag{2}$$

Where:

$c_{ve,eff,extra}$	adjustment factor for dynamic (inertia) effects and effectiveness (=1 if not otherwise specified)
$f_{ve,t,extra}$	time fraction of operation for the free or night-time ventilation per day
$q_{ve,extra}$	extra air flow rate due to free or night-time ventilation, m^3/s

Considering the monthly/seasonal method, the effect of the lower temperature during night-time, which is relevant in case of nocturnal free-cooling, may be taken into account by an appropriate correction value for the time-average airflow rate.
At national level, several countries have developed local procedures and reference values regarding the ventilation input data, that consistently influence the heat balance results. Some example are described in the following.

Austria

The calculation of the energy demand for the Austrian buildings follows the OIB (Austrian Institute of Construction Engineering) guideline, based on the monthly heat balance of the building method proposed by EN ISO 13790. The contribution of the ventilation is calculated according to standard air-change rates, listed by building type within the local norms. These rates are applied accordingly to predefined occupancy schedules. The possibility of implementing a night ventilation strategy is considered and applied with a $c_{ve,eff,extra}$ value of 1,0.

France

The French authorities propose the following options to be adopted for the calculation of the energy demand in buildings: a seasonal simplified method (3CL-DPE) in case of residential buildings and two hourly dynamic methods based on the EN ISO 13790, one for new buildings (Comfie-DPE) and one for existing buildings (DEL6-DPE). Regarding heat exchanges due to ventilation, in case of natural ventilation the amount of air-change rate has to be chosen among standard values which are listed in the reference regulation and basing on the building air-tightness. In case of mechanical ventilation, the different calculation methods adopt different assumptions: in the simplified seasonal method the air-change rate values are listed in the regulation depending on the ventilation system type, while in the hourly dynamic methods the heat exchanges are calculated basing on a detailed description of the ventilation systems.

Germany

The German norm DIN V 18599 defines the building heat balance needed for the assessment of energy demand, based on the monthly calculation method suggested by EN ISO 13790.
The heat exchanges due to ventilation are calculated as a function of standard air-change rates and proper occupancy schedules, which are listed by building type within the norm.

Italy

UNI TS 11300 norm states the procedure to be used in Italy for the determination of the energy demand in buildings, which is based on monthly calculation of the building heat balance as suggested by EN ISO 13790.
Regarding ventilation, the procedure allows users to perform a standard assessment, which applies reference air-change rate values, calculated for building type and occupation rate according to local standards, or to perform a detailed assessment in case of particular purposes. It is also possible to consider the free cooling effect of night-ventilation strategies, according to EN ISO 13790.

Portugal

Building energy certification in Portugal follows the suggestions of two different regulations, depending on the building type.
The RCCTE regulation refers only to residential and small tertiary buildings and proposes a simplified seasonal calculation based on EN ISO 13790, where the air-change rate has to be chosen from a list of standard values according to building typology, wind exposure and air-tightness. The RSECE regulation refers to a hourly dynamic heat balance to be performed by the means of a simulation tool, compliant with ANSI/ASHRAE Standard 140, and provides minimum air-change values per occupant and occupancy schedules related to the building type.

Spain

The Spanish regulation states that energy certification has to be performed by the means of hourly dynamic simulation software. The authorities have released two official calculation tools: Calener VYP is the one for residential and small tertiary buildings, which calculates the heat balance through the LIDER simulation code, while Calener GT, based on DOE-2 simulation code, is the one for large tertiary buildings. Regarding ventilation air flow, they are assessed according to the minimum fresh air requirements and related occupancy schedules defined by Spanish standards, which also prescribe free cooling through night ventilation when analysing residential buildings. Even if standard occupancy schedules are defined, the Calener GT software allows users to change settings, in order to properly represent different building typologies.

CASE STUDY

In the frame of a research carried out in Politecnico di Milano, the above mentioned national procedures have been collected and adopted for assessing the energy performance of a case-study building, in order to appreciate the effect of the different parametrical data assumptions provided by each method.

The case-study is a 6 storey building (5 levels occupied by open-space offices and an unconditioned ground floor with parking) located in Milan. The ventilation strategy considered is the natural one, performed through windows operation.
According to the different national regulations, the amount of the air-change rate have been assigned to the building and the resulting average daily values are shown in Table 1.

TABLE 1: Daily average air-change rate (h^{-1}) for the case-study building according to the national regulations.

Austria	France	Germany	Italy	Portugal	Spain
heating:0.60 cooling:1.10	0.88	1.15	1.06	0.30	0.61

In order to appreciate how much the different values of air-change rate adopted by the collected procedures can affect the building energy balance, the lowest (0.30 vol/h, Portugal) and the highest (1.15 vol/h, Germany) have been used within the same calculation procedures without changing any other input data, and the resulting heating and cooling demands have been compared.
The calculation has been performed through both a simplified monthly heat balance (according to the Italian standard) and a hourly dynamic simulation (according to Portuguese regulation, in this case by using EnergyPlus software).
As a further analysis, the implementation of a free cooling strategy through night ventilation has been considered in both the lowest and the highest reference values. Following the Spanish regulation for residential building, as an example, additional 4 vol/h have been set during 7 hours in the night-time: the resulting average daily air-change rate values are 1.47 vol/h in the minimum case and 2.32 vol/h in the maximum case[1].

RESULTS

The graph reported below shows the annual heating and cooling demand assessed by applying the two selected calculation method, assuming the minimum and the maximum air-change rate values for comparison.

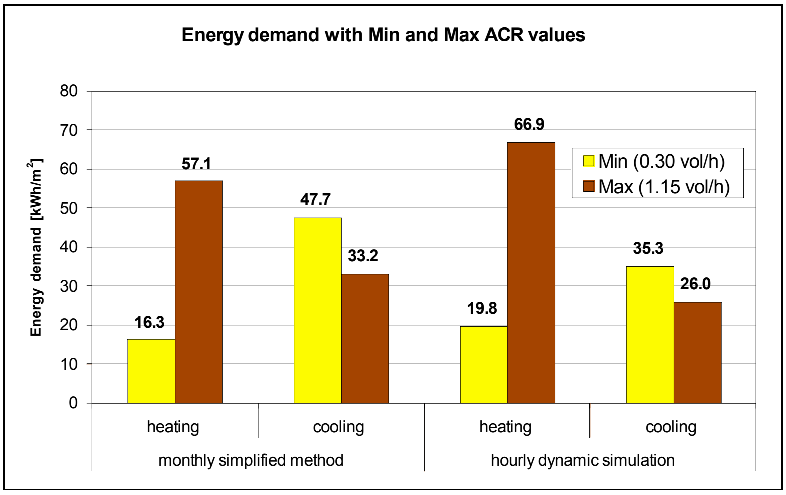

Figure 1: Thermal energy demand due to different air-change rates assessed by simplified and dynamic calculation methods.

[1] It has to be noted that when performing the simplified monthly calculation, since the reference outdoor temperature is still the mean monthly one, the additional ventilation does not take full advantage of the free-cooling strategy, while with the hourly dynamic simulation the extra ventilation takes into account the lower air temperature during night-time, thanks to the hourly weather data.

For both the considered evaluation methods, the differences between the adoption of the minimum and the maximum air-change rate values are significant: respect the case of 0.3 vol/h, by adopting 1.15 vol/h the amount of the energy demand increases more than three time for heating and decreases of about 26% and 30%, (dynamic and simplified methods respectively) for cooling.
Moreover, as the next graph highlights in details, considering the implementation of the night cooling strategy a range of 30-45% of cooling energy demand reduction is assessed.

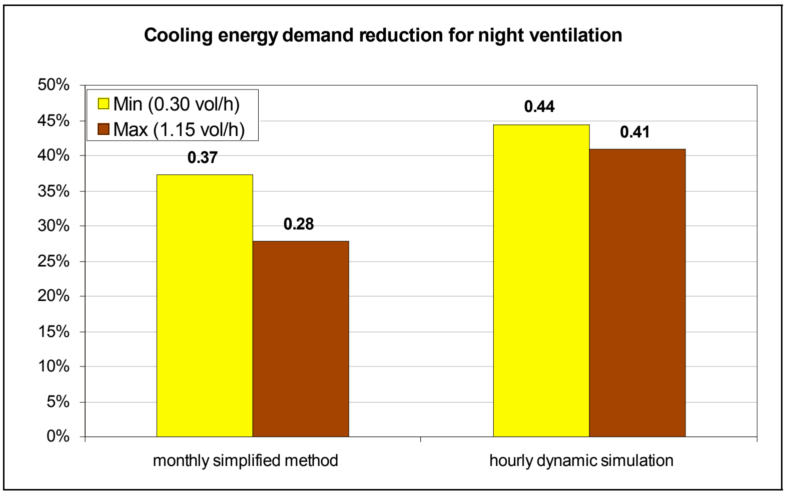

Figure 2: Cooling demand reduction with night ventilation strategy implementation.

CONCLUSIONS

The different procedures adopted among the EU counties for evaluating the buildings energy performances are obviously responsible of uneven results on thermal energy balance. Moreover, as shown in the present study, the uneven inputs regarding ventilation reflect on very different assessment of energy demand. In summer season the night ventilation strategy could implies a large amount of energy saving, that should be considered during the energy assessment of the building for its certification.
An harmonisation of the European procedures (and standards, rules, etc.) for the building energy certification should be suitable, in order to make more comparable the performance assessed for the energy certification of the buildings among European countries.

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