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## Advanced Use of EPBD based Standards

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### 1. ABSTRACT

The set of European standards on EPBD is a wealth of computational procedures and methods for assessment of the indoor environment quality and energy performance of buildings. Not only in assessing the energy performance of buildings, usually resulting from the law, but also in construction practice, only simplified methods are used, although the European standards provide comprehensive numerical procedures based on transient heat transfer. The problem of these comprehensive numerical procedures is their time and training intensity. This can be addressed through so-called generic models controlled via user-friendly interface. The generic models are computer models developed using complex software that allow for selected free design parameters, whereas the parameters related to the in-depth-knowledge are pre-defined. This contribution describes a generic model for assessment of the energy efficiency and indoor comfort of detached low-energy houses and discusses the future use of similar, perhaps less complex models of partial problems in architectural education and energy certification of buildings as well.

### 2. INTRODUCTION

It is obvious that each building physical problem can be treated with several levels of accuracy, e.g. one-dimensional steady-state/transient simplified/detailed approach (manual or computer aided calculation) or two/three dimensional steady-state/transient simplified/detailed approach (manual or computer-aided calculation). Provided the building physical models are correct, the computer-aided simulation delivers far more precise results than simplified calculation methods. This can be advantageous not only in the advanced design phase, when searching for detailed solutions, but also during the initial design phase, when crucial constructional and technological decisions are made. Though the advantages are obvious, architects and very often other building professionals do not make use of them. The obstacles, which keep them from using computer simulation methods on a larger scale, usually are:

- The complexity of quality software, e.g. for dynamic computer simulations, which requires advanced computer skills and good knowledge of building physics.
- The amount of time needed to create building physically correct simulation models.
- Over-standardization in terms of too many different standards related to specific building physical problems.

The distance between architects and the software can be decreased by developing generic models that allow for selected free design parameters, where those parameters requiring in-depth-knowledge are pre-defined. Then, non-experienced users would be able to perform accurate building performance simulations, as the generic models are based on existing, scientifically proven software. Another important benefit of the generic models is that they help to improve the thermal knowledge and experience of the user. This paper describes a Capsol-based generic model for assessing the future energy efficiency and indoor comfort of detached, low-energy houses. It treats the ground floor and the attic as two separate thermal zones, in order to take into account the difference in heat accumulation between the more (ground floor) and less (attic) heavy construction of their envelopes.

### 3. GENERIC MODEL

The principle of the generic model is based on the fact that Capsol input and output files are stored as text files and can be manipulated by external programs, such as Visual Basic for Applications (VBA) available in Excel. Hence the Capsol model can be “overloaded” with modeled wall types, heating and cooling systems and climate data. Not all of them must necessarily be used. The selection can be made via a tailor-made building-type specific interface (Fig. 1), which is in this case programmed in Excel using VBA. The user can

either define (green fields, e.g. areas, orientations or roof slopes) or choose (yellow fields) some design parameters (Figs. 2 and 3). The pre-defined parameters requiring an in-depth-knowledge are:

- Building type, which can be either brick-based or lightweight construction. The building type is already defined by selection of the initial Capsol file, but can be changed at this point. The possible change affects the thermal insulation thickness of the building walls as the brickwork wall composition is of a different thickness compared with the lightweight one.
- Climate data (in principle calculations can be made for any climate data, provided they are organized in the form required). The version currently available contains climate data of three cities - Bratislava, Brussels and Stuttgart, which can be edited, should particular calculations be required.

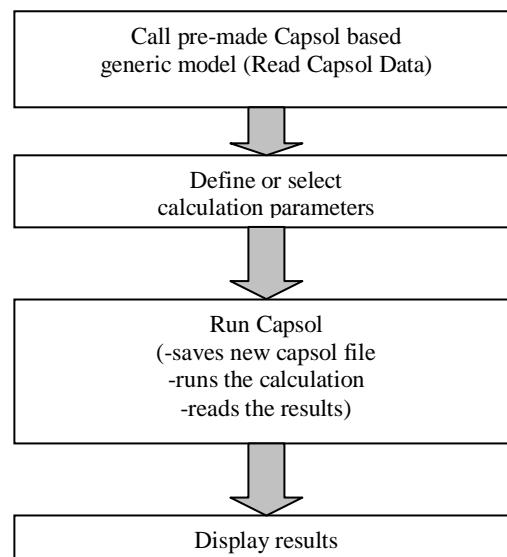


Fig. 1 Simplified scheme of the Excel VBA based interface

- Thermal insulation thickness, where the selection can be made from among 100, 150, 200, 250 and 300 mm in case of brick-based, and 140, 190, 240, 280 and 330 mm in case of lightweight, construction. The thermal insulation is part of the predefined wall compositions. The same applies to the roof construction, the thermal insulation of which is, in both cases, 220, 250, 275, 275 and 300 mm and automatically changes with the selection of the wall insulation thickness, so that if the wall insulation is 150 mm in the case of brickwork or 190 mm in the case of lightweight construction, the roof insulation is 250 mm (Table 1).

BRICKWORK CONSTRUCTION					
<b>Base plate</b>	0.020	0.020	0.020	0.020	0.020
<b>Walls</b>	0.100	0.150	0.200	0.250	0.300
<b>Roof</b>	0.220	0.250	0.275	0.275	0.300
LIGHTWEIGHT CONSTRUCTION					
<b>Base plate</b>	0.020	0.020	0.020	0.020	0.020
<b>Walls</b>	0.140	0.190	0.240	0.280	0.330
<b>Roof</b>	0.220	0.250	0.275	0.275	0.300

Table 1 Thermal insulation thickness [m] of the main parts of building envelope

- Quality of windows (glazing having the U-Value of 1.09 or 0.8 W/(m<sup>2</sup>K)).
- Heating system operation defined as air heating with or without heat exchanger. If the heat exchanger is applicable, the system is considered to be intermediate, having different target comfort temperatures for daytime and night. The heating system without heat exchanger can be either intermediate or without difference between the day and night target temperatures. Either way the required target temperatures (either a single value, if there is no difference between day and night, or values for daytime and night in case of intermediate heating) and the available heating power must be inserted. The expected necessary heating

power can be assessed based on the steady-state calculation of the transmission and ventilation heat losses. At this point it is important to note that the overall heating demand (apart from heat gains) does not depend on the differences between exterior and required interior comfort temperature and related heat loss only, but also on the available power and the time response of the heating system. The time response is the time necessary to reach the target indoor temperature plus upwards sensitivity after the indoor temperature's drop to the sensor's lower limit. The time response depends mainly on the accumulation properties of the surrounding building envelope. This fact is not considered in the course of the usual steady state or quasi-steady state calculations and hence very often not realized. In fact, it makes one of the major differences between them and the dynamic calculation methods.

1. Read CAPSOL initial data and enter a new data name <i>Click the Read Capsol Data button to read initial data.</i> <i>If you are starting from scratch, select Fin_B.cap for brick-based or Fin_LT.cap for lightweight construction type!</i>	
	<b>Read Capsol Data</b>
Capsol data file read:	Fin_B
Enter a new Capsol data file name:	Fin_B_temp
2. Select the building type	
	Brick-based
3. Define climate	
	<b>Select Climate Data</b>
Selected climate station	BRT
To view or edit the climate data: select the climate file type	Temperature
	.FTE
click the "Edit Climate Data?" Button to view or edit	<b>Edit Climate Data?</b>
4. Define building envelope areas and building volumes	
Volume - Ground floor (using outer dimensions) [m3]	194.00
Volume - Attic (using outer dimensions) [m3]	212.00
Facade 1 total area [m2] (Ground floor)	17.40
Facade 2 total area [m2] (Ground floor)	11.10

Fig. 2 Excel VBA based interface of the generic model for the assessment of the heating and cooling energy demand of detached houses

- Cooling systems operation offering three options - an air conditioning, natural ventilation and an outer movable shading of windows. Each option can be used separately or in any combination with another two. The principle behind the air conditioning is basically the same as the one behind intermediate heating. Natural ventilation, if applicable, means simply opening the windows, and is switched on and off at the inserted target comfort temperature (the natural ventilation should not be confused with the so called "hygienic" ventilation to outdoors, which is active the whole year round and set to 0.5 of total interior volume per hour whereas 30 per cent of the ground floor volume is ventilated via the attic (both floors are connected through the staircase)). The movable outer shading applies to all windows of the given facade, gable or roof and, if selected, is switched on and off at the solar radiation intensity of 200 W/m<sup>2</sup>.

- Sun obstacles in the surroundings defined as plane area, hilly country and forest / city, which correspond to maximum altitudes of 5°, 20° and 40° respectively of the foreseen obstacles.

After the definition and selection of the parameters has been completed, the Capsol software is started using the button "Run Capsol" (Fig. 3). This command initiates the creation of a new Capsol file based on a generic model with user-defined and selected data, the actual calculation in Capsol and the import of required results back to Excel. As the purpose of this generic model is to investigate the heating and cooling energy demand and indoor thermal comfort, a special final table and two buttons displaying either energy demand or thermal comfort chart have been arranged (Figs. 3, 4 and 5). In reality the interface Excel file for defining and selecting the user data for later calculation with Capsol contains three basic worksheets – "Input", "Data" and "Output1". The worksheet "Input" is the one, through which the definition and selection of appropriate user data occurs, and is shown in the Figs. 2 and 3. The data from the basic generic model prepared in Capsol are read into the worksheet "Data" by clicking on the button "Read Capsol Data" (Fig. 2). Any alteration to the "Input" worksheet is automatically transferred into the worksheet "Data" when initiating the Capsol calculation (button "Run Capsol"). Then, the new data are transferred into Capsol and saved as a new Capsol

file using a special VBA code (macro) developed by Physibel. The Capsol calculation is performed and the results are exported back to the interface Excel file, into the worksheet “Output1”. This happens thanks to a unique VBA code (macro) developed by Physibel as well. The results placed in the “Output1” worksheet are processed by some macros and displayed as charts and a table at the end of the “Input” worksheet (Figs. 3, 4 and 5).

12. Define the sun obstacles in the surroundings:	Plane area
13. Run CAPSOL	
Capsol run mode: wait at the end to see graphics? If yes, you have to save the graphics manually! Click the RunCapsol button	no
	RunCapsol
14. Main simulation results for following mean U-value:	
Yearly heating demand [kWh]- Ground floor	
Yearly heating demand [kWh]- Attic	
Yearly cooling demand [kWh]- Ground floor	
Yearly cooling demand [kWh]- Attic	
Nos. of hours with indoor T > 25°C [h]- Ground floor	
Nos. of hours with indoor T > 25°C [h]- Attic	
Maximum indoor temperature [°C]- Ground floor	
Maximum indoor temperature [°C]- Attic	
15. Open the graphics in the pop-window:	
Show heating and cooling energy demand:	Energy demand
Show indoor comfort: (max. Ti, number of hours with Ti > 25°C):	Indoor comfort

Fig. 3 Excel VBA based interface of the generic model for the assessment of the heating and cooling energy demand of detached houses – final table with selected result types and two buttons displaying either energy demand or thermal comfort chart

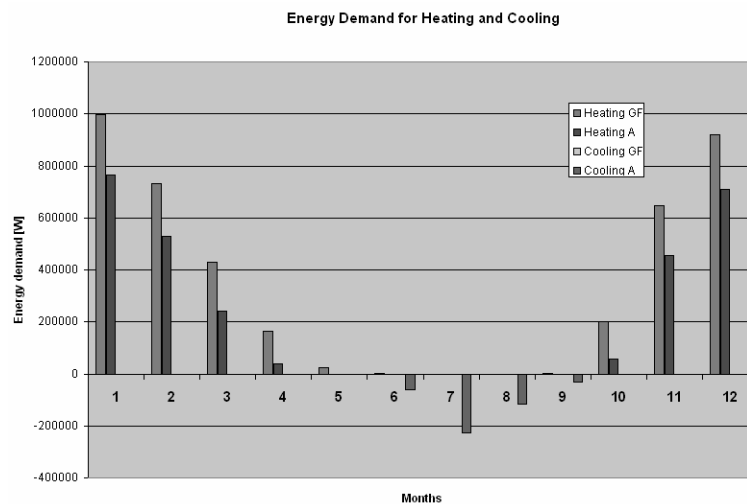


Fig. 4 Chart showing energy demand for heating and cooling

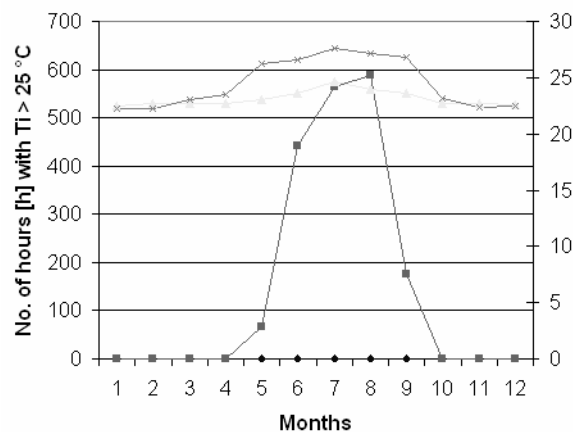


Fig. 5 Chart showing the indoor comfort in terms of number of hours with interior temperature higher than 25°C.

The basic generic model developed in Capsol can also be used separately from the Excel interface. Advanced Capsol users can use it as a base for creating their own modified models, as it contains prepared schemes of the heating and cooling operation. For such cases, the Excel interface is useless. While its purpose is to facilitate working with Capsol, it must not necessarily be used. The techniques used for modeling the single operations of heating and cooling systems are described in detail in the Capsol Manual and the Physibel Pilot Book (simulation of sunscreens).

#### 4. CONCLUSION

The idea of the generic models originates from Prof. Dr. Piet Standaert from the company Physibel, and the one described here, was developed in cooperation with this company. Both the generic model and the related Excel-based interface can be downloaded from the website [www.cab.sk](http://www.cab.sk).

In fact the generic models represent a way to overcome the obstacles which keep architects and designers from using computer simulation methods. By developing sets of ready-made simulation models (generic models) based on the existing accurate standardized calculation methods could be provided an easy access to these calculation methods. On the one hand, the existing standards provide sophisticated computational methods, on the other hand, often overlap and are not mutually coherent. Hence, when dealing with one building physical problem, several standards have to be consulted. These standards either represent different levels of accuracy on their own or contain optional calculation methods at different levels of accuracy. From time to time they also differ in certain terms or symbols. To bring some clarity to the current situation, CEN seeks to examine or revise existing standards. The objective is to create a new generation of standards, which should be much clearer, with a uniform methodology for Member States and in particular they should motivate their use and proper designing. Part of the standards should be transparent calculation methods in electronic form, for example programmed in MS Excel. Hence, the ready-made simulation models (generic models) could cover, for example, typical building physical problems occurring in today's design practice. Several simulation models could be developed at differing levels of accuracy for each building physical issue. Which simulation software is selected, would depend on the nature of the building physical problem. Less complex standardized calculation methods could be incorporated directly into Excel (Fig. 6). Actually it should be started with such simple calculations before developing comprehensive whole building models for multiple use, e.g. for the purposes of energy certification of buildings. The described generic model belongs to the sort of more complex models, whereas the limits of its application are clearly visible (just given building type). However, regardless of the complexity, the generic models should give the end user high certainty that the achieved results are building physically correct.

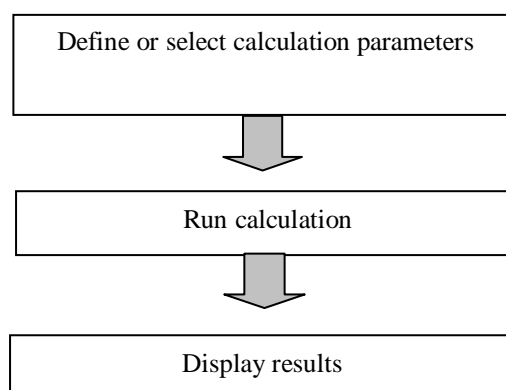


Fig. 6 Simplified scheme of the Excel based interface using calculation procedures included in Excel (less complex cases)

## 5. REFERENCES

CAPSOL, v.4.0 Computer Program to Calculate Multi-zonal Transient Heat Transfer, © 2002 PHYSIBEL

PHYSIBEL SOFTWARE PILOT BOOK - Practical problems solved using the Physibel Software © 2004 PHYSIBEL

EN ISO 13790:2008 Energy performance of buildings - Calculation of energy use for space heating and cooling

Fantl K., Panzhauser E. and Wunderer E. (1996). Der österreichische Gebäude – Energieausweis. Energiepass, TU Wien (in German)