

A GENERIC MODEL FOR ENERGY ASSESSMENT OF A DETACHED FAMILY HOUSE

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ABSTRACT

The paper describes a pre-made Capsol based generic model for assessment of the future energy efficiency and indoor comfort of detached low-energy houses including its Excel-based interface for input of selected free parameters and selection of the pre-defined ones. The generic model is “overloaded” with modelled wall types, climate data and heating and cooling systems including ventilation and movable shading. Not all of them must necessarily be used. The selection is made via the mentioned Excel-based interface. In addition to description of the generic model a simple case study on optimization of thermal insulation thickness in relation to the mean U-Value and the expected energy demand for heating will demonstrate the use of presented generic model.

INTRODUCTION

It is clear that the existing software for building performance simulations, be it esp-r or Capsol for assessing the energy efficiency and indoor comfort of buildings, is very complex and requires a high level of experience. Although they could profit from such software architects are rarely its users. 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.

Another good reason for using generic models is based on the fact that in 2008, the European Committee for Standardization (CEN) issued the

standard EN ISO 13790 on energy performance of buildings - Calculation of energy use for space heating and cooling. The EN ISO 13790 was obviously developed with a view of the future use of building performance simulation in the design and evaluation of the thermal and energy performance of buildings. It presents a coherent set of calculation methods at different levels of detail, including, among others, the the dynamic simulation method. However, putting the described simulation method into action depends very much on the correct use of the building performance simulation software. The physical model of the building and its simulation model are two different things, where the former has to be converted into the latter using the simulation software. As the simulation software available on the market varies, and the standard EN ISO 13790 does not describe in detail how to overcome this gap between the physical model of the building and its simulation model, this is currently left up to the user. The generic models provide a promising option that could help in the conversion process and, perhaps, even standardize it sometime in the future.

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.

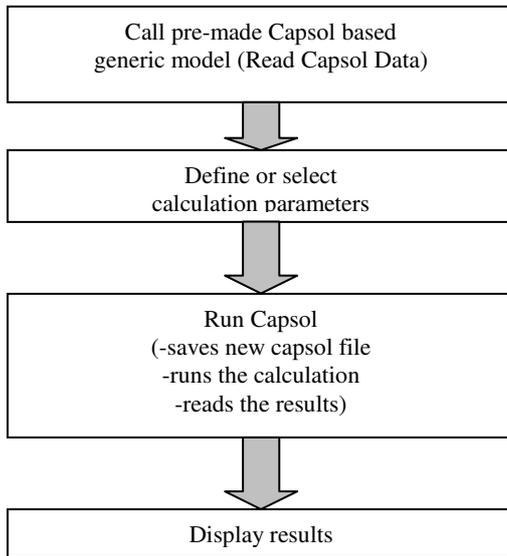


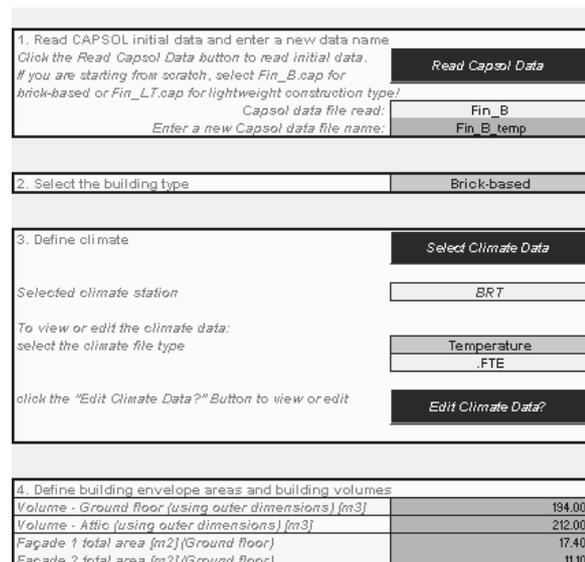
Fig. 1 Simplified scheme of the Excel VBA based interface

- 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).

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

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

- Quality of windows (glazing having the U-Value of 1,09 or 0,8 W/(m²K)).
- 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
 Click the Read Capsol Data button to read initial data.
 If you are starting from scratch, select Fin_B.oap for brick-based or Fin_LT.oap for lightweight construction type!
 Capsol data file read:
 Enter a new Capsol data file name:

2. Select the building type

3. Define climate

 Selected climate station:
 To view or edit the climate data:
 select the climate file type:

 click the "Edit Climate Data?" Button to view or edit

4. Define building envelope areas and building volumes

Volume - Ground floor (using outer dimensions) [m ³]	194.00
Volume - Attic (using outer dimensions) [m ³]	212.00
Façade 1 total area [m ²](Ground Floor)	17.40
Façade 2 total area [m ²](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/m².

- 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.

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

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).

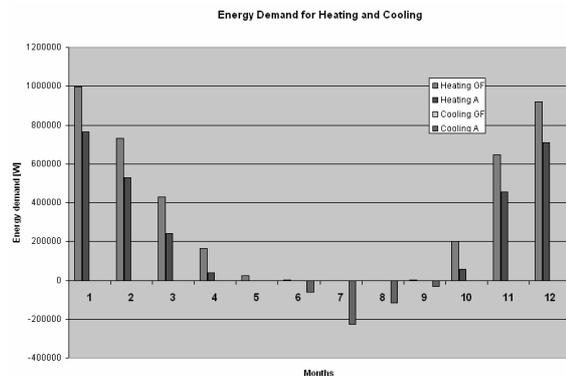


Fig. 4 Chart showing energy demand for heating and cooling

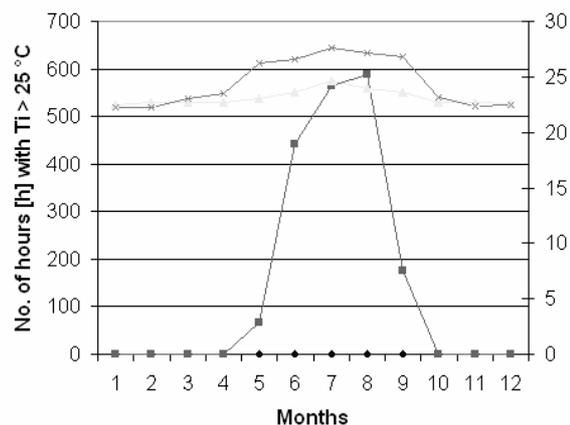


Fig. 5 Chart showing the indoor comfort in terms of number of hours with interior temperature higher than 25°C.

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).

CASE STUDY

The change of some selected parameters can be automated under certain circumstances, e.g. the newly created Capsol file can be run consecutively with varying thermal insulation thickness. This can save work, particularly when several cases are being investigated. The Fig. 6 shows the relationship between the improvements of the mean U-values by increasing the heat insulation thickness on one side and the reduction of energy demand for heating on the other side. It is quite obvious that the “linear” reduction of the heat energy demand is achieved by the “geometrical” increase of the heat insulation thickness.

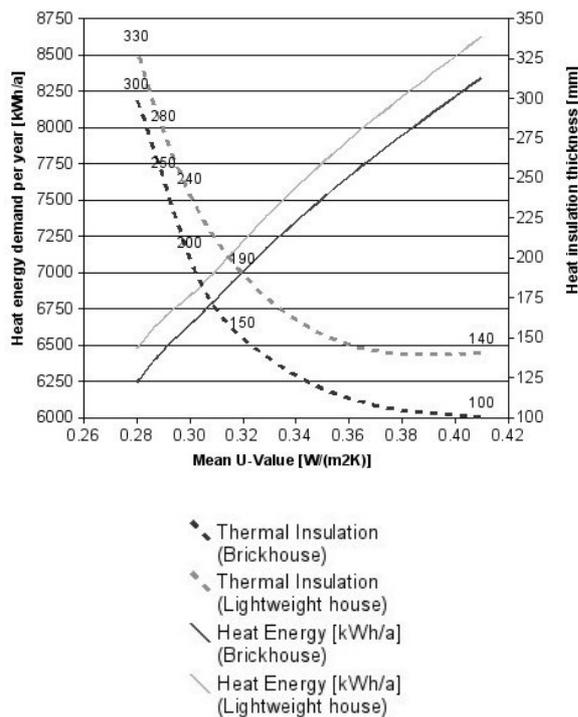


Fig. 6 The effect of the mean U-value [W/(m2.K)] improvement in dependence on heat insulation thickness [mm] upon the annual reduction of energy demand for heating [kWh/a]

Somewhere between the mean U-Values of 0.30 and 0.32 W/(m2K), which corresponds to approx. 17.5 cm of thermal insulation in the brick house and approximately 21 cm for the lightweight house, the rational increase of the thermal insulation thickness stops. Just to compare: to improve the mean U-Value

from 0.41 to 0.32 W/(m2K), and the reduction of heat energy demand in the range of 1500 kWh/a, 5 cm of additional thermal insulation is necessary. A subsequent 5 cm increase of thermal insulation brings about an improvement of the U-Value of only 0.02 W/(m2K) and the reduction of heat energy demand in the range of 300 – 400 kWh/a. This leads to the conclusion that the efficiency of the increase of thermal insulation thickness has both its economical as well as ecological limits.

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.

The generic models can be developed for any building type and, depending on their purpose, in more or less detail. Their application can reach from the early design stage up to the issuance of building energy passports. Whenever large numbers of calculations with changing parameters are required, the use of generic models can be an advantage, for example, when assessing various refurbishment options for the same building type like such as Eastern European panel buildings. Moreover, generic models can give users a high certainty that the achieved results are building physically correct and they can also contribute to the improvement of the users' thermal knowledge and experience.

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