Generic Models as Scientific Tools for Non-experienced Users

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Summary: Nowadays the existing software for building performance simulations, e.g. Capsol for the assessment of the various aspects of the building energy efficiency, is very complex and requires a high level of experience. Though they could profit from such software the architects are rarely its users. This distance between architects and the software can be shortened by developing generic models that allow for selected free design parameters, whereas the parameters related to the in-depth-knowledge are pre-defined. Then, the non-experienced users are able to perform correct 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.

In addition to this, the generic models make possible a quick performing of a high number of calculations with automatic change of the selected parameters and this way investigate their mutual relationship in form of derived functions. The paper describes a generic model for assessment of the future energy efficiency of detached low-energy houses and derived functions for optimization of the thermal insulation thickness in relation to the mean U-Value and expected heating demand.

1. GENERIC MODEL

The presented generic model is actually two zone model of detached house developed using Capsol software[1] for calculation of transient heat transfer. It assumes ground floor and attic as two separate zones ventilated to outdoors whereas 30 per cent of the ground floor volume is ventilated via attic (through staircase). 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, e.g. Visual Basic for Applications (further VBA) available in Excel[3]. 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, which is in this case programmed in Excel using VBA (figs 1, 2). The user can either define (green fields, e.g. areas, orientations or roof slopes) or choose (yellow fields) some design parameters. The pre-defined parameters requiring an in-depth-knowledge are:

- Building type, which can be either brick-based or lightweight construction,
- Climate data (in principle calculations can be made for any climate data, provided they are organized in required form),
- Thermal insulation thickness (100, 150, 200, 250 and 300 mm) and quality of windows (U-Value of 1.09 and 0.8 $W/(m^2K)$),
- Heating and cooling systems (heat-exchanger, air-conditioning, movable shading, natural ventilation),

and

- Sun obstacles in the surroundings (plane area, hilly country and forest / city).

After the definition and selection of the parameters has been finished the Capsol software is called using the button "Run Capsol" (fig.3). This command initiates the creation of a new Capsol file based on generic model with user defined and selected data, the actual calculation in Capsol and import of required results back to excel. The relevant results are displayed either as tables or charts or both. In this case the heating and cooling energy demand and the indoor thermal comfort were investigated. For this purpose a special final table and two buttons displaying either energy demand or thermal comfort chart has been arranged (fig. 3).

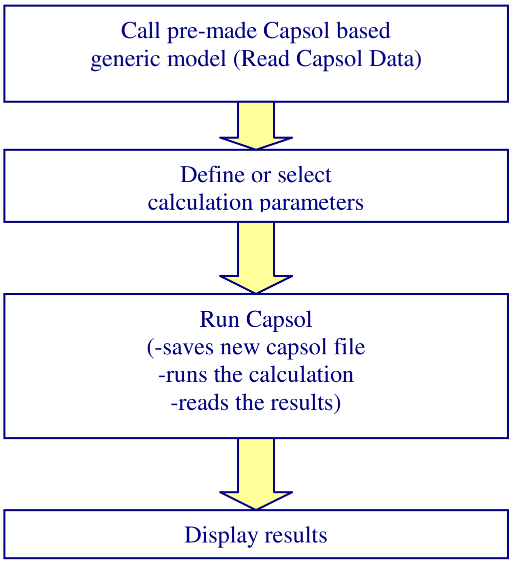


Fig.1 Simplified scheme of the Excel VBA based interface

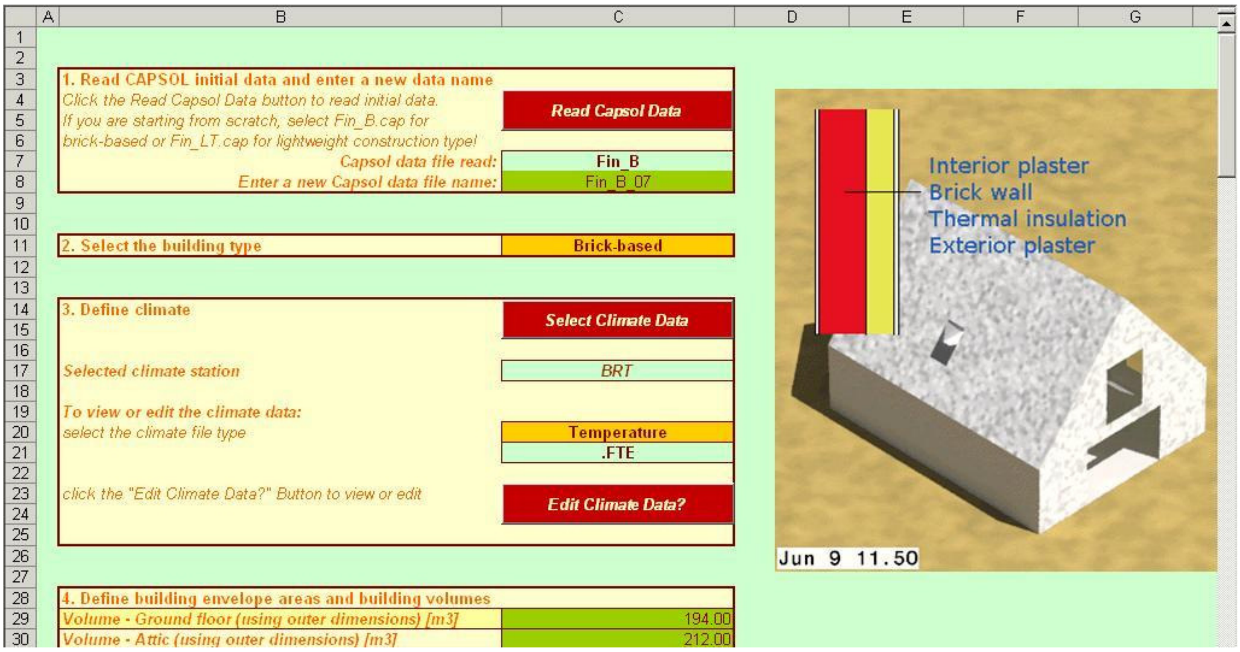
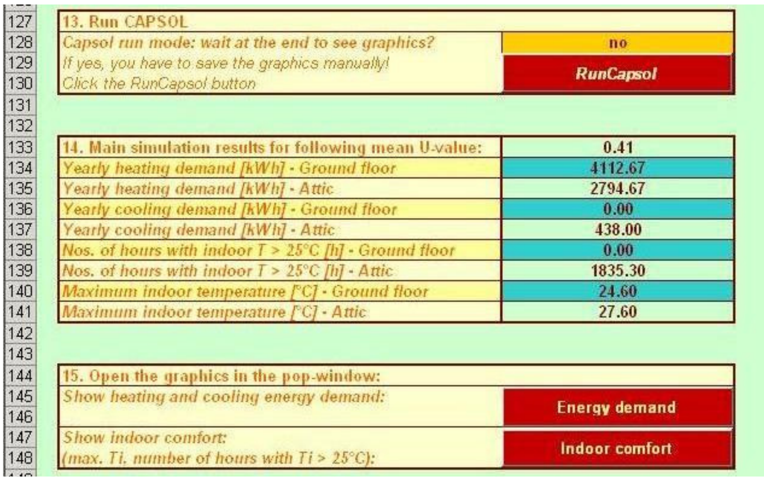


Fig.2 Excel VBA based interface of the generic model for the assessment of the heating energy demand of detached houses



13. Run CAPSOL	
Capsol run mode: wait at the end to see graphics?	no
If yes, you have to save the graphics manually! Click the RunCapsol button	RunCapsol
14. Main simulation results for following mean U-value:	0.41
Yearly heating demand [kWh] - Ground floor	4112.67
Yearly heating demand [kWh] - Attic	2794.67
Yearly cooling demand [kWh] - Ground floor	0.00
Yearly cooling demand [kWh] - Attic	438.00
Nos. of hours with indoor T > 25°C [h] - Ground floor	0.00
Nos. of hours with indoor T > 25°C [h] - Attic	1835.30
Maximum indoor temperature [°C] - Ground floor	24.60
Maximum indoor temperature [°C] - Attic	27.60
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 Final table with selected results and two buttons displaying either energy demand or thermal comfort chart

2. DERIVED FUNCTIONS

The change of some selected parameters can be under certain circumstances automated, e.g. the newly created Capsol file can be run consecutively with several different thicknesses of the thermal insulation. This can save work, particularly, if several cases are investigated.

The figure 4 shows the relationship between the improvements of the mean U-values by increasing the heat insulation thicknesses 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.

Somewhere between the mean U-Values of 0.30 and 0.32 W/(m^{2}K), which corresponds to approx. 17.5 cm of thermal insulation of the brick house and approximately 21 cm of the lightweight house, stops then the rational increase of the thermal insulation thickness. Just to compare: for the improvement of the mean U-Value from 0.41 to 0.32 W/(m^{2}K) and the reduction of heat energy demand in the range of 1500 kWh/a 5 cm of additional thermal insulation is necessary. But the next increase of the thermal insulation by 5 cm brings about the improvement of the U-Value by just 0.02 W/(m^{2}K) 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 the thermal insulation thickness has its economical and also ecological limits as described in[4].

3. CONCLUSIONS

The generic models can be developed for any building type and in dependence on their purpose more or less detailed. Their application can reach from the early design stage up to the issue of building energy passports. Always when high numbers of calculations with changing parameters are required the use of generic models can be of advantage, e.g. when assessing various refurbishment options for the same building type like the one of the Stuttgart’s Wilhelminian style or the East European panel buildings. Moreover the generic models give the users high certainty that the achieved results are building physically correct and can also contribute to the improvement of their thermal knowledge and experience.

4. ACKNOWLEDGEMENTS

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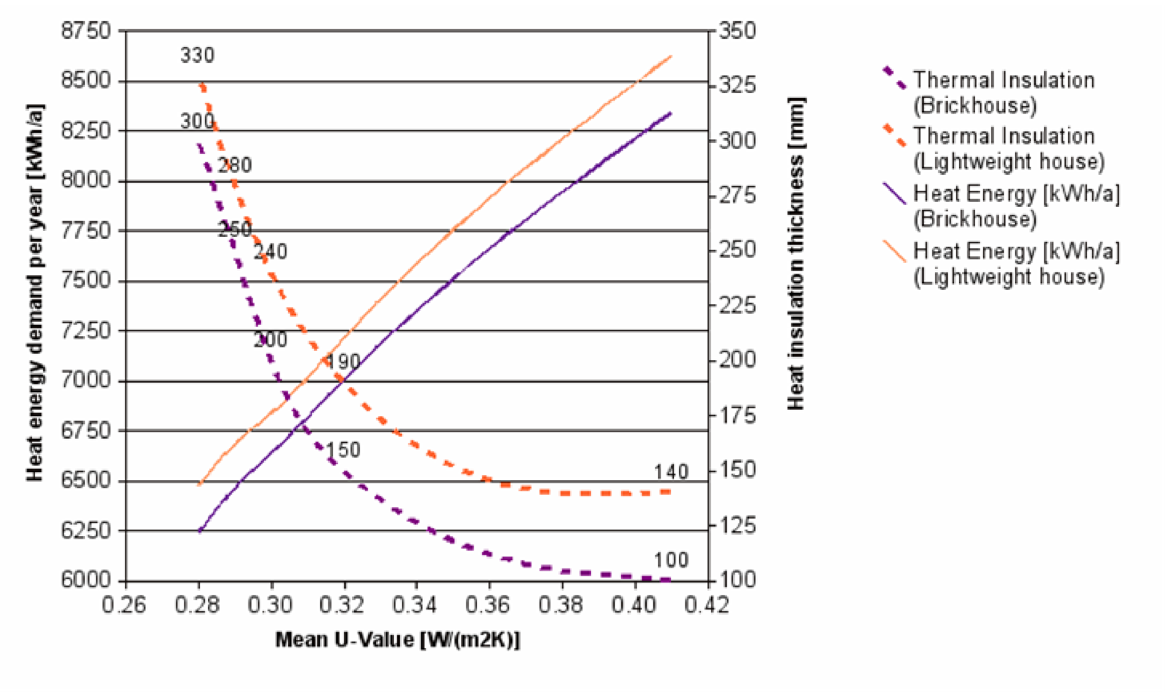

Fig.4 The effect of the mean U-value improvement in dependence on heat insulation thickness upon the heat energy demand reduction

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