Assessment of two different methods of calculating a heating demand

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Abstract

Phenomenon of today's era is lowering overall energy performance and greenhouse gas emissions. European Union and its members came from an "uncontrollable" fossil fuel usage to an era of dependence reduction from fossil fuel usage. EU industry is now in era of utilizing renewable energy sources. Construction industry is responsible for 40% of total energy performance of EU; hence the great emphasis on energy effective design on new buildings as well as importance on energy effective renovation of already constructed buildings. Effort on lowering total energy performance in construction industry has signed on research on new project solutions, new insulation materials and new building services technologies which are maximizing energy gain from renewable energy sources. Simulation software and different engines are more than helpful tool when predicting building thermal behaviour. That is why simulation software is used more often in the process of designing energy efficient buildings or in the process of energy performance optimization of existing buildings. simulation and analytics itself, is dealing with simulation of chosen buildings (family houses) on heating demand based on the newest knowledge of constructions and materials. Results of heating demands of different family houses were confronted against heating demands calculated according national standards – using non-variable conditions. Next, the differences between two calculation approaches were characterized in percentages.

Key words: heating demand, simulation software, family house

1 Introduction

This paper assesses two different family houses on the heating demand using dynamic simulation software tool DesignBuilder v4 and using calculation according national directives and standards (with permanent weather condition). Non-dynamic calculation using national directives and standards is still used more frequently than dynamic simulations. The benefit of using dynamic simulation when calculating heating demand is, that dynamic simulation is the closest method to observe real life behavior of the family house. Currently, there are more than 400 applications that can be applied to analyzing building energy and thermal simulation [1]. Optimization of energy use is up to date theme, and many publications are being written about it such as [5][6][8][7][9].

The purpose of this paper is to determine the difference between two different methods of calculating heating demand of the two assessed family houses. The results of this determination can be used in a design phase of the future projects.

2 Climate and location

Two family houses are located in Košice – Slovakia. Both houses are two-stories family houses that represent a typical type of residential buildings built in this area. Buildings are based on concrete footing foundation.

2.1 Family house A

Figure 1: Family house A

The family houses envelope was designed from materials with high thermal capacity insulated from outside with a thick layer of polystyrene (ETICS system) to minimize the heat losses during the heating period as well as to prevent the heat infiltration during the summer period. Roof structure creates unconditioned space between insulated ceiling and top of the roof. Transparent parts of the building envelopes were designed to meet the national standards and energy criteria.

Table 1: Thermo-technical parameters of the family house A

Shape factor (A/V ratio)	0.78 1/m
Volume of building space	726.18 m ³
Total heat transfer surface	569.48 m ²
Total floor area	222.09 m ²
Wall U-Value	0.168 W/(m ² .K)
Insulated ceiling U-Value	0.119 W/(m ² .K)
Ground floor R-Value	5.302 (m ² .K)/W
Wood-aluminum U-Value Internorm HF 350	0.60 – 0.95W/(m ² .K)

2.2 Family house B

Figure 2: Family house B

The family houses B envelope was designed from the same materials with high thermal capacity insulated from outside with a thick layer of polystyrene (ETICS system) to minimize the heat losses during the heating period as well as to prevent the heat infiltration during the summer period.

Table 2: Thermo-technical parameter of the family house B

Shape factor (A/V ratio)	0.62 1/m
Volume of building space	921.98 m ³
Total heat transfer surface	569.48 m ²
Total floor area	232.14 m ²
Wall U-Value	0,148 W/(m ² .K)
Insulated ceiling U-Value	0.123 W/(m ² .K)
Ground floor R-Value	4.38 (m ² .K)/W
Rehau geneo plastic window	0.75 – 0.95W/(m ² .K)

2.3 Climate and weather conditions

Dynamic conditions according to [2], used in dynamic simulation software DesignBuilder v4 to calculate heating demand:

Figure 3: Outside temperature during simulated year

Figure 4: Solar radiation intensity during calculated year

Figure 5: Airflow velocity during calculated year

Figure 6: Wind direction data used in simulation

Figure 7: Relative humidity

Non-dynamic conditions used in the heating demand calculation according to national standard STN 730540:2012 Part 1-3 [4] and STN EN ISO 13 790 on Energy Performance of the Buildings [3]:

Interior temperature $\theta_{int} = 20^{\circ}\text{C}$

Interior relative humidity $\phi_i = 50\%$

Outside temperature $\theta_e = -13^{\circ}\text{C}$ (mean outside /throughout the year/ temperature $3,86^{\circ}\text{C}$)

Outside relative humidity $\phi_e = 84\%$

3 Results

Results of heating demand calculated using dynamic simulation software and calculated using national standards and directives (non-dynamic conditions) are displayed in the graphs and tables below.

3.1 Family house A

Simplified model of the family house A was put into the dynamic simulation software interface DesignBuilder v4.

Figure 8: Heat gains and heat losses_family house A

Figure 9: Heating demand throughout the simulated year_family house A

Calculation of heating demand according national standards and directives – monthly method:

Table 3: Calculated heating demand – monthly method – family house A

$Q_{h,nd,1}$
43,78 kWh/m ² .a

3.1.1 Partial conclusion

Model of the family house A was put into the dynamic simulation software DesignBuilder v4 interface with the parameters according Tab. 1.

Figure 10: Difference between heating demand calculated with dynamic simulation tool and non-dynamic calculation_family house A

Yearly heating demand of the family house A, calculated according to national standards and directives with the monthly method, is 43,78 kWh/m².a. On the other hand, calculated heating demand using dynamic simulation software DesignBuilder v4 is 35,59 kWh/m².a.

As it can be seen from Fig. 10, the difference between two different types of heating demand calculation is 7,6 kWh/m².a, which represents the difference of 23%.

3.2 Family house B

Simplified model of the family house B was put into the dynamic simulation software interface DesignBuilder v4.

Figure 11: Heat gains and heat losses_family house B

Figure 12: Heating demand throughout the simulated year_family house B

Calculation of heating demand according national standards and directives – monthly method:

Table 4: Calculated heating demand – monthly method – family house A

$Q_{h,nd,1}$
43,19 kWh/m ² .a

3.2.1 Partial conclusion

Model of the family house A was put into the dynamic simulation software DesignBuilder v4 interface with the parameters according Tab. 2.

Figure 13: Difference between heating demand calculated with dynamic simulation tool and non-dynamic calculation_family house B

Yearly heating demand of the family house B, calculated according to national standards and directives with the monthly method, is 43,19 kWh/m².a. On the other hand, calculated heating demand using dynamic simulation software DesignBuilder v4 is 36,05 kWh/m².a.

As it can be seen from Fig. 13, the difference between two different types of heating demand calculation is 7,14 kWh/m².a, which represents the difference of 19,80%.

4 Conclusion

This paper is determining the difference between two different approaches of calculating heating demand of the family houses.

Figure 14: Difference in heating demand of assessed family houses

First method is dynamic simulation method, when dynamic data are being applied on the calculation. This method has great potential in the future as it can predict a close-to-real energy performance of the building in the pre design stage of a project. The disadvantage of this method is that simulation software is expensive and not many design companies and studios can afford it, thus most of project companies and studios are using heating demand calculation using non-dynamic calculation according national standards and directives.

This paper can help those designers, who cannot afford investing into simulation software on when calculating heating demand of a building. According to this assessment, the difference between dynamic simulation and non-dynamic calculation of the heating demand is 21,40 % /based on two family houses calculation/. To sum it all, when calculating heating demand using non-dynamic calculation method – according to national standards and directives – this 21,40% difference can be applied to calculations, to reach the close-to-real heating demand, which can be used in further energy calculations.

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References

- [1] Energy Efficiency and Renewable Energy (EERE). Building Energy Software Tools Directory, U.S. Department of Energy. Available online: http://apps1.eere.energy.gov/buildings/tools_directory/ (accessed on 18 January 2013).
- [2] Fanger, P.O. *Thermal Comfort, Analysis and Applications in Environmental Engineering*; McGraw-Hill Book Company: New York, USA, 1970.
- [3] STN EN 13790: Energetická hospodárnosť budov. Výpočet potreby energie na vykurovanie a chladenie, 2008.
- [4] STN 73 0540: 2012 Tepelná ochrana. Tepelnotechnicke vlastnosti stavebných konštrukcií a budov. Časť 1 až 3. (júl 2012).
- [5] Manuál energeticky úsporné architektúry. Vydavateľ: Státní fond životního prostředí ve spolupráci s Českou komorou architektů. ISBN: 978-80-904577-1-3.
- [6] Europe's buildings under the microscope. A country – by – country review of the energy performance of buildings. Buildings Performance Institute Europe (BPIE). October 2011. ISBN: 9789491143014 http://www.bpie.eu/eu_buildings_under_microscope.html
- [7] P TURCSANYI, P.: Výskum určujúcich parametrov energeticky efektívnych budov pomocou dynamickej simulácie. Dizertačná práca. TU Košice. 2019.
- [8] HOPFE, CH.,J.: Uncertainty and sensitivity analysis in building performance simulation for decision support and design optimization. Dissertation work.
- [9] SMITH, S.,T. : Modelling thermal loads for a non-domestic building stock. Associating a priori probability with building form and construction – using building control laws and regulations. Dissertation work.