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Heating demand – simulation and calculation

P Turcsanyi¹

¹Technical University of Kosice, Faculty of Civil Engineering, Institute of Architectural Engineering, Slovakia

Abstract. Energy efficient house is a term known very well to engineers and architects all over the world. In these times of minimizing the energy loads and negative emissions, energy efficient houses (ultra-low-energy, net-zero houses, positive houses) are one of the best ways to meet these targets. The main topic of this paper is a comparison between dynamic simulation and static calculation of heating demand of a family house designed for Slovak Republic climate. Two-storey family house was designed taking in account architectural, environmental and constructional requirements of today's European directives focusing on energy performance and energy efficiency. Our goal was to find out the differences between heating demand calculated using national standards and heating demand using dynamic simulation software.

1. Introduction

Building energy performance assessment is crucial to ascertain the efficiency of energy use in buildings and is the basis to make any decision for enhancing energy efficiency. Globally, buildings consume nearly half of the total energy produced, and consequently responsible for a large share of CO₂ emissions. The adoption of highly efficient energy production systems as well as high performance materials is being encouraged more and more in order to achieve the Nearly Zero Energy Buildings target. Energy efficient design (to create ultra-low-energy building, net-zero building or even energy-plus building) is a response to local climate conditions and global energy consumption. Thermal building simulation is a powerful tool to assess the energy performance of a building. Design Builder is currently the most comprehensive user-friendly Energy Plus interface. To sum it all, simulation software Design Builder is one of the most effective tools on the market, which can play very important part in the process of building design. When using Design Builder correctly, engineers can predict building behaviour throughout a reference year loaded to database.

1.1. Object information

Presented family houses are located in Kocice – Krasna, in the residential area of similar family houses. Two-storey family house represents a typical type of residential buildings built in this area. The floor layouts were designed for a family of two parents and three kids and the concept of a whole houses were made according to the latest energy efficient standards. Buildings are based on concrete footing foundation. Both envelopes of the houses were 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.





Figure 1. Family houses views (top A, bottom B).

Transparent parts of building envelopes were designed to meet the highest insulating standards.

Table 1. Family house “A” parameters.

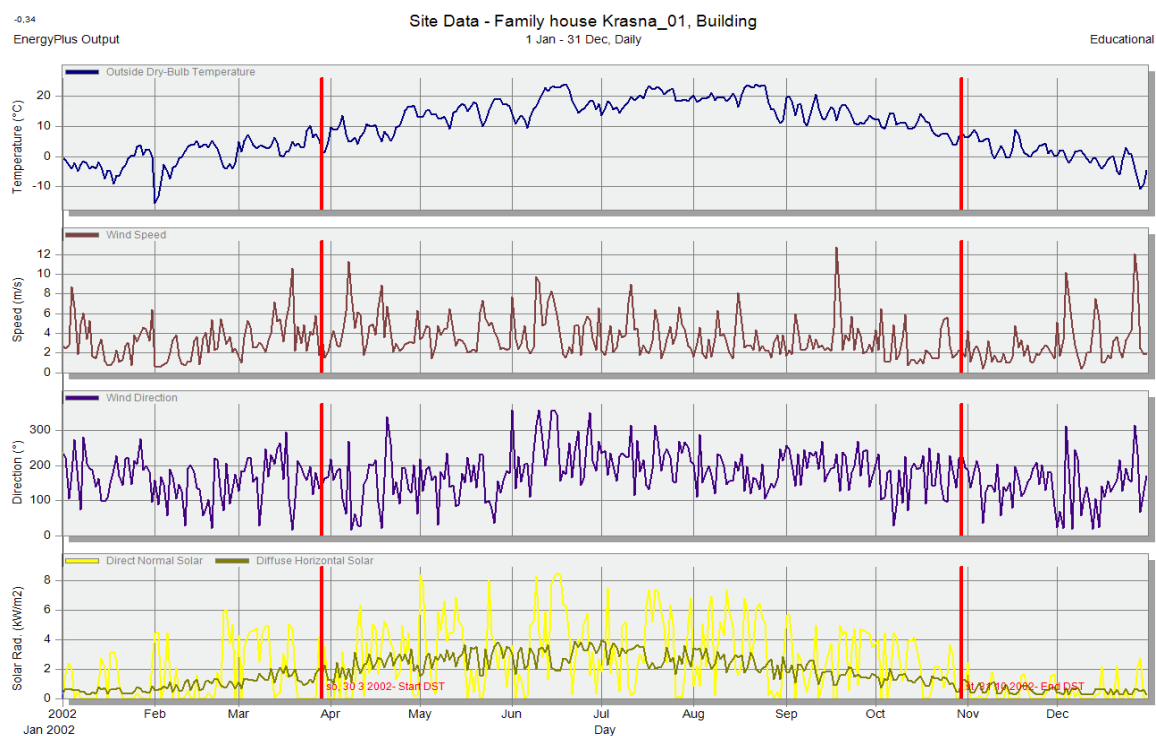
A/V Ratio	0.43 1/m
Building volume	254,10 m ³
Building envelope	149,80 m ²
Total floor area	108,64 m ²
U _{wall}	0.100 W/(m ² .K)
U _{roof}	0.120 W/(m ² .K)
R _{floor}	6,25 (m ² .K)/W
U _w – Schuco Alu Inside	0.60 – 0.76W/(m ² .K)

Table 2. Family house “B” parameters.

A/V Ratio	0.78 1/m
Building volume	726.18 m ³
Building envelope	569.48 m ²
Total floor area	222.09 m ²
U_{wall}	0.148 W/(m ² .K)
U_{roof}	0.123 W/(m ² .K)
R_{floor}	4.38 (m ² .K)/W
U_w – Internorm HF 350	0.60 – 0.95W/(m ² .K)

1.2. Locality

Košice lies in the North Temperate Zone and has a borderline continental and marine climate with four distinct seasons. If defined as marine due to the winters just above -3°C (27°F), it would be one of the farthest inland areas with this climate type.

**Figure 2.** Weather data used in the simulation.

2. Methods

Both buildings simulations were set up with the DesignBuilder v4 software, in which building performance data is generated by the simulation engine EnergyPlus. EnergyPlus is a building simulation program used by United States Department of Energy and has been extensively tested by field measurements and empirical methods

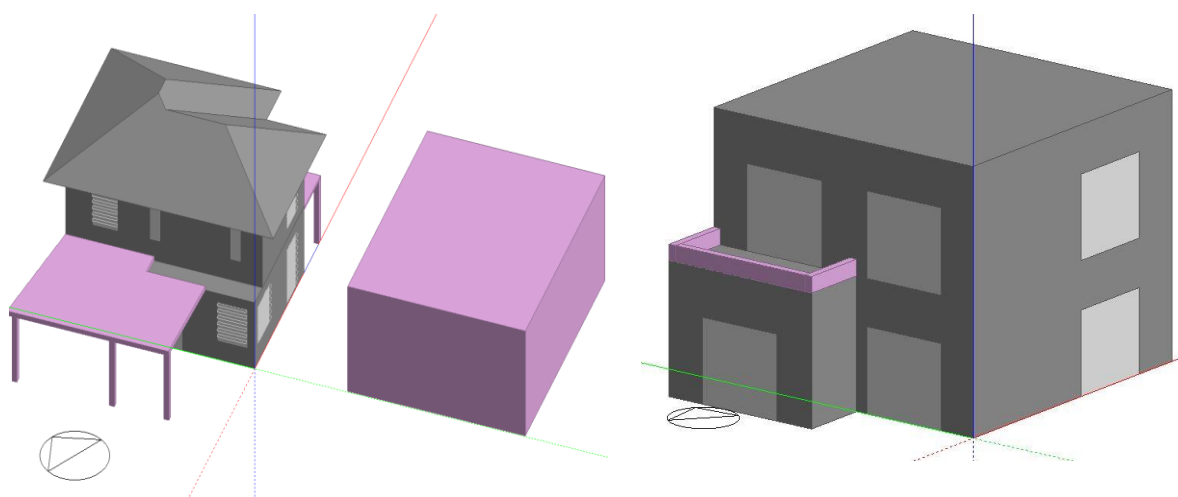


Figure 3. Left family house “B”, right family house “A”.

Second method, and the most commonly used one, is calculation of heating demand using national standards. When calculating heating demand of the family houses, these exterior and interior conditions were used (based on geographical situation):

Interior:

Interior temperature $\theta_i = 21^\circ\text{C}$

Interior relative humidity $\phi_i = 55\%$

Exterior:

Exterior temperature $\theta_e = -13^\circ\text{C}$

Exterior relative humidity $\phi_e = 84\%$

3. Results

Heating demand of the family house “A” (Figure 4), calculated using simulation software DesignBuilder v4 shows the amount of heating demand in direct dependence to weather – what is only logical. Yearly heating demand calculated on the square meter of floor area is $34,03 \text{ kWh/m}^2$.

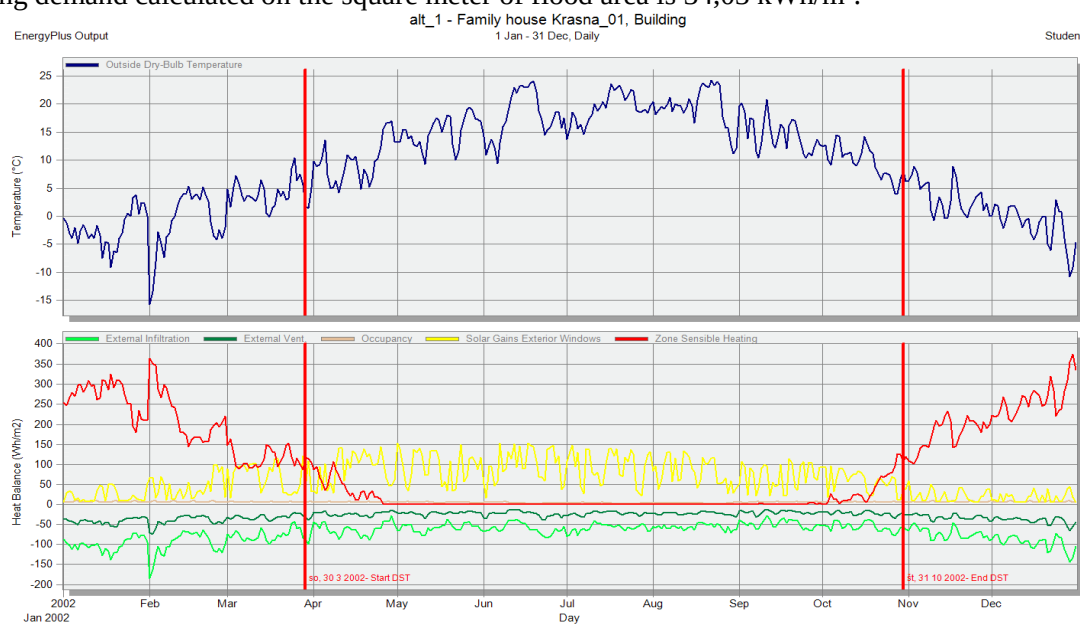


Figure 4. Heating demand /red line/ of the family house “A” – daily method.

Heating demand of the family house “B” (Figure 5), calculated using simulation software DesignBuilder v4 shows the amount of heating calculated on the square meter of flood area as 34,03 kWh/m².

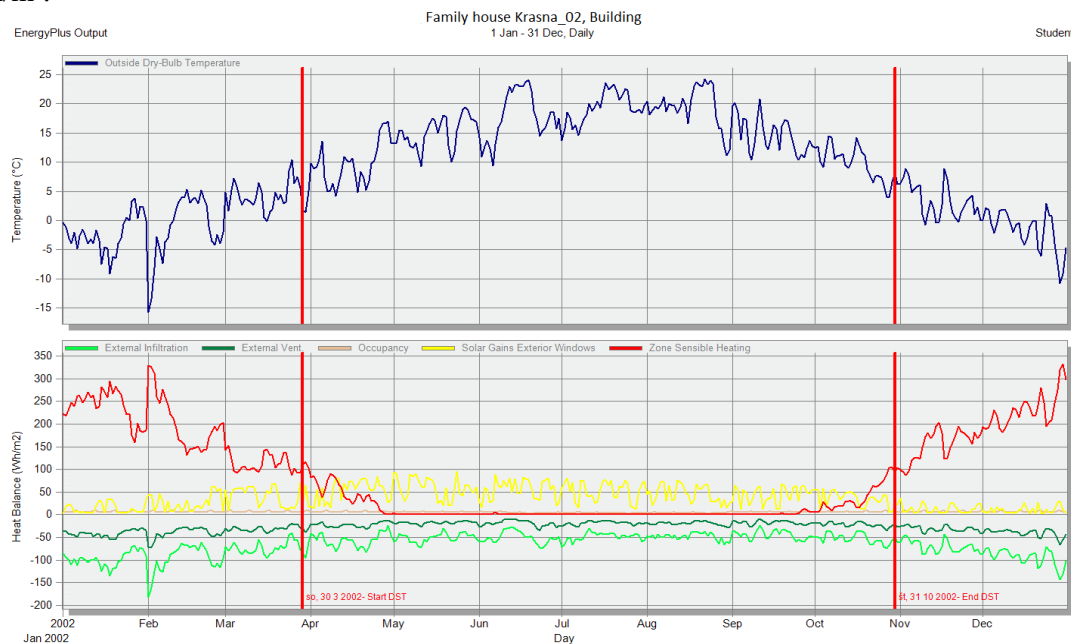


Figure 5. Heating demand /red line/ of the family house “B” – daily method.

As it can be seen (Figure 4, Figure 5), heating demand is directly to weather conditions, occupancy, solar gains through exterior glazing, external infiltration and external ventilation.

Table 3. Family house “B” results.

Simulation	Calculation
Heat demand for heating according to standard valid until 31.12.2020	
$Q_{h,nd,1} \leq Q_{h,nd,r1}$	$Q_{h,nd,1} \leq Q_{h,nd,r1}$
34,01 kWh/m2.a $\leq$ 41,90 kWh/m2.a	44,93 kWh/m2.a $\leq$ 41,90 kWh/m2.a
Heat demand for heating according to standard valid from 01.01.2021	
$Q_{h,nd,2} \leq Q_{h,nd,r2}$	$Q_{h,nd,2} \leq Q_{h,nd,r2}$
34,01 kWh/m2.a $\leq$ 21,15 kWh/m2.a	44,93 kWh/m2.a $\leq$ 21,15 kWh/m2.a
Difference between simulation and calculation 19,8 %	

Table 4. Family house “A”.

Simulation	Calculation
Heat demand for heating according to standard valid until 31.12.2020	
$Q_{h,nd,1} \leq Q_{h,nd,r1}$	$Q_{h,nd,1} \leq Q_{h,nd,r1}$
22.43 kWh/m2.a $\leq$ 29.75 kWh/m2.a	28.30 kWh/m2.a $\leq$ 29.75 kWh/m2.a
Heat demand for heating according to standard valid from 01.01.2021	
$Q_{h,nd,2} \leq Q_{h,nd,r2}$	$Q_{h,nd,2} \leq Q_{h,nd,r2}$

22.43 kWh/m².a ≤ 29.75 kWh/m².a

28.30 kWh/m².a ≤ 29.75 kWh/m².a

Difference between simulation and calculation 19,8 %

4. Conclusion

Nowadays, dynamic simulation software is on the rise. In the pre design stage, it is possible to optimize the future energy performance of a building more detailed and accurate than standardized national calculation. It is a very helpful tool for predicting energy behaviour, and all in all – to save future expenses. In this paper, we were comparing the accuracy of both different methods – dynamic simulation vs. standard calculation using non-variable conditions. The difference in both cases is close to 20%. The reason why I was comparing two approaches of calculating heat demand was to find out the difference between them.

5. References

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