[1.]Xhevat BERISHA, [2.]Drilon MEHA

ANALYSIS OF HEATING UNIFIED CONSTRUCTION CODE FOR REDUCING THE ENERGY CONSUMPTION IN BUILDINGS

[1,2.] University of Pristina, Faculty of Mechanical Engineering, Pristina, KOSOVO

Abstract: Human thermal comfort is dependent on both personal factors (clothes that we wear physical activity) and environmental factors (temperature, air humidity, airflow (wind), and radiation). The difference between the outside and inside air temperature of a building is the primary cause of heat loss in the winter months. Also, the wind, humidity levels, and radiation sources are the greatest sources of heat loss during the winter. Heat loss of a building depends on the size of its border walls and the factors of heat leakage boundary walls (through various building elements such as walls, roof, ceiling, floor, etc.). In this paper, thermal comfort is explained using a model of a private House in Pristina, Kosovo. Thermal analysis is based on two methods: specific heat consumption q_A (W/m^2) and heated space q_V (W/m^3), and also based on the Unified Construction Code of Kosovo with the Excel program ThermoCalc. Thermal analysis is conducted for the Model Private House (MPH) for the heating season of 3240 hours, t_i=20°C average design temperature within the room, and t_e= -18°C outside design temperature. The results of the thermal performance for heat consumption are presented using tables and diagrams.
Keywords: outside temperature, influence, unified code, design, heat consumption

1. INTRODUCTION

Thermal comfort and energy efficiency have gained the attention of numerous researchers around the globe [1]. Thermal comfort and assessment of indoor environmental quality depend on personal and outdoor factors. Personal factors include clothes and level of physical activity, while environmental factors include air temperature, airflow (wind), air humidity, and radiation. The human body's physiological and psychological responses to the environment are dynamic and integrate various physical phenomena that interact with space [2]. ASHRAE 55 standard explains thermal comfort as a state of mind which expresses satisfaction with the thermal environment [3]. It is believed that in a real environment, people do not only passively accept the thermal stimuli, but also positively interact with the environment through the 'human-environment' feedback cycle [4].

The difference between the outside and inside air temperature of a building is the primary cause of heat loss in the winter. Heat loss of a building depends on the size of its border walls and the factors of heat leakage boundary walls (through various building elements such as walls, roof, ceiling, floor, etc.). The wind, humidity levels, and radiation sources are the greatest sources of heat loss during the winter.

Indoor thermal comfort assessment is based on heat balance calculation and also on non-physical factors [5]. Thermal comfort, external air with meteorological parameters, and thermal characteristics of the building are the most influential factors for consumption of heating energy [6]. Some studies show the existence of strong relationships between thermal comfort and occupant's behaviour, considering indoor thermal environment [7, 8].

A facility's or building's heating, ventilating, and air conditioning system (HVAC) can maintain and enhance the desired conditions inside that particular installation. Refrigeration is frequently added to HVAC systems - (HVAC&R). HVAC&R systems are implemented for both cooling and heating of various facilities [9].

The important factors that determine the energy consumption of HVAC systems are [9]:

- design, layout, and operation of the building that affects the external environment impacts on internal temperatures and humidity;
- required indoor temperature and air quality;
- heat generated internally by lighting, equipment, and people;
- design and efficiency of the HVAC plant, which delivers heating, cooling, and moisture control when is desirable in the building;
- operating times of the HVAC equipment and functionality of the controls that limit operation to exactly when the system is necessary.

'Outside' air – or external air is defined by various meteorological parameters or factors. Meteorological parameters change on a daily basis, and their change significantly depends on the characteristics of the observed locations, such as latitude, altitude, and terrain configuration (sheltered, close to bodies of water, etc.). Additionally, meteorological parameters that define outside air are outside temperature, humidity, wind speed, solar radiation and also clouds, cloud height, air pressure, and precipitation. In the heating technique (of all climatic and meteorological parameters) outside temperature is considered to be the most accurate setting for analysis, while wind speed, humidity and the influence of solar radiation are considered parameters that are calculated using correction factors.

The meteorological observations are measured based on the daily mean temperature, daily maximal and minimal temperature, monthly mean, mid-year, and annual maximum and minimum temperatures. The daily mean temperature is calculated as the average arithmetic value out of high temperature measured every hour during 24 hours. Considering that this particular method of collection and energy efficiency of heating and air conditioning is relatively complicated, the average daily value is usually calculated by the temperature measured in the 7, 14 and 21 hours, according to the following formula [10, 11]:

$$t_m = (t_7 + t_{14} + 2 \cdot t_{21})/4 \quad (1)$$

The average monthly temperature is calculated based on the average daily temperatures:

$$t_{m,m} = \sum_{i=1}^{n} t_{m,i} / n \text{, n - number of days in a month.} \quad (2)$$

The average annual temperature is calculated based on the average monthly temperature:

$$t_{m,y} = \sum_{i=1}^{12} t_{m,m,i} / 12 \quad (3)$$

The annual heating temperatures determine the length of the heating period or the number of working days of the heating system. Outside air temperature correlates with the duration of the heating period affects the annual energy use for heating (size heating boilers, fuel consumption, pipelines, operating costs, etc.).

The primary objective of this paper is analysing the influence of the outside air temperature on the thermal performance of the Model Private House (MPH).

2. THERMAL PERFORMANCE AND TRANSFER OF HEAT

Thermal performance

The thermal performance of a building or facility is the process of modelling the energy transmission concerning a building and its surroundings. For a conditioned building, it estimates the heating and cooling load and hence, the sizing and selection of HVAC equipment can be correctly made [9, 12]. On the other hand, for a non-conditioned building, it measures or calculates the variation of the building's inside temperature during a particular period and assists on estimating the interval of uncomfortable times. The above analysis allows us to evaluate the quality of the design of an object/building, while simultaneously supporting us at developing enhanced models for creating energy-efficient facilities that contain appropriate indoor conditions. However, clients are usually interested to know how much energy will they spent and how much can they save. Understanding the relative performance of buildings will enable architects to choose the best alternative. Hence, to design a functional passive solar building, it is necessary to know methods of estimating the performance of the buildings.

Numerous heat exchange practices take place in-between a building (object) and the external environment. As presented in Figure 1, heat streams by passing through different parts of the building such as floor, ceiling, roof, walls, etc. Heat exchange also occurs from various surfaces by convection and radiation [12].

Additionally, while solar radiation enters through transparent windows inside a building, surfaces inside the building concurrently absorb the radiation. Another factor that adds extra heat inside space is the human presence and their activities such as the use of equipment, light, etc.

The way the human body reacts to its environment is presented in Figure 2. In the process of metabolism, the body generates heat from chemical reactions which are used to do work, and the rest is released into the environment as the body maintains a stable temperature. The exchange of heat between the body and the environment around it occurs through conduction, radiation, evaporation, and convection. When the body loses heat, it becomes colder. When the body gains heat, it becomes hot and begins to perspire. The dynamics of air movement affects how much the body sweats and thus, the level of comfort.

The following factors dictate the thermal performance of a building and how efficiently it retains heat [8]:

- Design variables (geometrical dimensions of building components, i.e., roof and windows, walls, shading devices, orientation, etc.);

- Material properties (density, transmissivity, thermal conductivity, specific heat, etc.);
- Weather data (ambient temperature, solar radiation, humidity, wind speed, etc.); and
- A building's usage data (internal gains from tenants living inside, lighting and equipment, air exchanges, etc.).

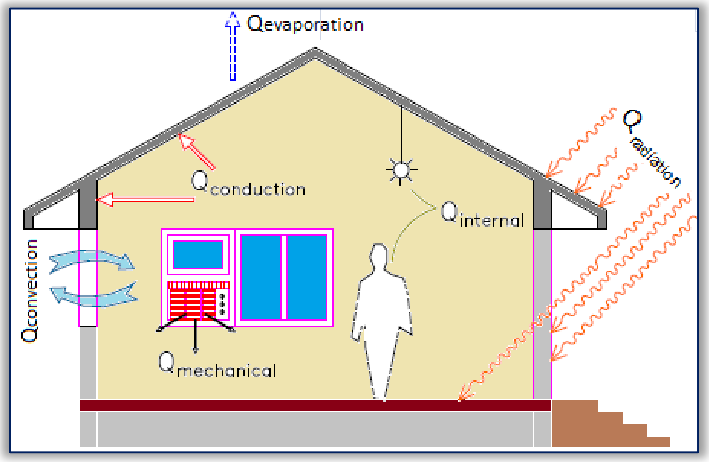


Figure 1. Heat exchange processes

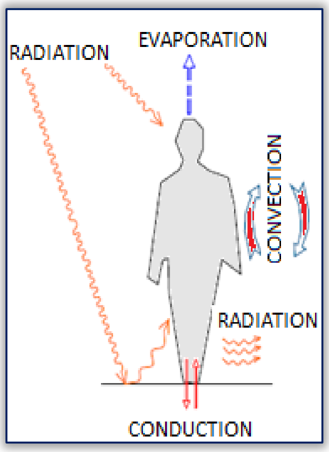


Figure 2. Heat transfer processes a human body

The following is a block diagram depicting the factors which influence the thermal balance in a building, Figure 3. Several analytical tools can be used to measure the effect that such factors have on the performance of a building (EnergyPlus, TRNSYS, Termis, BaseCalc, Therm Version 1.0, etc.) [13]. To estimate the performance of a building, the steady state, dynamic, and correlation methods are used. Some techniques are rather simple and provide data monthly or annually on temperature and average load. Others are more complex requiring more detailed information.

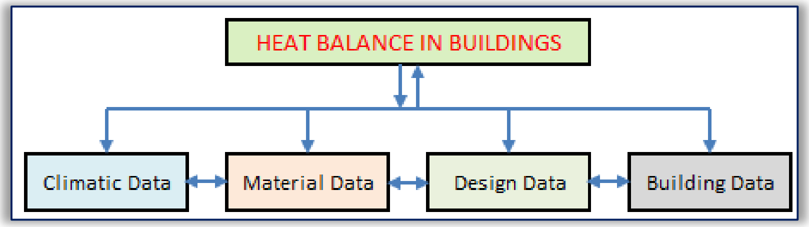


Figure 3. Thermal cycle for heat balance simulation flow paths of a building

A good way to understand the effect heat conduction, convection and radiation have on a building, imagine a wall which has one surface exposed to sunlight and the other surface facing another building (Figure 4). Also, heat can be exchanged between the different elements of a building as well (for example walls, windows, roofs, etc.). These processes can have an effect on the temperature within a building resulting in a change in the comfort which the inhabitants experience.

Understanding the inherent nature of heat exchange and solar radiation reveals how a building interacts with the external environment.

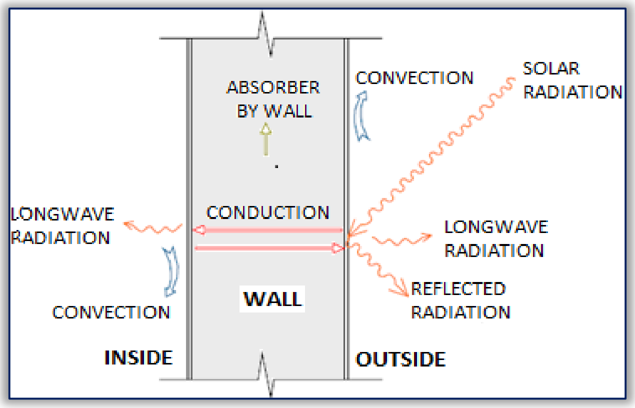


Figure 4. Heat transfer processes occurring in a wall [7]

Simplified method for performance estimation

In this section, basic concepts on conduction, convection, and radiation will be discussed.

— Conduction

Thermal conduction is the process of heat transfer from one part of a body at a higher temperature to another (or between bodies in direct contact) at a lower temperature. These happen with the negligible movement of the molecules in the body because the heat is transferred from one molecule to another in contact with it. Heat can be conducted through solids, liquids and gases. Some materials conduct more rapidly than others. The basic equation of heat conduction is:

$$Q_{cond} = \frac{k \cdot A \cdot (T_h - T_c)}{L} \text{ (W)} \tag{4}$$

where: k = thermal conductivity of the material (W/mK), A = area (m^2), L = thickness (m), T_h = temperature of the hot surface (K), T_c = temperature of the cold surface (K).

— Convection

The convection is the transfer of heat from one part of a fluid (gas or liquid) to another part at a lower temperature by mixing of fluid particles. Heat transfer by convection takes place at the surfaces of walls, floors and roofs. Because of the temperature difference between the fluid and the contact surface, there is a density variation in the fluid, resulting in buoyancy. These results in heat exchange between the fluid and the surface and are known as free convection. However, if the motion of the fluid is due to external forces (such as the wind), it is called forced convection. These two processes could occur simultaneously. The rate of heat transfer (Qconvection) by convection from a surface of area A can be written as:

$$Q_{conv} = h \cdot A \cdot (T_s - T_f) \text{ (W)} \tag{5}$$

where: h = heat transfer coefficient (W/m^2K), T_s = temperature of the surface (K), T_f = temperature of the fluid (K)

— Radiation

Radiation is the heat transfer from a body by virtue of its temperature; it increases as the temperature of the body increases. It does not require any fluid or medium for propagation. When two or more bodies at different temperatures exchange heat by radiation, heat will be emitted, absorbed and reflected by each body. The radiation exchange between two large parallel plane surfaces (of equal area A) at uniform temperatures T1 and T2 respectively can be written as:

$$Q_{12} = \frac{1}{(1/\varepsilon_1 + 1/\varepsilon_2 - 1)} \cdot A \cdot \sigma \cdot (T_1^4 - T_2^4) \text{ (W)} \tag{6}$$

where: σ = Stefan-Boltzmann constant (5.67×10^{-8} W/m^2K^4), A = area of surface (m^2), T_1 and T_2= temperature of surface 1 (K) and temperature of surface 2 (K), ε_1 and ε_2 = emissivity of surfaces 1 and 2 respectively.

In case of buildings, external surfaces such as walls and roofs are always exposed to the atmosphere. So the radiation exchange (Qrad) between the exposed parts of the building and the atmosphere is a major factor and is given by:

$$Q_{rad} = A \cdot \varepsilon \cdot \sigma \cdot (T_s^4 - T_o^4) \tag{7}$$

where: A = area of the building exposed surface (m^2), ε = emissivity of the building exposed surface, T_s = temperature of the building exposed surface (K), T_o = temperature of atmosphere (K).

Based on the concepts discussed above, we can calculate the various heat exchanges using a simplified method for performance estimation, based on Figure 1, taking place in a building.

— Conduction

The formula for calculating the rate of heat conduction (Qcond) in between any component of a building (roof, wall, etc.) under a fixed state is as follows [12]:

$$Q_{cond} = A \cdot U \cdot \Delta T \text{ (W)} \tag{8}$$

where: A= surface area (m^2), ΔT= temperature difference between inside and outside air (K), U= thermal transmittance (W/ m^2 K) is given by:

$$U = \frac{1}{R_T} \tag{9}$$

where R_T (m^2K/W) is the total thermal resistance and given by

$$R_T = \frac{1}{h_i} + (\sum_{j=1}^{n} L_j / k_j) + \frac{1}{h_0} \tag{10}$$

where: h_i and h_o = respectively, are the inside and outside heat transfer coefficients; L_j = is the thickness of the j-th layer and k_j is the thermal conductivity of its material.

The equation for calculating the rate of heat conduction (4) is resolved for each exterior constituent component or part of a building (roof, wall, door, window, etc.) and then they gained results are compiled. Moreover, the formula for expressing the heat flow rate through envelope by conduction is the sum of the area and the U-value products of all the elements of the building multiplied by the temperature difference [12]:

$$Q_c = \sum_i^{N_c} A_i \cdot U_i \cdot \Delta T_i \ (W) \tag{11}$$

where: i= building element and N_c= number of components.

— Ventilation

The heat flow rate due to ventilation of air between the interior of a building and the outside depends on the rate of air exchange. It is given by:

$$Q_v = \rho \cdot \dot{V}_r \cdot c \cdot \Delta T = \rho \cdot c \cdot \frac{N \cdot V}{3600} \cdot \Delta T \tag{12}$$

where: ρ = density of air (kg/ m³), $\dot{V}_r$ = ventilation rate (m³/ s), c = specific heat of air (J/ kgK), ΔT = temperature difference ($T_o - T_i$) (K), N = number of air changes per hour and V = volume of the room or space (m³).

— Solar Heat Gain

The solar heat gain that passes through transparent elements can be written as follows:

$$Q_s = \alpha_s \sum_{i=1}^{M} A_i \cdot S_{gi} \cdot \tau_i \tag{13}$$

where: α_s = mean absorptivity of the space, A_i = area of the i^{th} transparent element (m²), S_{gi} = daily average value of solar radiation (including the effect of shading) on the i^{th} transparent element (W/m²), τ_i = transmissivity of the i^{th} transparent element and M = number of transparent elements.

— Internal Gain

The heat flow rate, due to internal heat gain and occupation, is given by the equation:

Q_i = (No. of people x heat output rate) + Rated wattage of lamps + Appliance load (14)

3. THE INFLUENCE OF THE OUTSIDE TEMPERATURE ON THE MODEL OF A HEATING SYSTEM

The thermal analysis will be done on the Model Private House MPH: A_{MPH}= 183.6 m² and V_{MPH}=550.8 m³, Orientation: West.

The outside air temperature is the base parameter for determining the heating period; respectively, it is a parameter that has an impact on determining the annual energy quantities and operative costs.

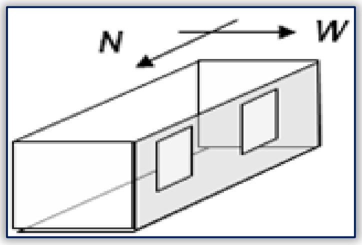


Figure 5. Design model MPH Pristina, t_o=-18°C

The outside air temperature measured at 21:00, for three days in a row, presents the critical temperature for the beginning and end of heating season. Thermal supply will be applied in cases when the data from metrological services show that outside temperature measured at 21:00, for three days in a row, is registered lower than 12°C, while it will stop when outside temperature is higher than 12°C [14]. Based on the outside air temperature, a heating season in Pristina begins on October 15th and ends on April 15th, amounting to 180 days or 3240 hours; nonetheless, there may be variations depending on the level of external air temperature [14].

The thermal analysis will be done based on two methods:

1. Specific heat consumption q_A (W/m²) and heated space q_V (W/m³), and
2. Based on the Excel program ThermoCalc.

The measured outdoor air temperature results are very well matched with the average values calculated by equation (1), the average value calculated at a temperature of 7, 14 and 21 hours, as seen in Figure 6.

The measured outdoor air temperature results are very well matched with the average values calculated by equation (1), the average value calculated at a temperature of 7, 14 and 21 hours, as seen in Figure 6.

Outside design temperature can be determined according to the Calpine criteria [11]:

$$1.\ t_{o10} = 0.4 \cdot t_{av10} + 0.6 \cdot t_{min10} = -15.30°C \tag{15}$$

where: t_{av10} = -5.70 °C – average monthly temperature of the coldest month in the last ten years, t_{min10} = -21.70 °C – the minimum monthly temperature in the last ten years [15].

Influential and necessary parameters to be analyzed are:

a. The average air temperature during heating,
b. The air temperature of the outside ambient.

Analysis is done for Pristina MPH model using climatic conditions and the air temperature for the period 2006-2015, figure 7. Moreover, maximum and minimum temperatures for January 2015, season 2015/16, and for the 2006-2015 periods are graphically presented, figure 8.

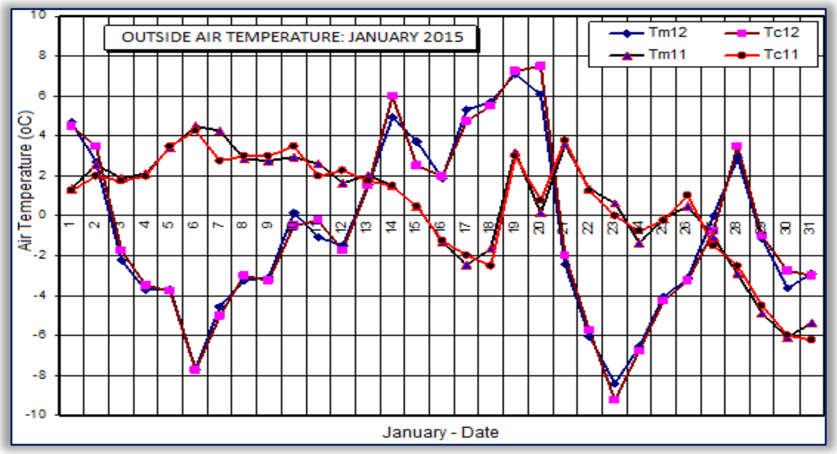


Figure 6. Daily outside temperature in Pristina, January 2015 [13]

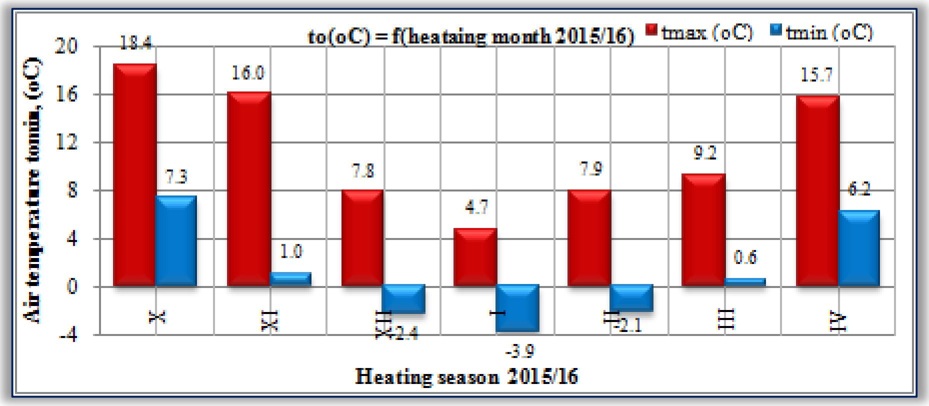


Figure 7. High and low air temperature during heating season in Pristina, 2015/16

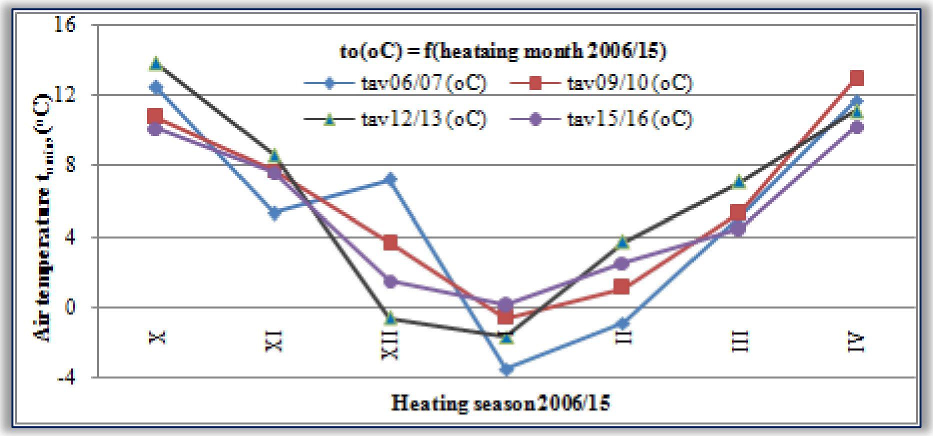


Figure 8. Average air temperature during the heating season in Pristina, 2006/15

— Analysis on the basis of specific heat consumption per q_A and q_V

The method for estimating the heat consumption per square meter or per cubic meter of heated space is not the most accurate approach; nonetheless, it can be used when we calculate approximately heating use or to check the specific heat consumption. In practice, as well as in literature, we can find different information about the specific heat consumption per square meter q_A (W/m^2) or per cubic meter q_V (W/m^3) in ranges [10, 11]: q_A= 70 to 170 (W/m^2) or q_V = 30 to 70 (W/m^3).

» Calculation Based on Specific Heat Consumption

The specific heat of the above model MPH can be calculated as follows:

$$q_0 = w \cdot (t_i - t_e) = 41.8 \text{ (W/m}^3\text{)} \quad (16)$$

where: w = 1.1 (W/m^{3}K) - the average transmission heat losses; t_i = 20 °C - average design temperature in the room; and t_e = -18 °C - outside design temperature for heating season, Pristina, Kosovo [13].

The heat consumption can be calculated using the following formula:

$$Q_k = \sum q_i V_i = 20953 \text{ (W)} \quad (17)$$

where: Σq_i = 41.8 (W/m^3) - specific mean heat for the heating space, and ΣV_i = 550.8 m^3 - total volume of the heating consumption for the model.

The obtained heat consumption value will increase from ventilation losses and heat transmission losses and will decrease from solar and internal gains of heat energy, as such that the total required heating sources is:

$$Q_t = Q_k + Q_v + Q_{tr} - Q_{sol} - Q_{ig} = 24683 \text{ (W)} \quad (18)$$

» Thermal performance of the model and heat consumption

For the calculation of annual heat consumption, Q_{ty} (kWh), it is necessary to determine the ratio of the average load of the heating season. This proportion can be calculated with the following formula:

$$k_{pr} = \frac{w \Delta t_m}{q_0} 100\% = 39.21\% \quad (19)$$

where: Δt_m= 14.9 ^{0}C - the daily mean temperature, calculated as the difference between the external and the internal temperature in the room and observed for a number of years (for Pristina it is: 20 to 5.77 = 14.9 ^{0}C).

From Figure 9 we obtain that the average load during the heating season is k_{ly} = 41.4% and the average air temperature during the heating period is t_{om} = 4.27 °C.

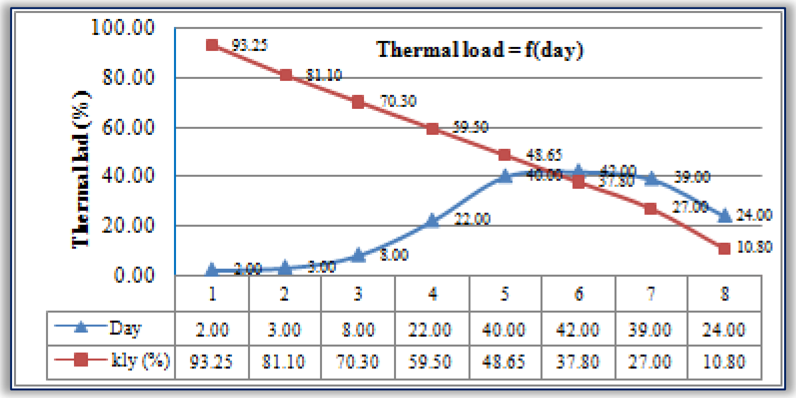
The average heat load during the heating period is:

$$Q_{tm} = Q_t \cdot k_{ly} = 24683/1000 \cdot 41.40/100 = 10.22 \text{kW} \quad (20)$$

The annual heat consumption can be determined with the following formula:

$$Q_{ty} = Q_{mt} \cdot t_{HS} = 10.22 \cdot 3240 = 33112.80 \text{kWh} \quad (21)$$

where: t_{HS} = 180 days x 18 hours = 3240 h - time of heating season.



	1	2	3	4	5	6	7	8
Day	2.00	3.00	8.00	22.00	40.00	42.00	39.00	24.00
kly (%)	93.25	81.10	70.30	59.50	48.65	37.80	27.00	10.80

Figure 9. The relative length of the temperature interval during the heating season

Average specific heat consumption:

$$q_{Aty} = \frac{Q_{ty}}{A_{mph}} = 33112.80/183.6 = 180.35 \text{kWh/m}^2 \text{ per year} \quad (22)$$

$$q_{Vaty} = \frac{Q_{ty}}{V_{mph}} = 33112.80/550.8 = 60.12 \text{kWh/m}^3 \text{per year} \quad (23)$$

The analysis based on the ThermoCalc Excel program

The analysis of air temperature influence on heating, for the model of a private house (MPH), is based on the Unified Construction Code of Kosovo, Section 3 – Buildings. This Technical Regulation Code regulates technical requirements for thermal energy savings and thermal protection. These requirements are related both to new construction projects and to reconstruction and adaptation of the existing buildings with an internal heating temperature above 12 °C.

The ThermoCalc Excel Program was designed based on part 2.2 Simplified method for performance estimation (basic concepts on conduction, convection, and radiation) based on the equations (8), (11), (12), (13) and (14) - Conduction, Ventilation, Solar Heat Gain and Internal Gain, respectively, for determining the amount of heat required for heating. The ThermoCalc Excel program has three files, Input File (climatic and material data), File for Calculations, and File for Results (tabulation and graphs).

The following figure provides detailed data derived from the ThermoCalc analysis [16].

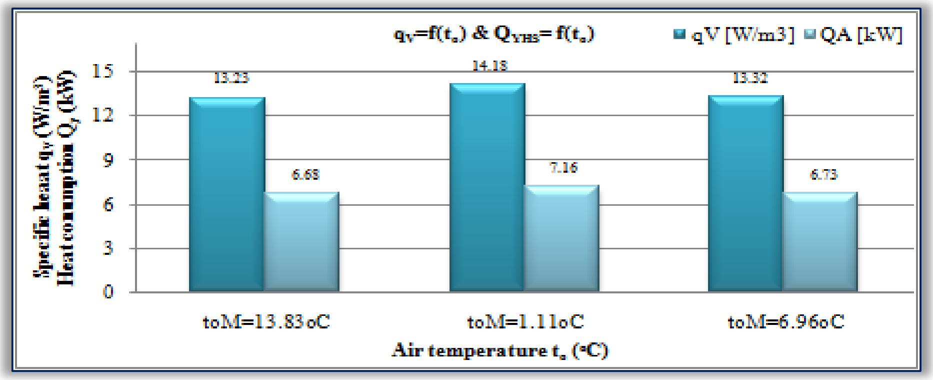


Figure 10. The influence of air temperature (t_{omax} °C, t_{omin} °C, t_{oav} °C) on the specific heat consumption $q_V=f(t_o)$; yearly heat consumption $Q_{YHV}=f(t_o)$ 2015/16

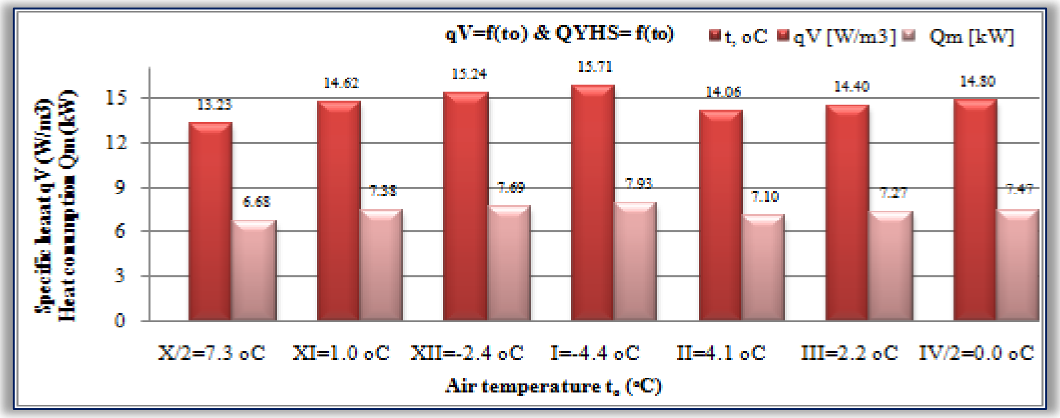


Figure 11. The influence of average air temperature (t °C) on the specific heat consumption $q_V=f(t_o)$ and on the monthly heat consumption $Q_m=f(t_o)$ from October 2015 to April 2016

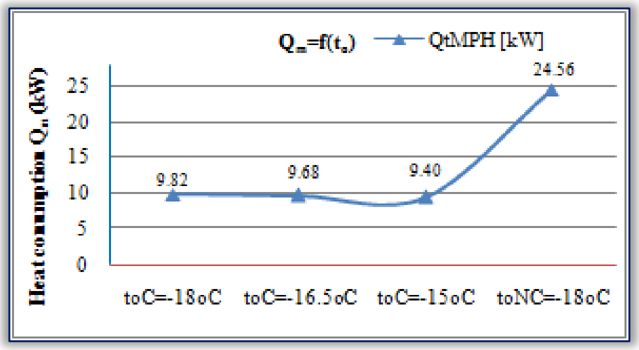


Figure 12. The influence of different design air temperatures on the heat consumption when the MPH model is designed based on the Unified Construction Code (t_{oC}) and when it is not designed based on the Unified Construction Code (t_{oNC})

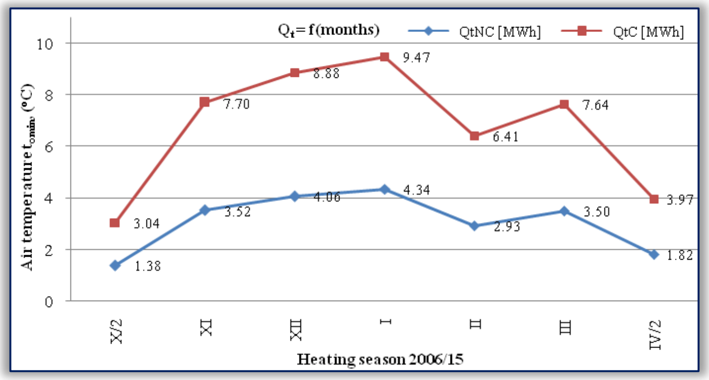


Figure 13. Monthly heat consumption when the MPH model is designed based on the Unified Construction Code (Q_{tyC}) and not based on the Unified Construction Code (Q_{tyNC})

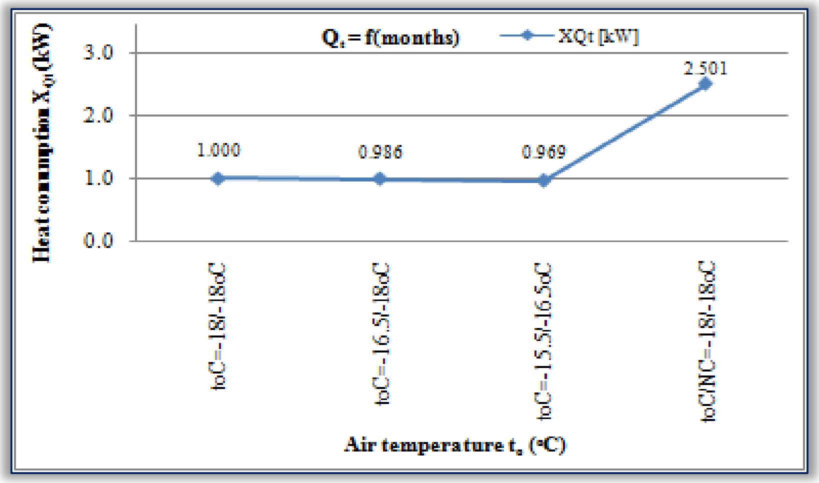


Figure 14. The influence of the outside temperature on the heating consumption savings

4. RESULTS AND DISCUSSION

In this paper, the influence of the outside temperature on the design of the heating system of Model Private House MPH: A_{MPH}= 183.6 m2, V_{MPH}= 550.8 m3 is based on two methods:

- Analysis by specific heat consumption per q_A (W/m^2) and q_V (W/m^3), and
- Excel Program ThermoCalc

through which we achieved the following results:

Based on figure 10, we can comprehend the influence or the impact of outside air temperature in the specific heat consumption q_V (W/m^3) and of heat consumption Q (kW) during the heating season based on the maximum, minimum and average temperature (t_{omax} °C, t_{omin} °C, t_{oav} °C) for the heating season of 2015/2016.

Figure 11 presents the influence of the outside air temperature, average outside temperature (t°C), for heat season from October 2015 to April 2016, on the specific heat consumption qv=f(to) (W/m^3) and on monthly heat consumption Q_M=f(to) (kW).

Based on the analysis on figure 10 and 11, the opportunity for applying modular systems of two boilers can be analysed as a choice for large municipalities. The first thermal boiler can be used for covering the average heat load, based on the results gained after calculating the average outside air temperature t_{oav} (°C), while the second boiler can be applied for covering the peak heat load, t_{omin} (°C); hence, resulting in increased efficiency of the boilers. If we take into consideration the monthly and yearly heating energy consumption, we can plan the amount of burning fuels needed to be used for heating during the following season.

Figure 12 presents the influence of different air temperature designs (t_{oC}=-18/-16.5/-15°C and t_{oNC}=-18°C) on the heat consumption when the MPH model is designed based on the Unified Construction Code (t_C°C) and when it is not planned based on the Unified Construction Code (t_{oNC}).

Figure 13 presents the monthly heat consumption when the MPH model is designed based on the Unified Construction Code (Q_{tC}) and not based on the Unified Construction Code (Q_{tNC}).

As a result, we can conclude that the outside air temperature influences the heating energy consumption. In figure 12 and figure 13 we can see the ratio of heat consumption $X_{NC//C}$=Q_{tNC}/Q_{tC}=24.56/11.73=2.09 for the object that is not designed based on the Unified Construction Code (objects in Pristina designed during 1950/85), and those who are designed based on the Unified Construction Code. The current level of heat consumption in Pristina is estimated at around 219 kWh/m^2 per year compared to 80 –150 kWh/m^2 per year in Western Europe, which indicates that there is a significant opportunity for energy efficiency improvements [18].

Figure 14 represents the influence of the air temperature on the heating consumption savings when MPH model is designed based on the Unified Construction Code Q_{tC}= f(to). In figure 14 we can see that the ratio of heat consumption is X_{Qto}=Q_{toC}-18/Q_{toC}-16=0.986 and X_{Qto}=Q_{toC}-16/Q_{toC}-16=0.969 i.e. heat consumption saving is 1.50% against the adjusted outside temperature of +1.5°C.

5. CONCLUSIONS

Based on the results gained from figure 7, 8, 13 and especially from figure 12 we can analyse and conclude the impact of outdoor design temperature on heating consumption. The analysis is based on the calculation of energy consumption for outdoor temperatures t_{out}=-18/-16.5/-15°C. The results gained show that for buildings constructed as per the Unified Construction Code the outside temperature influence is quite small, Y_1=Q_{tC}-18/Q_{tC}-16.5=1.40%; Y_2=Q_{tC}-16.5/Q_{tC}-15=1.70%; Y_3=Q_{tNC}-18/Q_{tC}-18=150.10% compared to those built not per the Unified Construction Code.

In conclusion, based on the results gained from this paper – figures 12, 13, and 14, the impact of outside design temperature on the heat energy consumption when the Unified Construction Code of Kosovo. Section 3 – Buildings is applied – we can recommend a correction on the outside design temperature (t_o=-18°C) for heating because it was adopted back in 1974.

References

[1] Ferrari, S., Zanotto, F., Thermal Comfort Approaches and Building Performance, Springer,
[2] Briefs in Applied Sciences and Technology, pp 47-60, 2015.
[3] Rupp, R.F., Vasquez, N.G., Lamberts, R., A Review of Human Thermal Comfort in Built Environment, Energy and Buildings, 105, pp 178-205, 2015.
[4] ASHRAE Standard 55-2013, Thermal Environmental Conditions for Human Occupancy. American Society of Heating, Refrigerating and Air-Conditioning Engineers, 2013.
[5] Luo, M., Cao, B. Ji, W., Ouyang, Q., Lin, B., Zhu, Y., The Underlying Linkage Between Personal Control and Thermal Comfort, Psychological or Physical effects, Energy and Buildings, 111, pp 56-63, 2016.
[6] De Dear, R.J., Brager, G.S., The Adaptive Model of Thermal Comfort and Energy Conservation in the Built Environment, International Journal of Biometeorology, 45, pp 100-108, 2001.
[7] Sing, M.K., Attia, S., Mahapatra, S., Teller, J., Assessment of Thermal Comfort in Existing Pre-1945 Residential Building Stock, Energy 98, pp122-134, 2016.
[8] Faye C. M., Jerald D. P., Jeffrey D. S. "Heating, Ventilating, and Air Conditioning". Analysis and Design. Fifth Edition. John Wiley & Sons Inc., 2000.
[9] Recknagel, Sprenger, Schramek, Ceperkovic: Heating and Air Conditioning, Interklima, Vrnjacka Banja, 2012.
[10] ASHRAE Handbook of Fundamentals, I-P Edition, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. Atlanta, Georgia, 2009
[11] Krasniqi, F., Heating and Air-Conditioning II, Faculty of Mechanical Engineering. Pristina, 2000.
[12] Zrnic, S., C. Zivojin. "Heating and Air-Conditioning". The Eighth Edition. Naucna Knijga, Beograd, 1987.
[13] Nayak, J.K., Prajapati, J.A., Handbook on Energy Conscious Buildings, Indian Institute of Technology, Bombay, India, 2006.
[14] Evangelisti, L., Battista, G., Guattari, C., Basilicata, C., De Lieto Vollaro, R., Analysis of Two Models for Evaluating the Energy Performance of Different Buildings, Sustainability 2014, 5311-5321, DOI:10.3390/su6085311.
[15] Termokos Pritina (District Heating Company), Distribution Code, Pristina, 2013.
[16] Energy Regulatory Office, Thermal Energy Tariffs, Kosovo, 2016.
[17] Berisha, Xh. Excel Program ThermoCalc, Faculty of Mechanical Engineering. Pristina, September, 2010.
[18] Energy Community, 2nd National Energy Efficiency Action Plan (NEEAP) of Kosovo, Pristina, 2013.
[19] Draft Final Report, National Building Energy Efficiency Study for Kosovo, EPTISA, 2013.

ISSN 1584 - 2665 (printed version); ISSN 2601 - 2332 (online); ISSN-L 1584 - 2665