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GLOBAL WARMING AND OUTDOOR DESIGN TEMPERATURE

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ABSTRACT
Global temperature increase on Earth, due to climate change, indicates the need for a data revision pertaining to outdoor design temperature and number of degree – days. In this paper, based on the relevant data pertaining to tempereture mesurements in Sarajevo for a period of ten years (since 2001 to 2010), new outdoor design temperature - 13°C is defined, instead of applicable temperature -18°C and number of degree days 2381°C-ann, instead of applicable 3077°C-ann. The results of calculation show that requirement for thermal energy is 22% less for outdoor design temperature of -13°C. Therefore, there is the need for data revision pertaining to outdoor design temperature and number of degree – days, wich could lead to a correction in the heating systems. As a consequence, atmospheric CO_2 emmision will be less in the building sector, which can play a key role in combating climate change.
Keywords: climate change, outdoor design temperature, greenhouse gas emissions

1. INTRODUCTION
The World Meteorological Organization (WMO) with its operational systems, scientific and research programs that include all national hydrometeorological services of member countries, including Bosnia and Herzegovina since 1994, plays an important role in the implementation of the United Nations Framework Convention on Climate Change and adoption of the Protocol to the Convention, as well as other legal mechanisms, which have a paramount importance for protection of planet Earth’s climate. Based on the data collected by the World Meteorological Organization, years 2005 and 2010 were ranked as the warmest ever since 1880, when the measurement has been introduced. The data confirm the Earth's significant long-term warming trend. Global temperature has increased by 0.6 - 0.9°C, and the rate of temperature increase has nearly doubled in the last 50 year. Climate change is caused by increased greenhouse gases emission into the atmosphere, such as CO_2, SO_2, NO_x, dust particles and similar. Since the beginning of industrial revolution until today, CO_2 concentrations in the atmosphere have increased for 30%, concentration of methanol has doubled and concentration of sodium oxide has increased for 15%. Current CO_2 atmospheric concentrations average 280 ppm, which means that they are higher today than for at least 420000 years, (Figure 1). Given that the number of people on Earth has more than tripled in the period from 1850 to 1970, the increase in energy demand was more than predictable. The problem, however, lies in the fact that 86% of primary energy production in the world has come from burning fossil fuels, the result of which is CO_2.

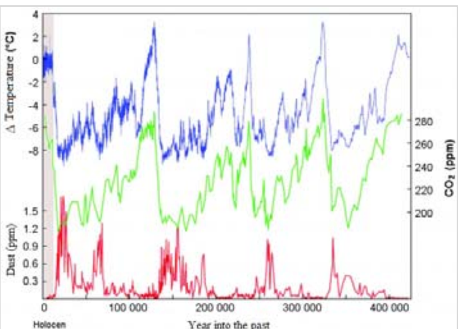

Figure 1. Temperature, CO_2 and dust concentrations on Planet Earth throughout history - ice core data from Vostok polar base, Antarctica (1999)[6]

The use of fossil fuels as energy source in the residential sector has caused the building sector to become one of the larger sources of atmosphere pollution. It is estimated that energy use in buildings accounts for more than 40% of all CO_2 emissions. Therefore, buildings can play a key role in combating climate change.

2. IMPACT OF THE GLOBAL CLIMATE CHANGE ON BOSNIA AND HERZEGOVINA

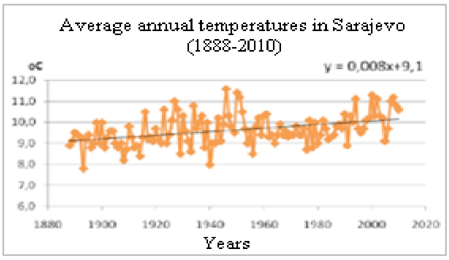

Figure 2. Average annual temperature trend in Sarajevo [5]

The research of the global climate change effects has shown that:

- (i) An increase of average annual temperatures in B&H in the past 100 years has been about 0.6 ºC (Figure 2),
- (ii) There are contrasts in these trends between different seasons, with summer and winter showing the greatest increase,

There are two important parameters to consider when designing heating plants:

- Outdoor design temperature that governs dimensioning of the heating plants
- A degree-day (CDD) - an index used to determine the amount of energy needed for heating.

In view of average annual temperature increase in B&H in the past 100 years, there is a need to revise data pertaining to design temperatures and number of degree-days. In the following text outside design temperature will be defined based on the relevant data pertaining to measurements of temperature over a 10 year period (2001-2010), as well as a number of degree days.

3. CALCULATION OF OUTDOOR DESIGN TEMPERATURE

Calculations of the heating overload in the building sector have so far been based on the applicable outdoor design temperature for Sarajevo, ODT= – 18°C[1]. Given the average increase of average annual temperature in B&H in the past 100 years for about 0.6°C, a need has arisen to determine new outdoor design temperature. Based on the air temperature data for the period 2001 – 2010 that were obtained from the Federal Institute for Hydrometeorology archives in Sarajevo [2] and calculation method according to a Russian scientist Chaplin, [3] a new outdoor design temperature for Sarajevo would be -13°C and it also satisfies other criteria, DIN 4701, 1983 and ASHRAE, 1985, as well.

TOTAL HEAT LOSS CALCULATIONS ACCORDING TO DIN 4701

Heat loss calculation design for a residential unit has been developed based on the project assignment, architectural-construction base, and heat loss calculation standards and regulations.

Two cases have been considered:

- Case I: outdoor design temperature (official) - 18°C
- Case II: outdoor design temperature (only used within the scope of this paper) - 13°C.

Other design-related data in both cases have remained unchanged:

- indoor temperature in heated areas 10-24 °C, depending on their intended use,
- staircase is not heated and adjacent apartments are heated,
- several energy sources shall be analyzed in the function of a primary energy source on the same surface for the official outdoor design temperature and the ODT used within the scope of this paper

3.1. Basic characteristics of the analyzed residential unit

Face wall composition: compo 2cm + perforated brick 20cm+expanded polystyrene 5cm+compo 1cm. Construction assembly of the building has been designed as a skeletal AB system with solid AB-slabs d=15cm of inter-floor structure. The slabs lean on 30x30cm AB-poles via AB–beams. The floor height is 2.55m. Heat transfer coefficient for particular construction elements is given in Table 1.

[1] According to the Yugoslav generic obligatory standard JUS U.J5.600 from 1987 that resulted from the revision of standard JUS U.J5.600 from 1980, ODT for Sarajevo is -18°C, and it has remained unchanged ever since and is being applied as a recognized technical rule pursuant to the Law on Construction.

Table 1. Heat transfer coefficient for particular construction elements

Heat transfer coefficient U [W/m²K]	Exterior wall – brick	Interior wall – 20cm	Interior wall – 25cm	Windows	Exterior door	Interior door
	0,55	1,62	1,4	3,1	3,5	2,0

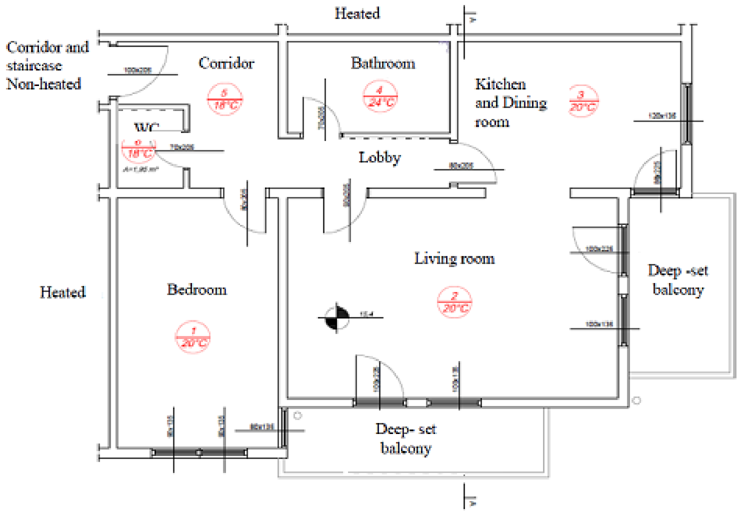

Figure 4. Plan of the apartment analyzed

The following are the results obtained after the analysis (Table 2). The difference between the results of heat load calculation for ODT = -18°C and ODT = -13°C, taking into consideration total heat load is 12.3%, (Figure 5).

Table 2. Heat load analysis results

ODT	Transmission heat load	Ventilation heat load	Total heat load
	Q_T [W]	Q_v [W]	Q_u [W]
-18°C	2789	2627	5416
-13°C	2470	2281	4751

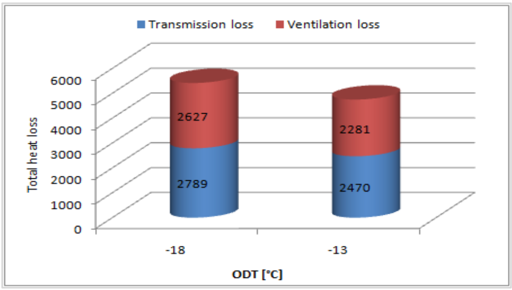

Figure 5. Results of the total heat loss analysis

5. THE CONCEPT OF DEGREE-DAYS

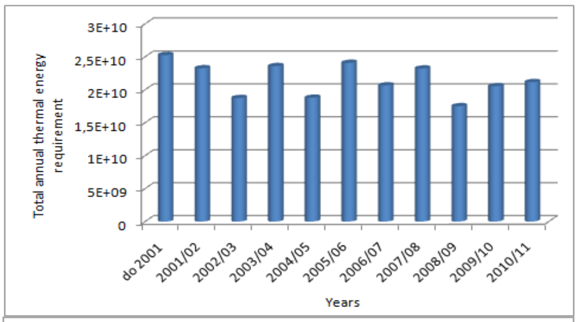

Figure 6. Graphic presentation of annual requirement for thermal energy for heating in J/year in the period 2001 – 2010 compared the period up to 2001.

Actual heating requirements change day by day and their calculation for a year is made based on the concept of "degree-days". According to the applicable data, number of heating days for Sarajevo is n=211, and number of degree days G_{SD}=3077°C-ann. The results of the analysis based on relevant temperature values for the period 2001 – 2010 in Sarajevo show a significant decrease of heating days (average number of heating days for the above-mentioned period is n=162), that have an impact on the total annual heating requirements, and the

number of degree-days would be G_{SD} =2381°C-ann.[4]
The results obtained show that the total annual requirement for thermal energy for heating is 22% lesser than in calculations where the input was the still applicable outdoor design temperature of -18°C and number of degree-days in the heating season per annum for Sarajevo G_{SD} = 3077°C-god, (Figure 6).

6. FUEL CONSUMPTION

Annual fuel consumption represents initial data for determining average annual heating costs, for dimensioning of liquid fuel reservoir, or the required room size for storing solid fuels .[4]An overview of annual fuel consumption and annual savings in KM for different energy sources per two analyzed outdoor design temperature scenarios is given in Table 3.

Table 3. Annual fuel consumption and annual savings resulting from the difference in the outdoor design temperature

	Energy source cost	Bottom thermal power, H_d	Annual fuel consumption		Financial costs [KM]		Annual savings [KM]
			-18°C	-13°C	-18°C	-13°C	
Gas, m^3	1,03 KM/m^3	33,34 MJ/m^3	842	658	867	677	190
Heating oil, l	2,10 KM/l	42 MJ/l	672	525	1411,2	1102,5	308,7
Electri., kWh	0,1427 KM/ kWh	3,6 MJ/kWh	7015	5483	1001	782	219
Pellets, kg	0,35 KM/kg	17,1 MJ/kg	1624	1269	568	444	124

7. CO_2 EMISSION

Table 4. CO_2 emissions depending on the outdoor design temperature and fuel type

	Coefficient of CO_2 emissions [kg/MWh]	Mass of CO_2 emitted, [kg/a]	
		-18°C	-13°C
Gas	277	1943	1519
Heating oil	330	2315	1809
Electricity	1340	9400	7347
Pellets	4	28	22

In this chapter, CO_2 emissions, depending on the external design temperature and type of fuel shall be reviewed.

CO_2 emissions will be calculated according to IPCC (Intergovernmental Panel on Climate Change) guidelines. [1] Results of the analysis are given in Table 4.

8. CONCLUSION

In this paper, the calculatin of heat load according to DIN 4701 for the analyzed residential unit was done. Two cases have been considered, for the valid ODT of -18 ° C, and the ODT calculated in this paper, of -13 ° C. The results of analysis show that with the new value of the design temperature, thermal load, for analysed residential unit, is 12.3% lesser. This means that the heating plants are oversized and it should be worked on this issue, because there is a need for correction of ODT. Analysis based on the concept of “degree-days” show that the total annual requirement for thermal energy for heating is 22% lesser for the period 2001 – 2010, compared to period until 2001 which has a direct impact on reduction of fuel consumption and CO_2 emission.

9. REFERENCES

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