OPTIMISATION OF ZERO-NET ENERGY HOUSE ORIENTATION IN CITIES OF DIFFERENT LATITUDE

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Abstract: *Reaching zero net energy buildings is one of the leading tracks in research nowadays. One of the factors that can definitely help reaching that level of energy saving is orientation of the buildings. During the daylight on specific location each side of the inspected building is absorbing different amount of solar energy. It is obvious that this dependence will change with geographic latitude but also with weather conditions on inspected location. Some specific angles of the object orientation to the cardinal direction is analyzed in this paper and simulations are done in EnergyPlus software. Characteristic period of the year are simulated, which include heating (winter) and cooling (summer) period. Analyses are done for the zero-net energy buildings for the geographic latitude of Belgrade, Athens and Berlin.*
Keywords: *Zero Net Energy Buildings, EnergyPlus, Heating and Cooling Period, Energy Consumption, Single double and triple window glazing*

1. INTRODUCTION

Nowadays, zero net energy buildings (ZNEB) are researched all around the world as they present new generation in building constructions. One of the factors that can definitely help reaching that level of energy saving is orientation of the buildings. During the daylight on specific location each side of the inspected building is absorbing different amount of solar energy. That amount of energy depends on many factors, which include orientation of the building according to cardinal directions. It is obvious that this dependence will change with geographic latitude, but also with weather conditions on inspected location.

Andersson et al. were first to research the impact of building orientation on residential heating and cooling [1]. The study was carried out for 25 climates in the United States. They used software program BLAST to analyze the influence of the orientation. They concluded that in these regions, it is better to have windows oriented towards south or north than to east or west. Yohanis and Norton investigated useful solar gains in multi-zone non-domestic buildings as a function of building orientation and thermal time constant [2]. Morrissey et al. experimented with building orientation and its influence on affordable passive solar design [3]. Mitchell et al. investigated influence of building orientation on climate weathering cycles in Hamptonshire, UK [4].

Bojic et al. did a research toward positive net buildings in Serbian conditions [5]. Bojic et al. also did a simulation and optimization of positive net buildings [6].

Some specific angles of the object orientation to the cardinal direction is

analyzed in this paper and simulations are done in EnergyPlus software. Characteristic period of the year are simulated, which include heating (winter) and cooling (summer) period, but also two transition periods like spring and autumn. Aim of the paper is to summarize these results and to suggest optimal orientation of the building from the aspect of the building solar energy absorption through the walls. Analyses are done for the zero-net energy buildings for the average geographic latitude of Athens, Belgrade and Berlin.

2. MODEL

2.1 Geometrical and thermal description

Investigated house model is located in Belgrade and it presents house for one family of four members. During the winter house is heated by using electric baseboard radiator, and during the summer house is cooled by air conditioners. House is shown on Figure 1.

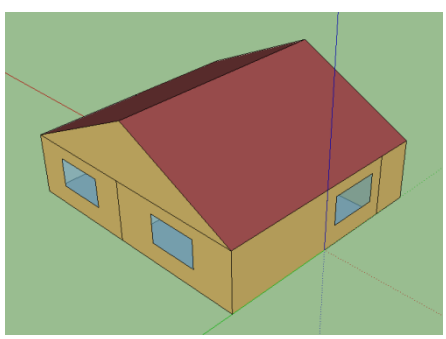

Figure 1. Investigated building

House basement plane is given on Fig. 2. It can be seen that house has 1 living room, 2 bedrooms, kitchen, corridor, toilet and WC. Area of conditioned space is 90 m^2.

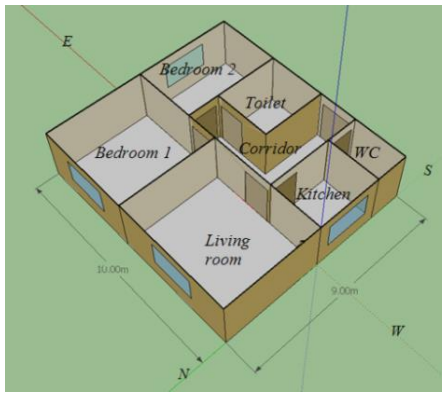

Figure 2. House plan

Originally, windows of the living room and bedroom 1 are oriented toward north.

Heating of the house and cooling is performed during whole year. House is heated from 6 am to 22 pm. During this time house is heated to 22°C in toilet, and to 20°C in living room, bedrooms, and kitchen. WC and corridor are heated to 18°C. During night setpoint temperature for heating is at 15°C.

As for cooling, only conditioned rooms are living room, bedrooms, and kitchen which all have 1 window. There is no need for cooling of the toilet, wc and corridor. Setpoint temperatures for cooling is from 6 am to 24pm is at 24°C.

2.2 Weather description

Investigated locations are different by its latitude and therefore its temperatures are not the same but also the energy needed for cooling and heating.

Latitude, longitude and elevation of used cities are given in table 1.

Table 1. Geographic position of cities

	Latitude North	Longitude East	Elevation, m
Athens	37°58’	23°43’	15
Belgrade	44°49’	20°28’	99
Berlin	52°30’	13°23’	49

Also average highest and lowest temperatures for summer and winter [7-9] are given in table 2.

Table 2. Average temperatures, °C

	Summer		Winter	
	High	Low	High	Low
Athens	32	22	13	6
Belgrade	27	16	3	-3
Berlin	23	13	2	-3

3. RESULTS AND DISCUSSION

Results show that buildings in the Athens require small amount of energy for heating and this is due to the hot winters in comparison with Belgrade and Berlin. This is presented on Fig. 3. Also it can be seen that if the house living room and bedroom are oriented toward south energy needed for heating presents only the half of the energy needed for heating if they are oriented toward the north. Energy consumption needed for heating in Athens if the house is oriented towards the south is 17 times smaller than for Berlin and 13.3 times smaller than for Belgrade. When energy needed for heating is considered in Belgrade, savings are about 17% when north and south orientation is compared. In Berlin case this saving is at 9%. This saving is because of the heat gain through the walls and windows. It can be also seen that if the house is oriented to east or south-east it has lower energy consumption than to the house oriented towards west or the south-west.

But when energy consumption needed for cooling is considered, results are different than that for the heating. These results are presented on the Fig. 4. It can be seen that in this case house in Athens has the biggest consumption, especially when it is oriented toward the south-east. This is due to high amount of solar heat gains during the summer days.

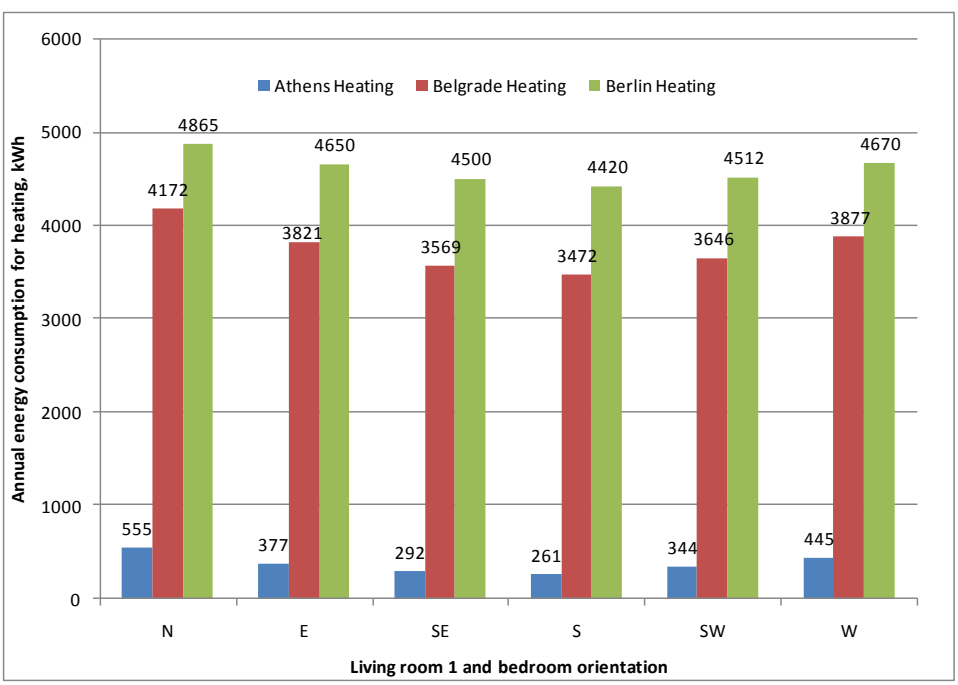

Figure 3. Energy consumption for heating depending on the orientation and location

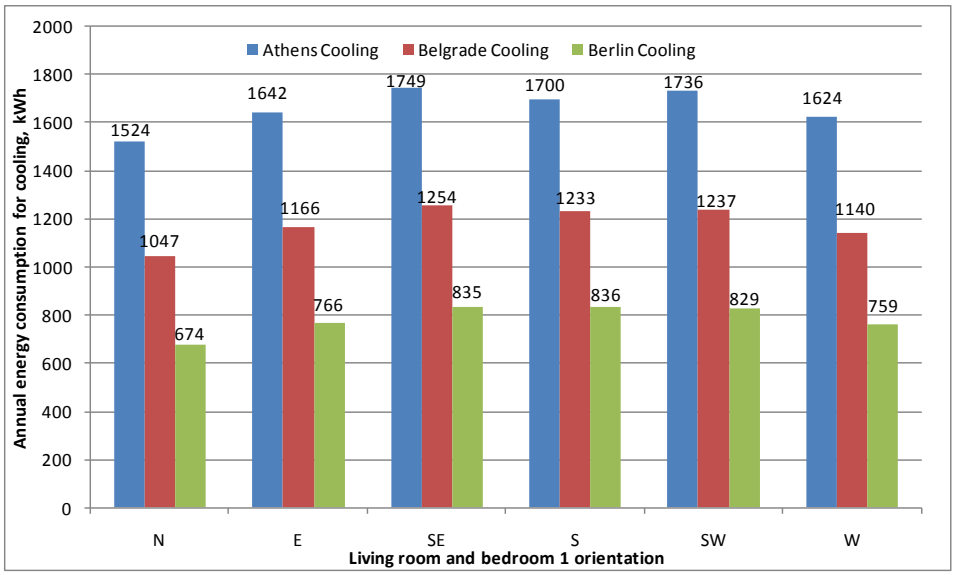

Figure 4. Energy consumption for cooling depending on the orientation and location

It can be seen that energy needed for cooling has about the 2 times bigger consumption in Athens than that in Berlin. Highest consumption of energy is in Athens then in Belgrade and the lowest energy consumption for cooling is in Berlin. Energy consumption for cooling is about 13%-20% smaller when house is oriented toward north than toward south-east depending on the location of the house. Total energy consumption for heating and cooling is given in Fig 5.

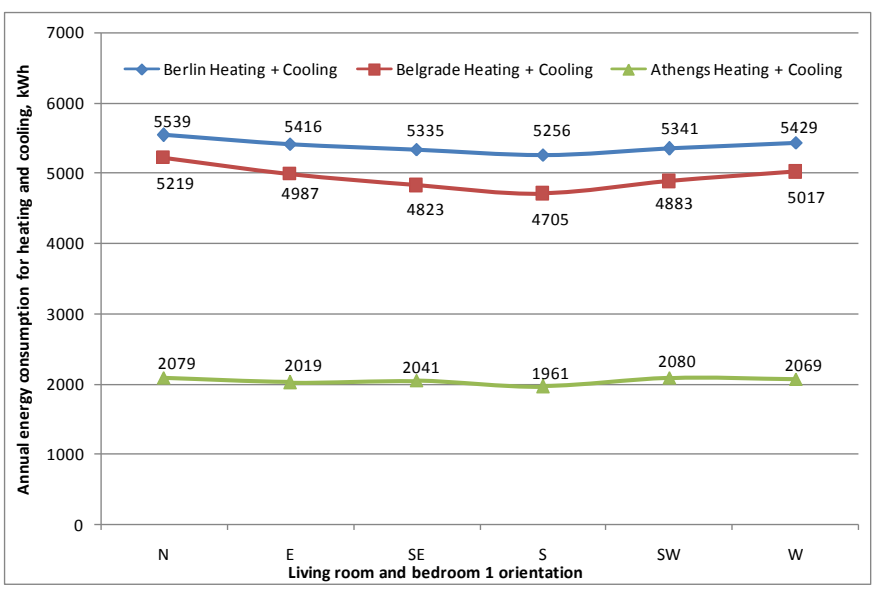

Figure 5. Energy consumption for heating and cooling depending on the orientation and

location

Total energy consumption shows that the best solution is to have the living room and bedroom 1 oriented towards the south, even in case of Athens where energy needed for cooling is higher than for the heating. In cases when house is located in Belgrade and Berlin there isn't any doubt in which cardinal direction house windows should be oriented.

5. CONCLUSION

Results show that the smallest total energy consumption is when the house is oriented towards south. In case of the heating this orientation saves a lot of energy, and when the cooling is considered a small amount of energy is lost when house is oriented south rather than to the north.

In cases of Berlin and Belgrade there is no doubt that savings are big and they are 5% and 10% respectively if the house is oriented toward south than to the north when total energy is considered. In case of the Athens this saving is about 5%.

Also when heating saving is considered, savings are unexpectedly highest when using proper orientation in Athens is 55%. This is due to a small energy needed for heating. This savings are 295 kWh annually but due to a solar heat gain during summer, total savings during the year in Athens are 110 kWh. As for the Belgrade savings in energy needed for heating are 603 kWh (17%), and total energy saving is 514 kWh. As for the Berlin savings in energy needed for heating are 445kWh (9%), and total energy saving is 283 kWh.

And finally, it can be seen that the south-east orientation has better results than the south-west orientation, and that the east orientation has better results than the west orientation.

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