UTICAJ NAČINA DEFINISANJA RASPOREDA PRISUSTVA LJUDI NA TOPLOTNE DOBITKE OD LJUDI U OKVIRU JEDNOG STUDENTSKOG DOMA

IMPACT OF THE METHODS OF OCCUPANCY SCHEDULE DEFINING ON PEOPLE HEAT GAINS WITHIN A STUDENT DORMITORY

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1. Introduction

The people occupancy within the room of an building is the information that significantly influences energy consumption as well as the quality of indoor environment of the same room (building). People releasing sensible and latent heat influence the temperature and humidity of the air in the room which they occupy. On the other side, the occupant behavior defined through the frequency and time of window and door opening, operation of lighting and electrical appliances also affects the heat gains and losses of the building. One of the major problems when using a software for simulation the energy and environmental behavior of a buildings is the fact that the people occupancy is most often defined using the fixed and unrealistic schedules. As a consequence, the obtained values of the estimated energy consumption significantly deviate from the values of the real energy consumption. In relation with that, this paper outlines the importance and the need for proper definition of the people occupancy within the simulation software with the aim of obtaining as real as possible data related to the energy consumption of the simulated building.

In this paper the impact of the methods of occupancy schedule defining on people heat gains within a student dormitory in the city of Kragujevac (Serbia) was analyzed. The schedules are defined for rooms which students and janitors occupy (bedrooms, toilets, bathrooms and a restaurant). The impact of the yearly schedule defined according to the occupancy for a single day of the year (fixed schedule) and the impact of the detailed yearly occupancy schedule (variable schedule), on the people heat gains, by using the EnergyPlus software, was considered.Basic text should be tagged as Normal style.

2. Description of the analyzed building

The analyzed building is located in Kragujevac.
It was assumed that the heat gain per person amounts 99 W, which is related to the activity of reading (seated).

Table 1. Names of the rooms with accommodation capacities

Name (2nd level)	Accommodation capacity	Name (3rd level)	Accommodation capacity
Restaurant (1st level)	75	Bathroom	4
Bathroom	4	Toilet	4
Toilet	4	Room 1	Three bed room
Room 1	Three bed room	Room 2	Three bed room
Room 2	Three bed room	Room 4	Three bed room
Room 4	Three bed room	Room 5	Three bed room
Room 5	Three bed room	Room 6	Four bed room
Room 6	Four bed room	Room 7	Four bed room
Room 7	Four bed room	Room 8	Four bed room
Room 8	Four bed room	Room 9	Four bed room
Room 9	Four bed room	Room 10	Three bed room
Room 10	Three bed room	Room 11	Four bed room
Room 11	Four bed room	Room 12	Three bed room
Janitor's room	One bed room	Janitor's room	One bed room

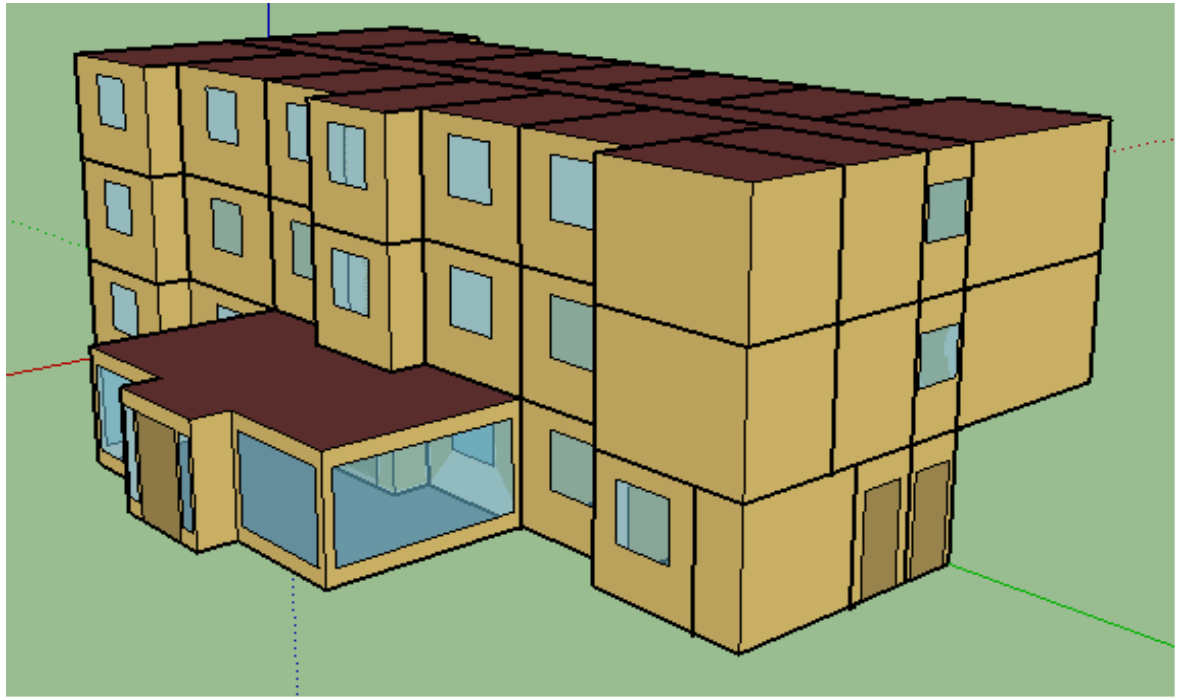


Fig. 1. Isometric view of the analyzed student dormitory

3. Detailed people occupancy for entire year

The occupancy schedules include people occupancy in the dormitory during the weeks (days) of lectures at faculties, the occupancy during the weeks of vacation, as well as the student occupancy in the dormitory during National holi-days of the Republic of Serbia for 2017 (Table 2).

Table 2. National holidays of the Republic of Serbia (in 2017)

Date	Holyday
01-05.01.	New Year holidays
05-08.01.	Christmas holidays
15.02. and 16.02.	National Day
14-17.04.	Easter holidays
01.05. and 02.05.	Labor Day
11.11.	The Day of Armistice in the First World War

3. Detailed people occupancy for entire year

Table 3. People occupancy for Monday and Tuesday

	00 – 06 h	06 – 07 h	07 – 08 h	08 – 12 h	12 – 13 h	13 – 14 h	14 – 17 h	17 – 18 h	18 – 19 h	19 – 20 h	20 – 22 h	22 – 23 h	23 – 24 h
Three bed room	1	0	0	0	0	1	0	1	0	1	0	0	1
Four bed room	1	0	0	0	0	1	0	1	0	1	0	0	1
Janitor's room	1	0	0	1	0	0	1	0	0	0	1	0	1
Restaurant	0	0	1	0	1	0	0	0	1	0	0	0	0
Toilet	0	1	0	0	0	0	0	0	0	0	0	1	0
Bathroom	0	1	0	0	0	0	0	0	0	0	0	1	0

Table 4. People occupancy for Wednesday

	00 – 06 h	06 – 07 h	07 – 08 h	08 – 12 h	12 – 13 h	13 – 14 h	14 – 18 h	18 – 19 h	19 – 20 h	20 – 22 h	22 – 23 h	23 – 24 h
Three bed room	1	0	0	0	0	1	0	0	1	0	0	1
Four bed room	1	0	0	0	0	1	0	0	1	0	0	1
Janitor's room	1	0	0	1	0	0	1	0	0	1	0	1
Restaurant	0	0	1	0	1	0	0	1	0	0	0	0
Toilet	0	1	0	0	0	0	0	0	0	0	1	0
Bathroom	0	1	0	0	0	0	0	0	0	0	1	0

Table 5. People occupancy for Thursday

	00 – 06 h	06 – 07 h	07 – 08 h	08 – 12 h	12 – 13 h	13 – 14 h	14 – 16 h	16 – 18 h	18 – 19 h	19 – 20 h	20 – 22 h	22 – 23 h	23 – 24 h
Three bed room	1	0	0	0	0	1	0	1	0	1	0	0	1
Four bed room	1	0	0	0	0	1	0	1	0	1	0	0	1
Janitor's room	1	0	0	1	0	0	1	0	0	0	1	0	1
Restaurant	0	0	1	0	1	0	0	0	1	0	0	0	0
Toilet	0	1	0	0	0	0	0	0	0	0	0	1	0
Bathroom	0	1	0	0	0	0	0	0	0	0	0	1	0

Table 6. People occupancy for Friday

	00 – 06 h	06 – 07 h	07 – 08 h	08 – 12 h	12 – 13 h	13 – 14 h	14 – 16 h	16 – 17 h	17 – 18 h	18 – 19 h	19 – 20 h	20 – 22 h	22 – 23 h	23 – 24 h
Three bed room	1	0	0	0	0	1	0	1	0.66	0	0.66	0	0	0.66
Four bed room	1	0	0	0	0	1	0	1	0.5	0	0.5	0	0	0.5
Janitor's room	1	0	0	1	0	0	1	0	0	0	0	1	0	1
Restaurant	0	0	1	0	1	0	0	0	0	0.58	0	0	0	0
Toilet	0	1	0	0	0	0	0	0	0	0	0	0	0.5	0
Bathroom	0	1	0	0	0	0	0	0	0	0	0	0	0.5	0

3. Detailed people occupancy for entire year

Table 7. People occupancy for Saturday

	00 – 07 h	07 – 08 h	08 – 09 h	09 – 12 h	12 – 13 h	13 – 14 h	16 – 18 h	18 – 19 h	19 – 20 h	20 – 22 h	22 – 23 h	23 – 24 h
Three bed room	0.66	0	0	0.66	0	0	0.66	0	0.66	0	0	0.66
Four bed room	0.5	0	0	0.5	0	0	0.5	0	0.5	0	0	0.5
Janitor's room	1	0	0	1	0	1	0	0	0	1	0	1
Restaurant	0	0	0.58	0	0.58	0	0	0.58	0	0	0	0
Toilet	0	0.5	0	0	0	0	0	0	0	0	0.5	0
Bathroom	0	0.5	0	0	0	0	0	0	0	0	0.5	0

Table 8. People occupancy for Sunday

	00 – 07 h	07 – 08 h	08 – 09 h	09 – 12 h	12 – 13 h	13 – 16 h	16 – 18 h	18 – 19 h	19 – 20 h	20 – 22 h	22 – 23 h	23 – 24 h
Three bed room	0.66	0	0	0.66	0	0	1	0	1	0	0	1
Four bed room	0.5	0	0	0.5	0	0	1	0	1	0	0	1
Janitor's room	1	0	0	1	0	1	0	0	0	1	0	1
Restaurant	0	0	0.58	0	0.58	0	0	1	0	0	0	0
Toilet	0	0.5	0	0	0	0	0	0	0	0	1	0
Bathroom	0	0.5	0	0	0	0	0	0	0	0	1	0

3. Detailed people occupancy for entire year

Table 9. People occupancy for student arrival day

	00 – 16 h	16 – 18 h	18 – 19 h	19 – 20 h	20 – 22 h	22 – 23 h	23 – 24 h
Three bed room	0	1	0	1	0	0	1
Four bed room	0	1	0	1	0	0	1
Janitor's room	0	1	0	0	1	0	1
Restaurant	0	0	1	0	0	0	0
Toilet	0	0	0	0	0	1	0
Bathroom	0	0	0	0	0	1	0

Table 10. People occupancy for National Day

	00 – 07 h	07 – 08 h	08 – 09 h	09 – 12 h	12 – 13 h	13 – 15 h	15 – 18 h	18 – 19 h	19 – 22 h	22 – 23 h	23 – 24 h
Three bed room	1	0	0	1	0	0	1	0	0	0	1
Four bed room	1	0	0	1	0	0	1	0	0	0	1
Janitor's room	1	0	0	1	0	1	0	0	1	0	1
Restaurant	0	0	1	0	1	0	0	1	0	0	0
Toilet	0	1	0	0	0	0	0	0	0	1	0
Bathroom	0	1	0	0	0	0	0	0	0	1	0

Table 11. People occupancy for 13th of April

	00 – 06 h	06 – 07 h	07 – 08 h	08 – 12 h	12 – 13 h	13 – 16 h	16 – 24 h
Three bed room	1	0	0	0	0	1	0
Four bed room	1	0	0	0	0	1	0
Janitor's room	1	0	0	1	0	1	0
Restaurant	0	0	1	0	1	0	0
Toilet	0	1	0	0	0	0	0
Bathroom	0	1	0	0	0	0	0

Table 12. People occupancy for 28th of April

	00 – 06 h	06 – 07 h	07 – 08 h	08 – 12 h	12 – 13 h	13 – 14 h	14 – 16 h	16 – 17 h	17 – 24 h
Three bed room	1	0	0	1	0	1	0	1	0
Four bed room	1	0	0	1	0	1	0	1	0
Janitor's room	1	0	0	1	0	0	1	0	0
Restaurant	0	0	1	0	1	0	0	0	0
Toilet	0	1	0	0	0	0	0	0	0
Bathroom	0	1	0	0	0	0	0	0	0

3. Detailed people occupancy for entire year

August examination period

Table 13. People occupancy for Monday

	00 – 07 h	07 – 08 h	08 – 09 h	09 – 12 h	12 – 13 h	13 – 14 h	14 – 17 h	17 – 18 h	18 – 19 h	19 – 22 h	22 – 23 h	23 – 24 h
Three bed room	0.66	0	0	0	0	0.66	0	0.66	0	0.66	0	0.66
Four bed room	0.75	0	0	0	0	0.75	0	0.75	0	0.75	0	0.75
Janitor's room	1	0	0	1	0	0	1	0	0	1	0	1
Restaurant	0	0	0.72	0	0.72	0	0	0	0.72	0	0	0
Toilet	0	0.75	0	0	0	0	0	0	0	0	0.75	0
Bathroom	0	0.75	0	0	0	0	0	0	0	0	0.75	0

Table 14. People occupancy for Tuesday

	00 – 07 h	07 – 08 h	08 – 09 h	09 – 12 h	12 – 13 h	13 – 16 h	16 – 18 h	18 – 19 h	19 – 20 h	20 – 22 h	22 – 23 h	23 – 24 h
Three bed room	0.66	0	0	0	0	0	0.66	0	0	0.66	0	0.66
Four bed room	0.75	0	0	0	0	0	0.75	0	0	0.75	0	0.75
Janitor's room	1	0	0	1	0	1	0	0	1	1	0	1
Restaurant	0	0	0.72	0	0.72	0	0	0.72	0	0	0	0
Toilet	0	0.75	0	0	0	0	0	0	0	0	0.75	0
Bathroom	0	0.75	0	0	0	0	0	0	0	0	0.75	0

Table 15. People occupancy for Wednesday

	00 – 07 h	07 – 08 h	08 – 09 h	09 – 12 h	12 – 13 h	13 – 15 h	15 – 18 h	18 – 19 h	19 – 20 h	20 – 22 h	22 – 23 h	23 – 24 h
Three bed room	0.66	0	0	0	0	0.66	0	0	0	0.66	0	0.66
Four bed room	0.75	0	0	0	0	0.75	0	0	0	0.75	0	0.75
Janitor's room	1	0	0	1	0	0	1	0	1	1	0	1
Restaurant	0	0	0.72	0	0.72	0	0	0.72	0	0	0	0
Toilet	0	0.75	0	0	0	0	0	0	0	0	0.75	0
Bathroom	0	0.75	0	0	0	0	0	0	0	0	0.75	0

Table 16. People occupancy for Thursday

	00 – 07 h	07 – 08 h	08 – 09 h	09 – 12 h	12 – 13 h	13 – 14 h	14 – 17 h	17 – 18 h	18 – 19 h	19 – 22 h	22 – 23 h	23 – 24 h
Three bed room	0.66	0	0	0	0	0.66	0	0.66	0	0.66	0	0.66
Four bed room	0.75	0	0	0	0	0.75	0	0.75	0	0.75	0	0.75
Janitor's room	1	0	0	1	0	0	1	0	0	1	0	1
Restaurant	0	0	0.72	0	0.72	0	0	0	0.72	0	0	0
Toilet	0	0.75	0	0	0	0	0	0	0	0	0.75	0
Bathroom	0	0.75	0	0	0	0	0	0	0	0	0.75	0

3. Detailed people occupancy for entire year

August examination period

Table 17. People occupancy for Friday

	00 – 07 h	07 – 08 h	08 – 09 h	09 – 12 h	12 – 13 h	13 – 14 h	14 – 17 h	17 – 18 h	18 – 19 h	19 – 22 h	22 – 23 h	23 – 24 h
Three bed room	0.66	0	0	0	0	0.66	0	0.66	0	0	0	0.66
Four bed room	0.75	0	0	0	0	0.75	0	0.5	0	0	0	0.5
Janitor's room	1	0	0	1	0	0	1	0	0	1	0	1
Restaurant	0	0	0.72	0	0.72	0	0	0	0.58	0	0	0
Toilet	0	0.75	0	0	0	0	0	0	0	0	0.5	0
Bathroom	0	0.75	0	0	0	0	0	0	0	0	0.5	0

Table 18. People occupancy for Saturday

	00 – 07 h	07 – 08 h	08 – 09 h	09 – 12 h	12 – 13 h	13 – 14 h	16 – 18 h	18 – 19 h	19 – 22 h	22 – 23 h	23 – 24 h
Three bed room	0.66	0	0	0.66	0	0	0.66	0	0	0	0.66
Four bed room	0.5	0	0	0.5	0	0	0.5	0	0	0	0.5
Janitor's room	1	0	0	1	0	1	0	0	1	0	1
Restaurant	0	0	0.58	0	0.58	0	0	0.58	0	0	0
Toilet	0	0.5	0	0	0	0	0	0	0	0.5	0
Bathroom	0	0.5	0	0	0	0	0	0	0	0.5	0

Table 19. People occupancy for Sunday

	00 – 07 h	07 – 08 h	08 – 09 h	09 – 12 h	12 – 13 h	13 – 15 h	15 – 17 h	17 – 18 h	18 – 19 h	19 – 20 h	20 – 22 h	22 – 23 h	23 – 24 h
Three bed room	0.66	0	0	0.66	0	0	0.66	0.66	0	0	0.66	0	0.66
Four bed room	0.5	0	0	0.5	0	0	0.5	0.75	0	0	0.75	0	0.75
Janitor's room	1	0	0	1	0	1	0	0	0	1	1	0	1
Restaurant	0	0	0.58	0	0.58	0	0	0	0.72	0	0	0	0
Toilet	0	0.5	0	0	0	0	0	0	0	0	0	0.75	0
Bathroom	0	0.5	0	0	0	0	0	0	0	0	0	0.75	0

4. People occupancy for entire year according to the occupancy for a single day

Table 20. People occupancy for entire year according to the occupancy for a single day

	00 – 06 h	06 – 07 h	07 – 08 h	08 – 12 h	12 – 13 h	13 – 17 h	17 – 18 h	18 – 19 h	19 – 22 h	22 – 23 h	23 – 24 h
Three bed room	1	0	0	0	0	0	1	0	1	0	1
Four bed room	1	0	0	0	0	0	1	0	1	0	1
Janitor's room	1	0	0	1	0	1	0	0	1	0	1
Restaurant	0	0	1	0	1	0	0	1	0	0	0
Toilet	0	1	0	0	0	0	0	0	0	1	0
Bathroom	0	1	0	0	0	0	0	0	0	1	0

5. Results

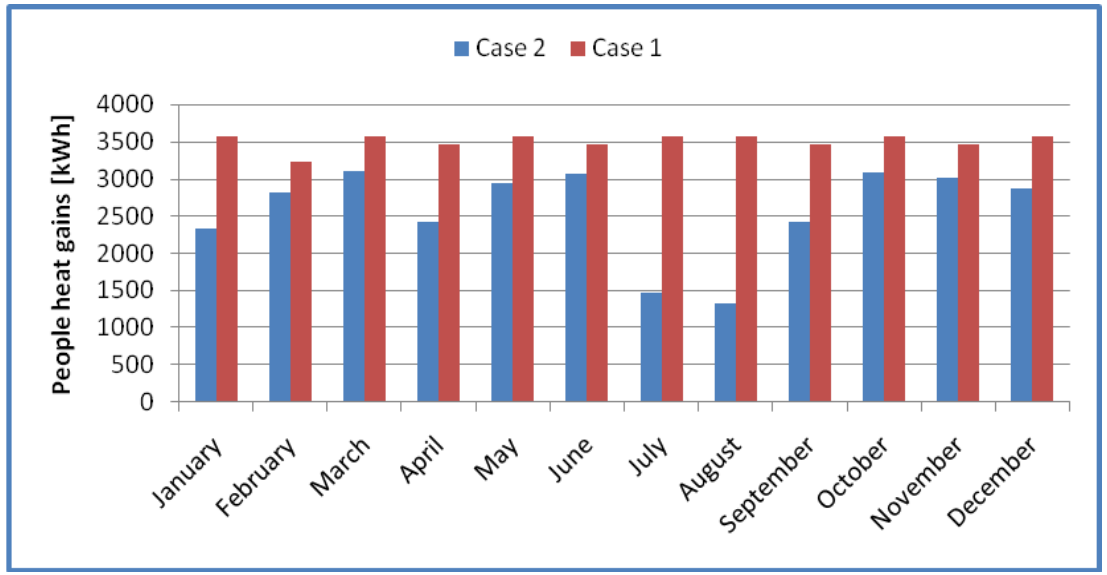
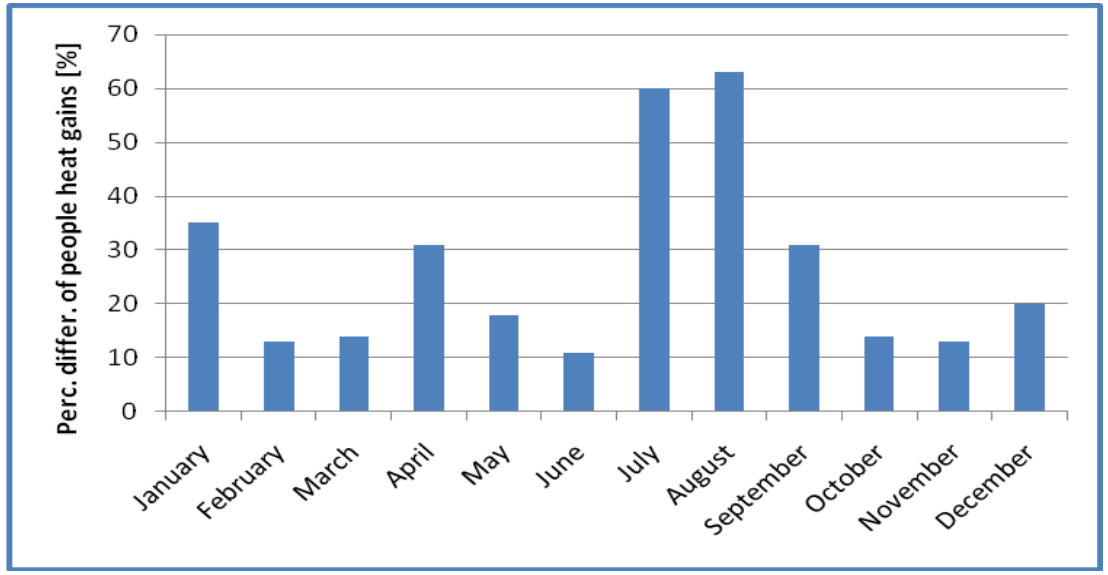


Fig. 2. The people heat gains for two analyzed methods of occupancy schedule defining: yearly occupancy schedule defined according to the occupancy for a single day (Case 1) and detailed yearly occupancy schedule (Case 2)

Fig. 3. Percentage difference of people heat gains for two analyzed methods of occupancy schedule defining



6. Conclusions

In this paper the impact of the methods of occupancy schedule defining on people heat gains within a student dormitory in the city of Kragujevac was analyzed. The schedules are defined for rooms which students and janitors occupy (bedrooms, toilets, bathrooms and a restaurant). The total number of considered rooms is 28. The impact of the yearly schedule defined according to the occupancy for a single day of the year and the impact of the detailed yearly occupancy schedule, on the people heat gains, by using the EnergyPlus software, was considered. The occupancy schedules include people occupancy in the dormitory during the weeks (days) of lectures at faculties, the occupancy during the weeks of vacation, as well as the student occupancy in the dormitory during National holidays of the Republic of Serbia for 2017. The results indicate a significant difference in people heat gains for two analyzed methods of occupancy schedule defining. The average percentage difference of heat gains is 27%. The highest difference amounts 63% (August) and the lowest amounts 11% (June). This paper outlines the importance and the need for a proper and detailed definition of the people occupancy within the simulation software with the aim of obtaining as real as possible data related to the heat gains or losses of the simulated building.