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Milos Matejic[1)]
Mirko Blagojevic[1)]
Nenad Petrovic[1)]
Dragan Cvetkovic[1)]
Milorad Bojic[1)]

1) Faculty of Engineering, University of Kragujevac, Serbia
{mmatejic, mirkob,npetrovic, bojic}@kg.ac.rs, dragan_cw8202@yahoo.com

INFLUENCE OF THE MEANS, INTENSITY AND POSSIBILITIES OF EXPLOATING LOW-RISE BUILDINGS ON ENERGY SAVINGS AND RESULTS OF THEIR OPTIMIZATION

Abstract: *This research is oriented on maximizing beneficial and at the same time minimizing negative effects when creating energy efficient buildings. Optimization is done in Design Builder software based on various criteria. An object was designed for the needs of this paper using standard materials and systems built into the software. For creating objects meant for examination a minimization of CO_2 emissions, costs of building and installation, while a maximization of efficiency inan energy sense has been performed. Variables have been selected only as systems which are assumed to have the greatest influence on the optimization process. Pareto optimum suggests specific values which would be best for creating the final model. This approach has a great perspective for analysis and forecasting behavior of energy efficient buildings, in order to have theirexploitation benefit the overall life comfort.*
Keywords:*energy efficiency, exploitation, comfort, optimization, Design Builder*

1.INTRODUCTION

One of the important aspects of energy savings is definitely the means of building exploitation. With energy savings a decrease in CO_2 emissions is achieved. Today energy efficiency and energy efficient building are primary themes amongst researchers in this field. Means of using heating, ventilation and night lighting have a very large influence on energy efficiency, [1, 2, 3]. By means of use is considered the number of tenants, as well as their attitude towards use of heating, ventilation and night lighting. For researching energy efficiency tenant habits as well as their lifestyle are also important, [4]. Energy use changes depending on weather the tenants are awake, sleeping of away. Dividing walls also have influence on a building's energy efficiency [5]. In order to achieve the best possible thermal comfort the means of heating is very important, [6]. It is very important that the temperature of a house gravitates towards a constant value throughout the entire year and that it has the smallest possible oscillations regardless of the season. It is also important to have a certain amount of fresh air in the entire house, which is achieved either through natural or mechanical ventilation [7,8]. All these parameters which are considered up to now can be also viewed as variables of a multi-criteria optimization, [9].

The increase of energy efficiency is

viewed through approaching a zero-net energy consumption, [10]. Approaching a zero-net energy consumption is achieved through making the house not only an energy consumer, but also a producer. This is in most cases done through installing PV panels on the house roof.

For the purposes of this research a model of a house has been created in Design Builder. Simulations of the usual building conditions and exploitation for the territory of Serbia have been performed. After that a multi-criteria optimization was performed in order to determine the optimal conditions of exploitations and house infrastructure. The paper ends with drawn conclusions and given directions towards possible further research in this field.

2. PROBLEM STATEMENT

This paper is based on a real project of a house, therefore it can have a great use in practice. The base motivation behind writing this paper comes from the need for optimizing a developed house model's characteristics according to the lifestyle in Serbia.

2.1 Base assumptions on house type

This house is designed as a ground floor housing unit with a net area of 76.5m^2. The house contains two bedrooms, a dining room, kitchen with dining room, bathroom and hallway. The house is intended for families of two to five members. The house has a porch. The house is designed for level or slightly gradated terrain.

2.2 Base assumptions on house building methods in Serbia

Houses in Serbia are usually intended for two to three tenant. The most commonly used method of heating is by radiators, with a small efficiency. Ventilation is helped by use of fans since the floor plan is generally bad for natural ventilation. The most commonly used windows are aluminum without thermal interrupt. Windows take up, up to, 30% of the outer wall area.

3. ANALYZED HOUSE MODEL

In regard to assumptions, which are founded on real knowledge, a model of a house has been made in Design Builder software. Wall material and siding are chosen according to common practice. The model is shown in figure 1.

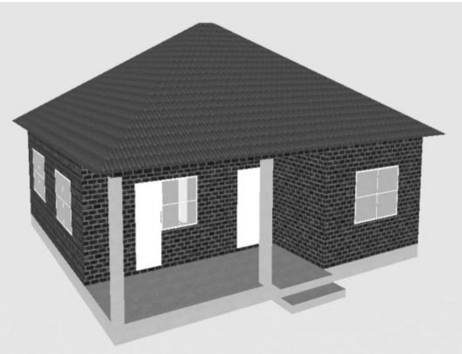

Figure 1 - Model of analyzed house

The floor plan is modeled so that the house is suitable for three to five tenants. The layout of the floor plan is shown in figure 2.

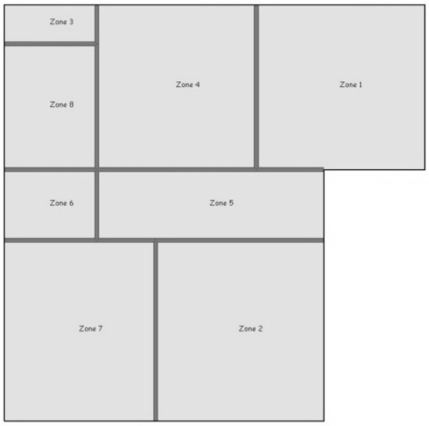

Figure 2 - Floor plan

The house is modeled so that all rooms have at least one outside wall, which contains one or more windows. Thermal isolation of the house is done with siding brick, therefore it is possible to make this house for all climate conditions. From the front side of the house as an exit from the bedroom a porch with an overhang is made which enables the roof to have square shape even though the house does not have a square base. The roof is pitched. The bearing structure of the roof is wooden, and is covered by roof tile. The roof angle is pitched at 30^0.

4. RESULTS

Calculation and simulation results are also attained from Design Builder software, with the help of Energy Plus. For optimization purposes Design Builder has developed an interface which works on the principles of the Genetic algorithm. For the purposes of this paper a previous calculation and simulation were made, followed by optimization and final calculations and simulations.

4.1 Previous calculations and simulations of yearly house behaviour

Initial calculation parameters for the house are as follows: two tenants, radiator heating using hot water with fan ventilation of CoP=0.35 efficiency, aluminum frame windows and a window coverage of 30% of the outer walls. Radiators are heated by wood and coal.

These parameters are taken from the most frequent practice in Serbia. Families most usually account for two to three members. The heating system is a most commonly found system which uses hot water radiators which burn wood and coal. This system has an efficiency of 0.35. Windows are most frequently aluminum framed without thermal break. For ventilation instead of frequent natural ventilation electric fans are used. The amount of daily light with a 30% wall coverage on outer walls is shown on figure 3.

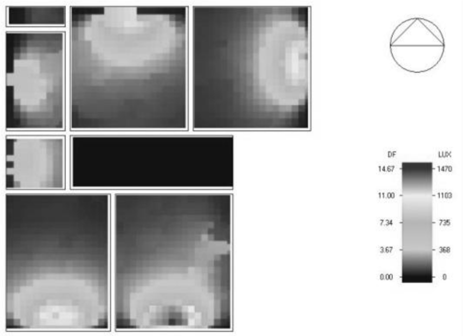

Figure 3.*Amount of natural light before optimization*

This configuration emits 12258 kg of CO_2 and costs 154780 GBP yearly. Invested power going into the heating system is 15.6 kW.

4.2 CO_2emission and house price optimization

Optimization of the house is done according to goal functions for minimizing CO_2 emissions and minimizing costs. Aside from minimizing prices it is necessary to maintain comfort and maximize house utilization. As optimization variables parameters which influence comfort and maximize utilization of space are used:

- occupancy in relation to the house,
- weekly occupancy,
- window coverage of outer walls,
- window type.
- heating system type,
- efficiency of heating system

Occupancy in relation to the entire house is chosen so that it varies the number of tenants from 3 to 5. Occupancy during the week is set to vary from four to six days. Window coverage of outer walls is set from 30to 50%. For window types the options are: aluminum frames without thermal stop, aluminum frames with thermal stop, PVC windows, windows with lacquered wood frames, and normal wood frame windows. Heating systems taken into consideration are: fan heaters, six types of radiators with hot water, and floor heating system. During optimization various conditions were set so that the price of the house with its systems does not exceed 160000 GBP and that the CO_2 emissions do not exceed 10000 kg. yearly. Optimization is done in 125 iterations. Results of the optimization are shown in figure 4.

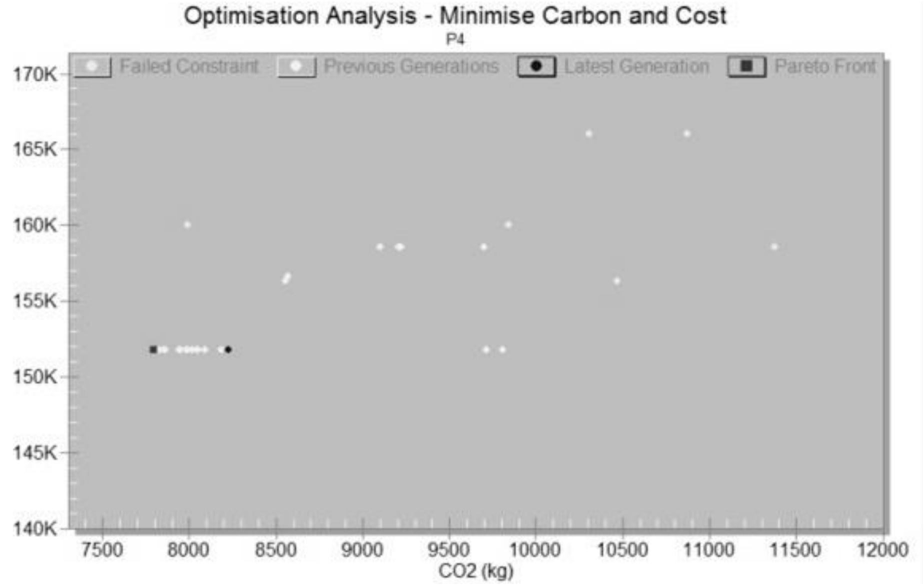

Figure 4 - Optimization diagram

From figure 4 four types of points can be seen: white, yellow, blue and red. Yellow points represent the solutions which exceedset limits. White points represent solutions which are located within the acceptable boundaries. Blue points represent the final iteration of the solution, while the red points represent the optimal solution. In this case for reaching an optimal solution which represents a minimization of CO_2 emissions and price, the following parameters are attained:

- four tenants should have this house in order for the space to be the optimal solution,
- tenants should be in the house 5.3 out of 7 days a week,
- window coverage on outer walls should be 44%,
- windows should be made from lacquered wood,
- heating should be done by hot water radiators and natural ventilation, and
- the heating system should have an efficiency of 0.94.

A house of this configuration has CO_2 emissions of 7798 kg yearly, while its price would be 151800 GBP. Invested power in heating the system which gives this CO_2 emission is 16.3 kW. Other solutions which are close to optimal have the same price with a lowered CO_2 emission. Solutions close to optimal vary in heating system efficiency, occupancy of the house and number of days spent in the house weekly. These variations from the optimal values are very small.

4.3 Final calculation and simulation of yearly house behaviour

In the final calculation simulations and calculations were done according to attained optimal parameters. Calculation of necessary heating system power, simulation of yearly behaviour and simulation of daily light were completed. Figure 5.shows simulation results for daily lighting according to the optimal solution.

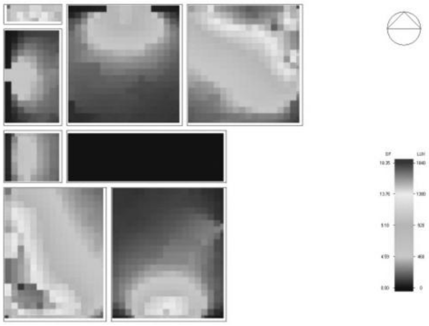

Figure 5 - Results of natural light simulation

5. CONCLUSION

Comparison of results before and after optimization gives the best picture of how much traditional solutions and habits are worse than optimal. CO_2 emissions with the optimal solution have a decrease of 35% in relation to the initial model. Cost of building and installing systems in the house is decreased by 2% from the traditional building. In orger to achieve the optimal solution and maximize house utilization the number of tenants is increased from two to four. Windows are changed from aluminum to lacquered wood. Window coverage has increased from 30 to 44%. Heating systems are not changed, but as a result of lowering CO_2 emissions natural ventilation can be used. Efficiency is increased from 0.30 to 0.94. Due to an increase of window area an unnoticeable increase in projected heating power was achieved.

Lastly it can be concluded that with minor changes, in building planning as well as in changes a big drop in CO_2 emissions and increase of efficiency can be achieved.

Further research in this field of house optimization could be renewed in order to determine the influence of specific parameters on optimization results.

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