AN ENERGY CONSUMPTION ANALYSIS ON PUBLIC APPLICATIONS IN THE CITY OF NOVI SAD

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Abstract:
The aim of the paper was to analyse energy efficiency indicators of energy consumption over public buildings in the territory of the City of Novi Sad. Also, the paper analyses the costs of energy and water consumption, as well as the emission of CO_2 and other greenhouse gases. Analysis of energy consumption was carried out on 200 public buildings in the territory of the City of Novi Sad. The time frame for observing energy consumption is 2013-2015. years. Total average primary energy consumption for the mentioned period amounted to 8,142 teo, and the average value of emissions of harmful gases with greenhouse gases was 25,527.23 tCO_2.

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Energy, public utility objects, energy efficiency, CO_2 emission

1. INTRODUCTION

The world's rapidly growing energy consumption rates, coupled with the associated environmental impacts of such energy consumption, has raised concerns in different communities and among researchers, engineers, and even politicians [1,2]. This concern raised the problem of increasing energy consumption as one of the most important geopolitical issues of today [3]. From fossil fuels today, coal is the largest source of CO_2 emissions in the world with emissions of 43.9%, followed by oil 35.3% and natural gas with 20.3% emissions. [4]. Actual global emissions increased by 1.4% over 2011, reaching a total of 34.5 billion tonnes in 2012. The CO_2 emissions trend reflects energy-related human activities which were determined by economic growth, particularly in emerging countries. In 2012, a decoupling of the increase in CO_2 emissions from global economic growth (in GDP) took place, which points to a shift toward less fossil fuel-intensive activities. Furthermore, trend reflects enhanced use of renewable energy and increased energy saving [5,6]. Even if humans stop combusting fossil fuels and discharging CO_2 into the atmosphere, the average global temperature of the Earth will continue to increase for the rest of the century. The long lifetime of CO_2 (estimated in the 100-300 year range [7,8]) means that the excess atmospheric stocks (515 Gt Carbon) would continue to drive radiative forcing and global warming for many decades [8,9].

2. ENERGY EFFICIENCY OF PUBLIC BUILDING

One of the main reasons for the application of energy efficiency in buildings is the protection of the environment, reducing CO_2 emissions and other harmful gases into the atmosphere [10-13]. The building sector is responsible for 40% of global energy consumption and 30% of anthropogenic greenhouse gas (GHG) emissions [14,15]. The energy consumption of buildings is responsible for 38% of CO_2 emissions to the atmosphere, 52% of SO_2 emissions, and 20% of N_{ox} emissions [2,16]. For example, by applying energy efficiency measures, CO_2 emissions and other harmful gases in FR of Germany are reduced by 27%, and today FR of

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Germany 1/3 receives its energy from renewable energy sources [17].

The largest number of residential buildings in the Republic of Serbia is now in the energy class G, which means that it consumes more than 175 kWh/m^2 for heating purposes [18], cases for public buildings consume about 169 kWh/m^2 [17,19]. Here we should add the fact that due to the old age of buildings and installations on them from year to year increase maintenance costs. The average energy needed to heat buildings in the Republic of Serbia is about 2.5 times higher than in the countries of the European Union. In the Republic of Serbia, 70% of buildings have no isolation, which is one of the reasons why they consume about 40% of the energy. An investment of 18 €/m^2 is required today to invest in quality insulation [17].

3. MATERIALS AND METHODS

Research to date on climate change related uncertainties has primarily focused on technological, economic, political and climatic factors [20-29]. The problem of research in the work is that on the example of one City it is shown that the aforementioned factors influence the consumption of energy at public buildings.

The aim of the paper is to present indicators of energy efficiency of energy consumption over public buildings in the territory of the City of Novi Sad. The paper also analyses the costs of energy and water on the same facilities as well as the CO_2 and other greenhouse gas emissions.

The paper analyses the consumption of energy over 200 public buildings (kindergartens, primary and secondary schools, schools and social protection centres, health centres, city centres, etc.) in the territory of the City of Novi Sad. The time frame for observing energy consumption is 2013-2015. years.

In order to better demonstrate energy consumption, the following energy efficiency indicators have been analyzed:

- Consumption of heat energy (district heating and natural gas) in public buildings for the period 2013-2015. years, Tab.1-3;
- Electricity consumption in public buildings for the period 2013-2015. years, Tab.4-6.

The paper also presents the analysis:

- Cost of energy and water for public for the period 2013-2015. years, Fig.1-3;
- Consumption of heat, electricity and water for the period 2013-2015. years, Fig.4;
- Emissions of harmful gases with greenhouse effects for the period 2013-2015. year, Fig.5.

In order to perform energy consumption analysis in the territory of the City of Novi Sad, data on who, where, in which quantity and when using certain types of energy or energy, how much are the costs incurred by using these energy sources or energy, were collected and systematized based on which appropriate energy indicators have been identified. The analysis of energy consumption in the territory of the City Novi Sad is carried out on the basis of these data, by comparing the values of the indicators and other parameters with reference values.

3.1. General data on the City of Novi Sad

Novi Sad is the largest city of the Autonomous Province of Vojvodina. The city of Novi Sad is the administrative, economic, cultural, scientific and tourist center of AP Vojvodina and is the seat of the provincial authorities and the administrative center of the South Bačka District. The city of Novi Sad has 15 suburban settlements, the municipality of Novi Sad covers an area of 702.7 km². The city of Novi Sad is the second city in Serbia according to the number of inhabitants in the administrative territory of Novi Sad, which has 341,625 inhabitants. The climate in the territory of Novi Sad moves from a moderate continental to a continental one, so the city has all four seasons. The average air temperature in the city is 10.9° C, the average temperature in January is -1° C, while in July it is 21.6° C [11].

4. ANALYSIS OF RESEARCH RESULTS

Analysis of the energy efficiency indicators of thermal energy consumption in public buildings for the City of Novi Sad for the period 2013-2015. years it was concluded that the average values: specific heat consumption amounted to 168.12 kWh/m^2, the specific costs for thermal energy amounted to 10.35 €/m^2 and the specific costs for thermal energy per user of the building amounted to 134.66 €/user, (Tab.1-3).

By analyzing the energy efficiency indicators of electricity consumption in public buildings for the City of Novi Sad for the period 2013-2015. The year was concluded that the average values: specific electricity consumption amounted to 56.38 kWh/m^2, specific costs of electricity amounted to 4.3 €/m^2 and the specific costs of electricity per user of the building amounted to 63.40 €/user, (Tab.4-6).

Table 1. Energy efficiency indicators of heat consumption in public buildings - 2013. year

Indicator	Unit	
Specific consumption of heat energy	180.63 kWh/m^2	2,215.89 kWh/user
Specific costs for heat energy per m^2	1,270.63 RSD/m^2	11.08 €/m^2
Specific costs for thermal energy per building user	14,532.56 RSD/user	126.77 €/user

Table 2. Energy efficiency indicators of heat consumption in public buildings - 2014. year

Indicator	Unit	
Specific consumption of heat energy	154.58 kWh/m^2	2,494.62 kWh/user
Specific costs for heat energy per m^2	1,172.62 RSD/m^2	9.69 €/m^2
Specific costs for thermal energy per building user	19,018.82 RSD/user	157.23 €/user

Table 3. Energy efficiency indicators of heat consumption in public buildings - 2015. year

Indicator	Unit	
Specific consumption of heat energy	169.15 kWh/m^2	2,102.69 kWh/user
Specific costs for heat energy per m^2	1,250.03 RSD/m^2	10.28 €/m^2
Specific costs for thermal energy per building user	14,592.49 RSD/user	119.97 €/user

Table 4. Indicators of energy efficiency of electricity consumption in public buildings - 2013. year

Indicator	Unit	
Specific electricity consumption	61.77 kWh/m^2	734.64 kWh/user
Specific costs of electricity	495.28 RSD/m^2	4.32 €/m^2
Specific costs of electricity	5,913.75 RSD/user	51.59 €/user

Table 5. Energy efficiency indicators for electricity consumption in public buildings - 2014. year

Indicator	Unit	
Specific electricity consumption	56.45 kWh/m^2	812.79 kWh/user
Specific costs of electricity	516.15 RSD/m^2	4.27 €/m^2
Specific costs of electricity	7,894.16 RSD/user	65.26 €/user

Table 6. Energy efficiency indicators for electricity consumption in public buildings - 2015. year

Indicator	Unit	
Specific electricity consumption	50.94 kWh/m^2	843.22 kWh/user
Specific costs of electricity	524.33 RSD/m^2	4.31 €/m^2
Specific costs of electricity	8,923.47 RSD/user	73.36 €/user

Average cost of public buildings for the period 2013-2015. year amounted to 60.88% for thermal energy, 23.22% for electricity and 15.9% for water, (Fig.1-3).

Total average values of energy consumption for the City of Novi Sad for the period 2013-2015. year were: Total heat consumption - total 43,618.23 GWh, consumption heat energy (district heating) 23,002.73 GWh, consumption heat energy (natural gas) 20,615.50 GWh, consumption electricity 15,254.07 GWh and water consumption 435,923.33 m^3, (Fig.4).

Total average primary energy consumption for the period 2013-2015. the year was 8,142 teo.

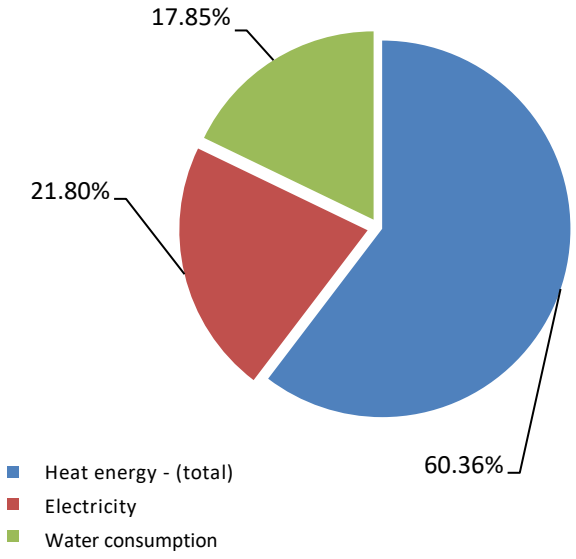

Fig.1. Share of energy and water in costs - 2013. year

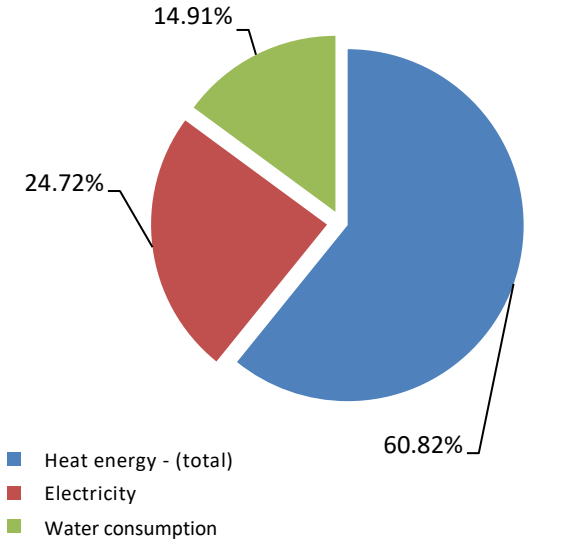

Fig.2. Share of energy and water in costs - 2014. year

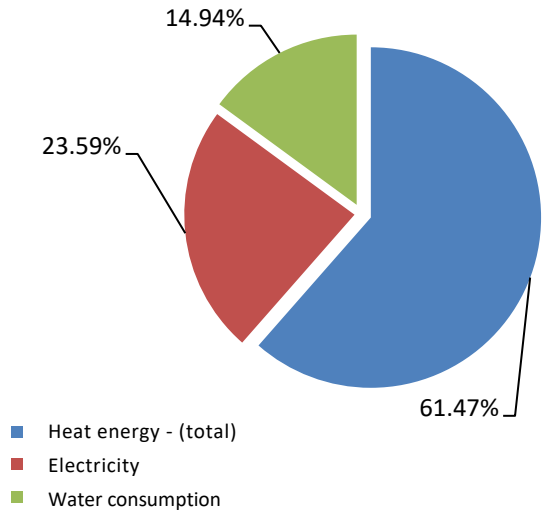

Fig.3. Share of energy and water in costs - 2015. year

Average value of emissions of harmful gases with greenhouse effects for the City of Novi Sad for the period of time 2013-2015. the year was 25,527.23 tCO_2/year, (Fig.5).

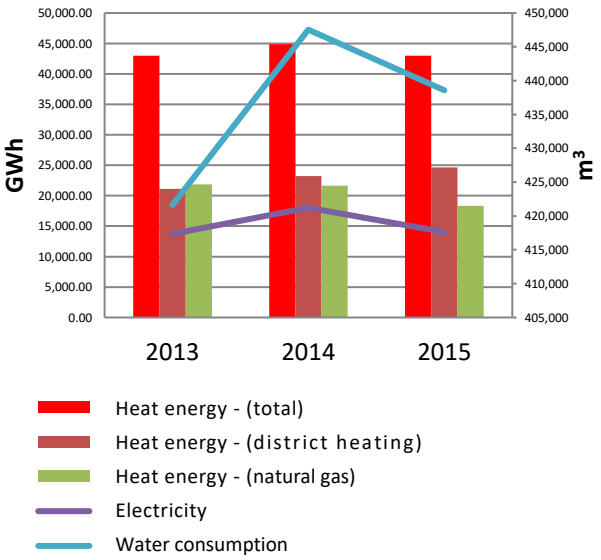

Fig.4. Consumption of heat, electricity and water 2013-2015. Years

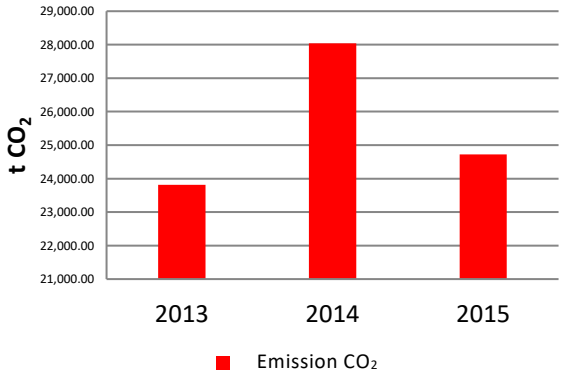

Fig.5. Emission of harmful gases with greenhouse effects 2013-2015. years

In order to further improve energy efficiency, architectural solutions that require the use of green roofs and vegetation walls [30], installations with renewable energy sources, etc. should be used when constructing new public buildings. In the already existing buildings, energy reconstruction measures should be applied: replacement of worn-out joinery, insulation of buildings, reconstruction of old roofs, etc. One of the models of improving energy efficiency on public facilities could certainly be the model of public-private partnership, the so-called ESCO investment model.

5. CONCLUSIONS

In recent years, it is said that energy efficiency is the most recent renewable source of energy, since the benefits of energy saving and lower CO_2 and other greenhouse gas emissions are very significant. Also, the legislation stipulates that measures to improve energy efficiency are considered public interest. Leaders of energy efficiency flows should be local government units, which should become producers, and not only energy consumers. Presented research results show that there is room for improvement of energy efficiency on certain public buildings on the territory of the City of Novi Sad. The energy sizes presented in this way should be a benchmark for future energy projects to be performed in order to achieve energy savings of at least 1% of primary energy annually.

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