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Specific heating consumption in the residential sector of Serbia—Example of the city of Kragujevac

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ABSTRACT

In this paper, the specific consumption of the heat energy supplied by three most utilized heating systems (district heating, gas and electricity system) in the residential sector of the city of Kragujevac (Serbia) is analysed. Required data are provided by combining data from local utility companies with national census results. Comparison of present tariff systems shows that consumers in the residential buildings are the most motivated for energy savings if they use electricity or gas as energy source. The specific energy consumption in district heating system shows relatively high quantities, primarily as a consequence of dominant unmotivating tariff payment system. The average heat consumption from gas and electricity sources relatively fits to EU average, but the electricity consumption of the electric heaters is not acceptable in long term. Low electricity price in Serbia and high price of unit of energy from district heating system of the city of Kragujevac (and Serbia) will lead to an increase of electric energy consumption which will cause additional problems related to covering of that consumption from domestic energy sources.

1. Introduction

Scientific and technological development has contrived to modern society high level of thermal comfort that requires high energy consumption. In the year 1995 each of 6 billion people on the planet Earth consumed 2 kW, while the resident of USA consumed 13 kW of energy consumption [1]. Although in 2009 developed countries reduced their energy consumption per capita (US 10.3 kW, EU 4.8 kW) global energy consumption per capita has grown up to 2.37 kW [2]. These are a very high quantities considering that the physiological functioning of human requires only 120 W [1]. Parallel to the increasing need for the energy consumption the awareness of the need for more efficient use of energy was increasing too, especially in developed countries. More efficient use of energy is encouraged by states that impose law restrictions and subsidies. However, the strongest influence on increasing energy efficiency has a market and rising prices of practically all energy sources.

To form a strategy to reduce specific energy consumption it is necessary to analyze the final energy consumption by sector. It is common that these sectors be divided into industry, transportation and buildings. Furthermore, the energy consumption in buildings is divided into residential and non-residential sector (commercial and public buildings). In the EU these shares (2009) has been as following: 41% for the building sector, 32% for the transportation sector, 25% for the industry sector (and 2% for the agriculture) [3]. In 1990, energy consumption in the EU industry had a share of 34% and in the building sector 36%. These data confirm the trend in developed countries that energy consumption moves from the building to the industry sector [1]. With the exception of the southernmost states of the EU, all the other consumes significant amounts of final energy in the building sector for space heating (60–80%) (the average for the EU is 67%) [3].

This share decreases slightly (in 1997 it was 71%) on account of increase of energy consumption of lighting and electrical appliances. The average specific consumption of final energy in the residential sector of the EU was 200 kW h/m^2 a, while the non-residential sector consumed significantly more 300 kW h/m^2 a [3]. Although new buildings in the EU consume considerably less energy for heating, the average consumption of the existing residential sector according to the mentioned data was 134 kW h/m^2 a (data for 2009). Within the total energy consumption in the residential sector (2009), the most consumed is gas (39%) and electricity (25%), while coal as an energy source is almost completely eliminated (3%). The share of district heating in the EU is relatively low (7%), and it is still pronounced in the Baltic and East European countries, although even there this share decreases.

Serbia, as a potential member of the EU is burdened with very unfavorable indicators in the energy sector. In comparison with the 1989 in 2000 Serbia had 2.5 times lower gross domestic product

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(GDP) and the highest consumption of energy in Europe per unit of GDP [4]. In Serbia, shares in final energy consumption by sector (2008) amounted to: industry 34%, transportation 28% and buildings 38% (27% residential, non-residential 11%) [5]. Averagely 65% of final energy consumption in Serbia is consumed for heating, which is close to the European average [6]. In Serbia, after the Second World War the urban environments were intensively built, so that the share of apartments of 27% (1961) was changed to 56% (2008) [5]. Unfortunately, the most of these apartments were built until 1980 as a part of the building within the urban areas. These buildings are characterized by oversized heating systems, lack of insulation and high specific heating consumption [7,8]. According to the scarce information about the specific heating consumption in the residential sector in Serbia, for space heating and heating of a domestic hot water in apartments in Serbia an average of 220 kW h/m^2 a is consumed, which is far more than the average in the EU [9]. In literature it can be found data that this consumption in Serbia is significantly higher [4]. According to [10] the share of certain energy sources used for heating of the residential buildings in Serbia is as follows: wood 43%, district heating 22%, electricity 15.5%, gas 10%, coal 9% (and all other fuels 0.5%).

Although the state of Serbia stimulated different measures to increase energy efficiency and reduce energy consumption in the residential sector by adopting laws and regulations, supporting and funding various projects (NEEP [4], NEAP [5], Energetic lows 2004, 2014, the Law on Efficient Use of Energy 2013) significant advances in this area have not been made [11]. We believe that the main cause of poor energy indicators in the Republic of Serbia is the significant absence of market incentive of citizens to save energy. First of all, this relates to low cost of electricity, market price of the mainly imported oil and gas, as well as tariff payment system for district heating defined per m^2 of the residential area and independent of the consumed heat energy.

In the case of the city of Kragujevac and achieved consumption of energy sources (electricity, gas and district heating) in the residential sector for heating seasons 2009–2013, the achieved specific consumptions as well as relations between consumption, tariff payment system and weather conditions will be shown.

2. The tariff systems and ratios of heating prices for household for the city of Kragujevac

2.1. Current prices for electricity, gas and district heating

The Serbian energy sector pulls longstanding problems of the socialist economy with controlled policy of low prices of energy sources, with low energy efficiency in all sectors, with high debts for imported energy sources which were uneconomically consumed. One of the most significant structural problems is extremely low price of electricity (the lowest in Europe), which is mainly produced in thermal power plants, which burn domestic low-calorie coal (lignite) [12]. It has led to that the currently 1 kW h of thermal energy of the supplied gas (0.05 €) costs approximately as 1 kW h of electricity (approximately €0.06), although the conversion factor of converting thermal energy into electrical is 2.5–3.5. In Serbia, the buildings within the urban areas are heated by district heating, electricity and gas. The prices of gas and electricity are virtually the same for the entire state, while the prices for the district heating vary from city to city. The tariff payment system for consumed electricity in Serbia is shown in Table 1.

The tariff system is defined so that the price of electricity for small and medium consumers is very favorable, especially during night. To avoid excessive consumption of electricity, this non-market tariff system has disincentive price of electricity for consumers who consume more than 1600 kW h per month (red zone). The official mean price of electricity in Serbia is 7.32 RSD/kW h (RSD/EUR = 120).

The price of natural gas supplied by the main distributor of this energy source in Serbia currently amounts to 55.33 RSD/N m^3 (adopting the lower heating value (LHV) for gas of 34,000 kJ/N m^3 and the price of 13.56 €/GJ).

The tariff system and the price of district heating in Serbia is formed at the city level and currently the double tariff system is in effect: for most consumers the tariff is fixed and defined per m^2 of the residential area of the apartment and for the smaller number of consumers it is variable defined per consumption with a significant fixed part. Specifically, in the city of Kragujevac district heating defined per consumption currently pay about 20% of connected consumers in the residential sector. The double tariff payment system of district heating in the city of Kragujevac for residential sector is given in Table 2.

2.2. Comparison of the heating prices for households in the city of Kragujevac

For a comparison of the heating costs for various energy sources used in Kragujevac the following data were adopted:

- household of 100 m^2 of useful living space is considered,
- heating season lasts 6 months (180 days),
- ratio of daily and nightly electricity tariff is 70/30,
- electricity consumption unrelated to the heating is 500 kW h per month,
- engaged electrical power of a household is 10 kW,
- efficiency of a gas boiler is $\eta_g = 0.9$,
- adopted LHV of natural gas is 34,000 kJ/N m^3,
- four specific heating consumptions are analyzed: 50, 100, 150 and 200 kW h/m^2 a,
- four options of the heating in the city of Kragujevac are analyzed: electricity (heaters), gas (boiler), district heating – fixed charge and district heating – charge per consumption.

Fig. 1 shows the unit price of energy (kW h) which pays the owner of the household of 100 m^2 for heating expressed in €/kW h for four defined options of heating and for different specific consumptions.

From Fig. 1 it can be seen that the price of energy from gas is fixed, irrespective of consumption which maximally simplifies the calculation of a household to save energy or to invest in insulation of an object. The price of heating by conventional electric heaters for low specific consumptions is more cost effective than district heating. Although it is not shown in the diagram the heating by electricity as a part of a system with heat pump (estimated heating factor of 2–5) would be undoubtedly the cheapest heating option under this ratio of prices in Kragujevac (Serbia).

District heating system has been built in a time of urbanization of Serbia and cheap energy. Long-time charging system fixed per unit of residential area of the residential building discouraged the investment in increasing the efficiency of production and transport of heat energy. For a long time the price for heating based on square meter of heating area is built in that manner that now it is the most expensive heating option for well insulated buildings (consumption less than 100 kW h/m^2 a).

The charging system based on consumption, which will soon become the only tariff system within the district heating makes this system slightly competitive especially for consumptions to 100 kW h/m^2 a. It is clear that in these circumstances and with fixed tariff thinking of a family in the residential apartment connected to the district heating system about investment in insulation of the object is excluded without any economic sense.