APPLYING THE ECONOMETRIC MODELLING ON THE MONITORING OF WOOD ENERGY CONSUMPTION IN HOUSEHOLDS
Case Study Southwestern Serbia

by

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This paper focuses on two main research topics: the situation in the field of wood energy efficiency utilization in households in the region of Southwestern Serbia, and econometric modelling of wood energy consumption dependent on the size of the heating surface, the existence of thermal insulation on residential buildings, the age of heating appliances and moisture content of wood fuels. The results of the conducted research showed that the consumption of wood energy in most household's ranges between 300 and 400 kWh/m^2. This is considered energy inefficient. Although in the majority of households the size of the heating surface ranges between just 20 and 80 m^2, exactly in these households the highest and the most inefficient consumption of wood energy expressed in kWh/m^2 was registered. The first reason for the high consumption of wood energy is the fact that only 29% of residential buildings have thermal insulation, while 71% do not have any thermal insulation. Additionally, the wide diffusion of heating appliances aging over ten years and firewood with the average moisture content of 37% further contribute to such unfavourable situation in terms of energy efficiency. The parameters of the obtained econometric model of wood energy consumption clearly show that the greatest savings in the consumption of wood energy in the short term could be obtained by improving the condition of the thermal insulation of the residential buildings, replacing the old heating appliances with the new and the more efficient ones, as well as by using drier firewood.

Key words: *wood energy, efficiency, consumption, factors, model*

Introduction

The efficiency of wood energy utilization in households in Serbia has not yet become the subject of attention of policy makers to the necessary extent. The already implemented or on-going individual projects conducted by international and domestic organizations, or some local administrations contribute slightly to the improvement of the situation in this field. However, the national programs designed by competent institutions with adequate measures and budgets for improving the energy efficiency in households in the area of heating do not exist. Such programs are necessary due to the fact that 40.9% of the total number of households in Serbia use solid (wood) fuels for heating purposes, out of which nearly 2/3 use firewood [1].

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The importance of the issue of wood energy efficiency in households is also shown by the results of projects implemented within the GIZ DKTI program [2] and the GEF UNDP project [3] in certain regions in Serbia. According to the results of these projects, the firewood utilization in households for heating purposes is unsatisfactory from the point of energy efficiency. Therefore, the support to policy makers is needed, so that they can define the appropriate programs for improving the situation in this field. One of the important steps in this process is defining the adequate methodology for monitoring the consumption of wood energy in households, as well as models for monitoring the effects of measures that should be implemented in the field of energy efficiency improvement.

When it comes to models for estimating the effects of planned energy efficiency measures in households in advance, the situation is such that there are not many published papers relating to Serbia and the region of Southeastern Europe. There is some experience in the examples of Slovakia in which authors Dzian *et al.* [4] have developed a model for monitoring the impact of the particular factors on energy wood supply in Slovakia. Using econometric modelling, Paluš [5] developed a model for monitoring the relationships between the supply of energy chips, its price, and the supply of other complementary products. Glasenapp *et al.* [6] applied a Tobit model to a cross-sectional dataset to quantify factors affecting household-level German residential wood energy consumption in the years 2005, 2010, and 2014. They considered the following variables: heating technology, dwelling characteristics and alternative energies; woody biomass accessibility and weather; and households' socio-demographic characteristics. The results of their methodology showed that there is a positive correlation between households' wood energy consumption, residence area and elastic responses to the year of building construction. Furthermore, their results suggest more elastic and positive effects of changes in heating degree days on wood energy consumption. Song *et al.* [7] also used Tobit models to evaluate the impact of the selected factors on wood energy consumption in the USA households. One of the results of their research shows that household wood energy consumption was affected mainly by non-wood energy prices in rural areas. In urban areas, though, the wood energy consumption was influenced mainly by household size and income levels.

Given examples of statistical tools utilization for determination of relations between wood energy consumption and its dependence on key factors, clearly show how much these tools can be useful for policy makers in the process of taking adequate measures for improving efficiency in the particular segments of wood energy consumption.

The main topic of the research is the assessment of wood energy consumption in Southwestern Serbia with the following main goals:
- monitoring the wood energy consumption in households,
- identifying the key factors influencing the wood energy consumption,
- identifying the functional dependence and intensity between the key factors and the wood energy consumption by applying econometric modelling, and
- defining the key recommendations for municipal policy makers for improving the efficiency of wood energy consumption in the shortest time possible.

Materials and methods

The first step necessary to be made was collecting the data on wood energy consumption in households of the five biggest municipalities in Southwestern Serbia by conducting field research and face-to-face interviewing of the householders. The sample encompassed 2097 households in urban and rural areas, representing 4.6% of total households in this region using solid fuels for heating purposes. The methodology thoroughly described in Glavonjić *et al.* [8]

was implemented for determining the number of households, fig. 2. Share of the urban and rural households in the sample corresponds to their share in the total number of households of the selected region obtained in the 2011 census. For these purposes, the questionnaire containing questions about the size of the households, type and characteristics of their residential buildings, characteristics and consumption of wood fuels, as well as characteristics and age of heating appliances was developed. Interviewing the households was conducted within the GIZ DKTI programme, the GEF UNDP project, and the annual research programmes of the Faculty of Forestry in 2017 and 2018.

Figure 1. Position of Southwestern Serbia on the map of Serbia

After the interviewing, the data were entered into MS Excel 2019, systemised and logically checked. The next step was statistical analyzing with regression and correlation analysis in the programme STATISTICA v.7.0. Assessment of parameters of the obtained model was then conducted according to the methodological instructions developed in Ranković [9] and Jovičić [10].

Four key factors influencing the wood energy consumption were selected for the econometric modelling: the size of the heated surface, existence of thermal insulation in residential buildings, age of heating appliances, and moisture content of firewood. For thermal insulation and age of heating appliances some adaptations and calculations were necessary. The thermal conductivity, λ [$Wm^{-1}K^{-1}$] was chosen as parameter describing the impact of (non-) existence of thermal insulation. In professional literature [11, 12] it has different values for different materials used in constructing and insulating. For each household within the sample this parameter was entered based on the type of materials these households were constructed from, and the existence or non-existence of thermal insulation. In the case of the heating appliances' age, the first step was determining the parameter of combusting efficiency, since the influence of the age itself on wood energy consumption is not representative enough. Namely, the quantity of energy released in heating appliances does not depend only on their age, but on the series of other factors as well, amongst which moisture content of firewood and efficiency of the combusting regime are most remarkable. Determination of this parameter was conducted in real conditions [13].

The examined heating appliances were of different age and from different domestic producers. For each model the degree of combusting efficiency was determined when burning firewood with the following moisture contents: up to 25% (dry wood), between 25% and 35% (air dry wood), and over 35% (wet wood).

Age ranges of the appliances examined in the study [13] correspond to the age ranges of the heating appliances in the sample of this paper. Types of heating appliances in almost 85% of the sample households are the same as the two main types of heating appliances examined in the study [13]. For the rest of about 15% of the sample households, the efficiency of combusting was approximated using the values of the group *other producers* from the study [13]. Although there are some differences between the heating appliances from the study [13] and the heating appliances from the sample in terms of their power and combustion regimes, the chosen approach is acceptable enough for obtaining the necessary information for making concrete decisions in order to improve the efficiency of wood energy consumption. After deriving the parameter of combusting efficiency for each heating appliance in the sample the annual loss of energy was calculated as the product of the following: the annual quantity of the consumed wood fuels, the energy value per unit of the wood fuels for the corresponding moisture content, and the parameter of their combusting efficiency. This annual energy loss was taken as a variable in the econometric modelling of the wood energy consumption. The values of the fourth variable (moisture content of the wood fuels) were derived from the questionnaire, based on the time of the firewood procurement and according to the coefficients from Glavonjić [14]. For wood pellets and briquettes, the standard moisture values of 8% and 10% were accepted in this paper. Table 1 shows the name of the variables chosen for the econometric modelling, their symbols and measuring units.

Table 1. Set of variables used in the models

ID	Variable	Unit	Source
TWEC	Total wood energy consumption	[kWh]	HH questionnaire and authors calculations
HS	Heated surface	[m^2]	HH questionnaire and authors calculations
λ	Thermal conductivity	[$Wm^{-1}K^{-1}$]	Authors calculations based on HH questionnaire and values from official regulations on energy efficiency in buildings
EC	Efficiency of wood fuels combustion in heating appliances	[%]	Authors calculations
MC	Moisture content of wood fuels	[%]	HH questionnaire

TWEC [kWh] – total wood energy consumption, HS [m^2] – heating surface, λ [$Wm^{-1}K^{-1}$] – thermal conductivity, EC [%] – efficiency of wood fuels combustion in heating appliances, MC [%] – moisture content of wood fuels, R is correlation coefficient, R^2 is a coefficient of determination, Se is the standard error; DW is Durbin- Watson statistic, F is F-test, p level (0,05)

Results and discussion

The results of analyses for each of the selected key factors with appropriate discussion are presented below, followed by the model of multivariate regression analyses with values of the obtained parameters and their assessments.

Characteristics of wood energy consumption in households of Southwestern Serbia

Wood energy consumption in households for heating purposes in the selected region can be assessed in its total value or as consumption per unit of the heating surface. In both cases, wood energy consumption is directly dependent on the quantity of fuel consumed and their characteristics (moisture content, specific weight, and other factors). The value of total wood energy consumption for heating is the starting point for calculating the energy consumption per unit of the heated surface, the parameter much more frequently used for energy efficiency analyses, as well as for policy making in this field. Concerning this, the results of wood energy consumption per unit of the heated surface in the households of the selected region are presented below.

The average consumption of wood energy per 1 m^2 of heated surface in the households amounts to 322.1 kWh. This can be considered as energy inefficient compared to the consumption of 250 kWh/m^2 which represents the maximum consumption in the last class of energy passport (F class). This class represents a level with minimal energy efficiency. Only 15% of households in this region have energy consumption up to 200 kWh/m^2 which can be considered acceptable according to the energy efficiency criteria. The 24% of households have the energy consumption between 200 and 300 kWh/m^2, while the third of households register energy consumption in the range between 300 and 400 kWh/m^2, fig. 2.

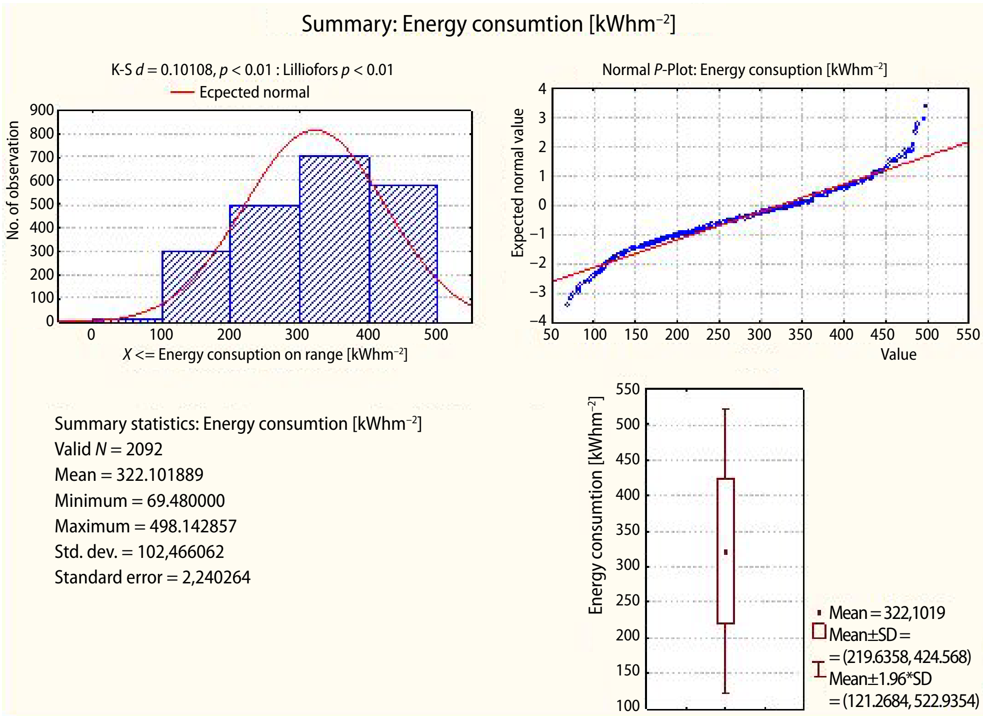

Figure 2. Distribution of households in respect of wood energy consumption per unit of the heated surface in the selected region

Some 28% of households have extremely high energy consumption over 400 kWh/m^2. The analyses of household structure from this group show that the average heated surface in these households is in the range from 10 to 30 m^2. Despite such a small heated surface, these households consume on average 5.8 stacked m^3 of firewood annually, which is high consumption compared to the size of the heated surface. There are many reasons for such high consumption, some of which are:

– most of these households do not have thermal insulation on their residential buildings,
– in most of these households, the average age of the heating appliances is 11.8 years, and
– a huge number of these households have low efficiency of firewood utilization because they use wood with the average moisture content of 38%.

The households having energy consumption up to 200 kWh/m^2 of the heated surface use wood pellets and briquettes and/or have central heating systems (boilers) installed. Such households usually heat surface over 130 m^2.

Generally, the efficiency of wood energy consumption for heating purposes in households in Southwestern Serbia is unsatisfactory. Because of that, it is necessary to define appropriate policy measures to start with the organized and planned improvement of the situation in this field.

Characteristics of the heating surface as a factor of wood energy consumption

The size of the heating surface is one of the four key factors having influence on wood energy consumption in households. When it comes to households in Southwestern Serbia, the results of the conducted research show that the average heated surface per household amounts to 78.1 m^2. Its lowest value is 10 m^2 and its highest value is 350 m^2, fig. 3.

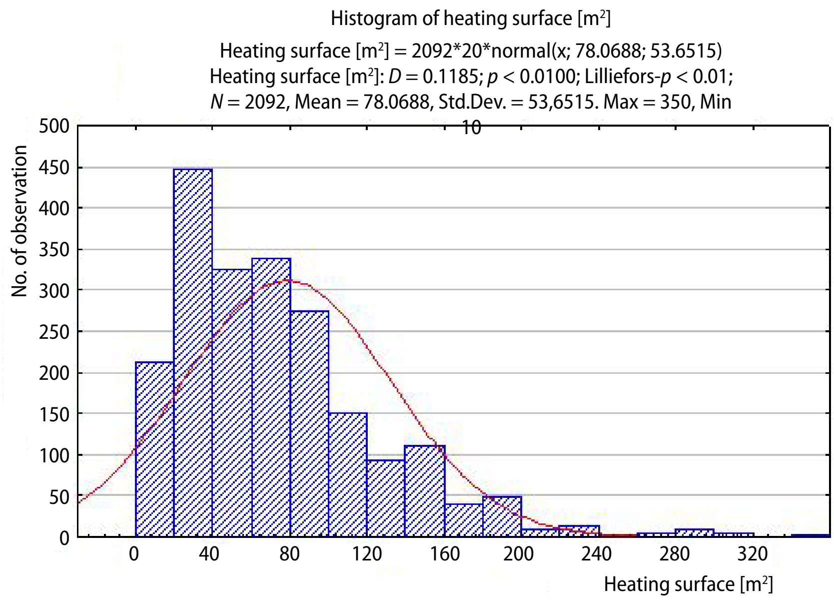

Figure 3. Distribution of households in respect of the size of the heated surface in Southwestern Serbia

The share of households with heating surface up to 20 m^2 (the lower extreme value) is 10% while the share of households with the heating surface over 200 m^2 (the higher extreme value) is 4% only. Almost 53% of households have the heating surface between 20 and 80 m^2, while 20% of households have the heating surface from 80 to 120 m^2. The size of the heating surface is related to the number of rooms heated in an individual household: 48.3% of households heat all rooms in their residential buildings during the heating season, while 51.7% of households do not heat all rooms. The distribution of households in respect of the number of the rooms heated in their residential buildings is depicted by fig. 4. The share of households heating between one and three rooms amounts to 34%.

The average room size heated in the households which heat only one room amounts to 21.8 m^2. In households heating two rooms the average room size is 33.4 m^2, while in the households heating three rooms it is 45.3 m^2. The sizes of the heated surface are small in all three cases. If the households heat only one room, this room is the living room. If the households heat two or three rooms, these are the living room, bathroom and entrance hall.

Existence of thermal insulation in residential buildings

The existence of thermal insulation in residential buildings represents an important factor influencing energy efficiency in construction and, consequently, energy consumption. The situation in households of Southwestern Serbia according to this criterion is unsatisfactory. Only 29% of residential buildings possess thermal insulation while 71% do not have any type of thermal insulation, fig. 5.

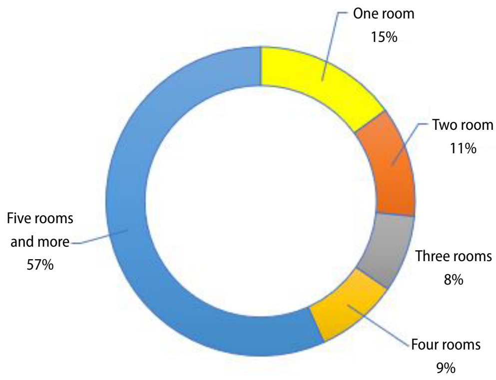

Figure 4. Distribution of households in respect of the number of the rooms heated during the heating season

Especially unsatisfactory is the situation with small residential buildings (below 60 m^2). In this category, only 14.4% of residential buildings possess thermal insulation while the rest of 85.6% do not have any type of thermal insulation. A slightly better situation is in the case of larger buildings (over 100 m^2) where 42.1% of them possess thermal insulation, and the rest of 57.9% do not have thermal insulation.

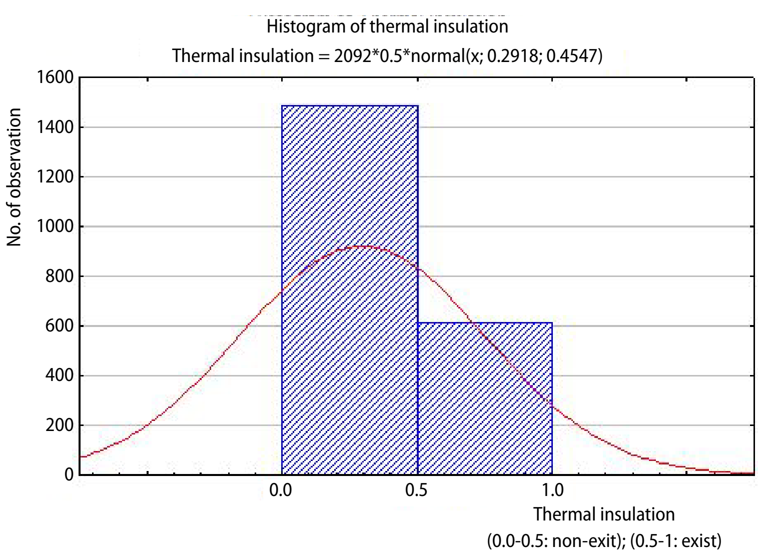

Figure 5. Distribution of households in respect of existence of thermal insulation in residential buildings

Age of heating appliances

When it comes to the age of heating appliances in the households of this region, the results of the conducted research show that its average age amounts to 9.5 years. The heating appliances aged from 6 to 10 years are the most dominant representing 30.2%, followed by the heating appliances aged between 1 and 5 with a share of 29.9%. The appliances aged from 11 to 15 years are in the third place (20.5%), and the devices aged over 20 years are in the fourth place (10.8%). The share of devices aged between 16 and 20 years is 8.6%, fig. 6.

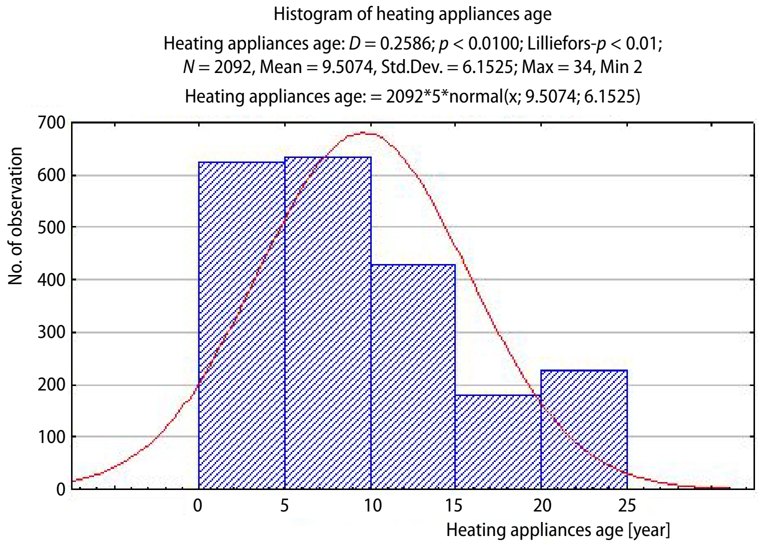

Figure 6. Distribution of households in respect of heating appliances age

In addition to the age of heating appliances, the important factor of energy efficiency and wood energy consumption is a type of device. When it comes to the type of heating devices, the dominant ones are individual cookers and stoves, the devices with lower efficiency compared to the devices for central heating (boilers). The share of individual cookers and stoves is 59%, while the boilers for central heating are present in 41% of the households. In 22.3% of the households heating the surface up to 80 m^2 (the dominant ones in this region) the heating appliances are 19.7 years old on average.

Moisture content of firewood

The timing of firewood procurement before the beginning of the heating season is one of the factors with the strongest impact on the efficiency of its utilization, since the firewood moisture content determines to the greatest extent the quality of the combustion process, *i. e.* the quantity of useful energy released. In that sense, it is very important to use dried firewood for household heating purposes, *i. e.* the firewood that was being dried at least four months before the heating season. It is necessary between 4 and 5 months for firewood to decrease the moisture content from approximately 55% after logging to 25%, which is optimal moisture content for combusting in heating devices [15]. Firewood up to 25% of moisture content combusts *with the satisfactory energy efficiency* and releases significant quantity of energy.

When it comes to the timing of firewood procurement, fig. 7, shows that the largest number of the households (48%) procure their firewood at least 4 to 6 months before the heating season.

Generally, 52% of total households in the region purchase firewood in a period longer than 4 months before the beginning of the heating season. The rest of 48% purchase firewood in a shorter period, with 20% of the households having this period even shorter than one month. In this 48% of the households, firewood is used with high moisture content. This is considered to be inefficient firewood consumption. The general assessment of the situation in households in respect of the timing of firewood procurement is unsatisfactory because the number of households that procure firewood in the period shorter than 4 months is large. For this reason, it is

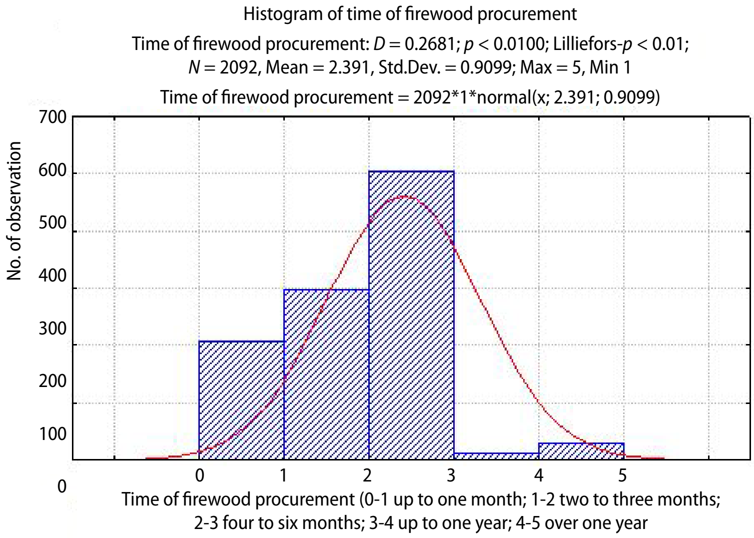

Figure 7. Distribution of households in respect of the timing of firewood procurement before the beginning of the heating season

necessary to work on the education of the householders about the importance of purchasing firewood more than 4 months ahead of the heating season, in order to combust it efficiently and cut the heating costs.

Econometric modelling of the wood energy consumption in the households of Southwestern Serbia

The results of the multifactor regression model of the wood energy consumption in Southwestern Serbia is parametrically shown in tab. 2.

Table 2. The model results

Model	Constant	HS	λ	EC	MC
TWEC (y)	10900.4	23.41	323.66	1.29	–283.94
St.error	290.3	1.493	206.28	0.0093	7.138
t-test	37.543	15.685	1.569	138.8	–39.775
|*t*-test|	$\|t_a\| > t_{005}$	$\|t_a\| > t_{005}$	$\|t_a\| > t_{005}$	$\|t_a\| > t_{005}$	$\|t_a\| > t_{005}$
Statistical Characteristic					
R	R^2	R^2 cor	F(4,2087)	S_e	DW (+)
0.98	0.97	0.96	14385	2226.4	1.924

TWEC [kWh] – total wood energy consumption, HS [m^2] – heating surface, λ [Wm^{-1}K^{-1}] – thermal conductivity, EC [%] – efficiency of wood fuels combustion in heating appliances, MC [%] – moisture content of wood fuels, R is correlation coefficient, R^2 is a coefficient of determination, Se is the standard error; DW is Durbin- Watson statistic, F is F-test, p level (0,05)

The high correlation coefficient and its significance level, meaning that 97% variations of the wood energy consumption are explained by variations of the factors entered in this multifactor regression model, show the indisputable impact of the selected factors on the wood energy consumption. Since all parameters of this multifactor regression model are significant, the obtained values could be fully reliable.

Based on the parameters of the obtained econometric model, the following conclusions could be deducted:

– For every marginal increase of the heated surface for 1 m^2, the expected marginal increase in the wood energy consumption amounts to 23.41 kWh.
– Each thermal insulation of the residential buildings leading to a marginal decrease in thermal conductivity of 1 W/mK contributes to the marginal reduction of the wood energy consumption of 323.66 kWh per year.
– With each 1% of the marginal increase in the efficiency of the wood fuels' combustion in the heating appliances of the new generation, the expected reduce energy losses ie. annual decrease in the wood energy consumption amounts to 1.29%. Practically, this could be interpreted in the following manner: if a household, having purchased the heating appliances of the new generation with higher combustion efficiency and combusting drier firewood, increases the efficiency of combusting for 10%, it could expect the annual decrease in the wood energy consumption of 12.9%.
– The negative sign of the parameter with the moisture content variable is the result of the multicollinearity of this variable with the efficiency of wood fuels combustion in heating appliances variable (high correlation coefficient in a simple regression model). The simple regression model of these two variables shows that for each marginal decrease in the firewood moisture content of 1%, the expected increase of its combustion efficiency amounts to 0.8%. It means that the influence of firewood moisture content is permeated through the influence of the efficiency of its combustion in the heating appliances. It can be concluded that the influence of moisture content on wood energy consumption exists, but this influence in this model, and under the given conditions, is covered to a certain extent by the efficiency of wood fuel combustion in heating appliances variable. Taking into account the above mentioned, the parameter with moisture content variable, in this model, has a corrective role.

The aforementioned interpretations of the parameters of the obtained econometric modelling lead to the conclusion, that the strongest impact on the wood energy consumption, in the households of the chosen region and the existing conditions, exert the thermal insulation and age (*i. e.* the efficiency) of the heating appliances (including the moisture content of the combusting wood fuels).

Conclusions

The results of the conducted research show that wood energy consumption in the households of Southwestern Serbia is unsatisfactory. This is especially obvious when looking at the average annual consumption of wood energy per unit of the heated surface, amounting to 322.1 kWh/m^2. The additional worrying fact is that almost 30% of the households consume over 400 kWh/m^2, which could be considered as a totally inefficient wood energy consumption. Numerous reasons contribute to this, but the two main ones are the following: 71% of the households in the region do not have any thermal insulation in their residential buildings, and their heating appliances aged on average 9.5 years and combusting the firewood with the average moisture content of 37% have very low efficiency of firewood utilization.

The parameters of the obtained econometric model show very well the importance of the existence of thermal insulation in residential buildings, the use of highly efficient new generation heating appliances and the consumption of dried rather than wet wood. Exactly these three segments should be targeted by necessary measures and activities, in order to reach the best results in increasing the efficiency of the wood energy consumption in the shortest time possible. Some of the mentioned measures comprehend subsidies to households:

– for purchasing the contemporary energy-efficient heating appliances and
– for improving the thermal insulation in their households.

These measures are already known and were pretty successful in some other Serbian regions, where the policymakers timely recognized their importance for reaching the satisfactory levels of energy efficiency. The especially important and effective measure is the education of the householders about the importance and effects of the consumption of dry wood instead of wet wood, and how to properly light the fire. The main limiting factors for efficient consumption of the firewood are wrong habits and the delusion transferred from generation to generation that less firewood is consumed when using the firewood with the high moisture content. The parameters of the obtained econometric model, though, show that for each marginal decrease in the firewood moisture content of 1%, the expected increase of its combustion efficiency amounts to 0.8%. That is why the education of the householders should play the main role in changing the wrong habits and overcoming the existing delusions. Since the Republic of Serbia has the funds for financing the implementation of the aforementioned suggested measures, *e. g.* the Fund for the energy efficiency and the Fund for environmental protection, the local policy creators from the region should develop and apply with the corresponding programs, in order to obtain the necessary national financing.

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References

[1] Glavonjić, B. D., *et al., WISDOM Serbia: Spatial Wood Fuels Production and Consumption Analysis,* FAO, Rome, 2015, http://www.fao.org/3/a-i4394e.pdf
[2] ***, GIZ DKTI Programme: Efficiency of Firewood Utilization in Households in the Pilot Regions in Serbia, http://www.bioenergy-serbia.rs/index.php/en/giz-dkti-programme, E4Tech/Quiddita, Belgrade, (January 2020)
[3] ***, Position paper: Status of Using Wood Biomass for Energy Purposes in Serbia, GEF UNDP project, Belgrade, http://biomasa.undp.org.rs/wp-content/uploads/2018/11/POSITION-PAPER-Status-of-Using-Wood-Biomass-for-Energy-Purposes-in-Serbia-FINAL.pdf
[4] Dzian, M., *et al.,* Factors Affecting the Supply of Energy Wood in Slovakia, *Proceedings,* 11th International Scientific Conference WoodEMA, Belgrade, Serbia, 2018, pp. 347-353
[5] Paluš, H., Changes in Energy Wood Supplies in the Slovak Republic, *Proceedings,* 8th International Scientific Conference WoodEMA and Forest Products Society, Dubrovnik, Croatia, 2015, pp. 261-266
[6] Glasenapp, S., *et al.,* Assessment of Residential Wood Energy Consumption Using German Household-Level Data, *Biomass and Bioenergy, 126* (2019), July, pp. 117-129
[7] Song, N. *et al.,* Factors Affecting Wood Energy Consumption by U. S. Households, *Energy Economics*, *34* (2012), 2, pp. 389-397
[8] Glavonjić, B. D., *et al.,* Consumption of Wood Fuels in Households in Serbia – Present State and Possible Contribution to the Climate Change Mitigation, *Thermal Science*, *15* (2011), *3,* pp. 571-585
[9] Ranković, N., *Ekonomika Šumarstva*, Šumarski Fakultet, University of Belgrade, Belgrade, 1996
[10] Jovičić, M., Dragutinović-Mitrović, R., *Ekonometrijski Metodi i Modeli*, Ekonomski Fakultet, Belgrade, 2018
[11] Muravljov, M., *Gradevinski Materijali*, Gradevinska Knjiga, Belgrade, 2007
[12] ***, Pravilnik o Energetskoj Efikasnosti Zgrada, Sl. Glasnik RS br. 61/2011, https://www.paragraf.rs/propisi_download/pravilnik_o_energetskoj_efikasnosti_zgrada.pdf

[13] ***, GIZ DKTI Programme: Report on efficiency measurements of residential heating and cooking appliances in selected households, E4Tech/Quiddita, Belgrade; Available at: http://www.bioenergy-serbia.rs/index.php/en/giz-dkti-programme (January 2020)
[14] Glavonjić, B., *Drvna Goriva: Vrste, Karakteristike i Pogodnosti za Grejanje*, SNV Montenegro, Podgorica, 2011
[15] Taylor, A., *Moisture Content of 'Seasoned' Firewood*, Tennessee Forest Products Center, The University of Tennessee Agricultural Extension Service, Knoxvile, Tex., USA, 2015

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