

..... Pirc Barčić, Grošelj, Oblak, Motik, Kaputa, Glavonjić, Bego, Perić: Possibilities of...

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Possibilities of Increasing Renewable Energy in Croatia, Slovenia and Slovakia – Wood Pellets

Mogućnosti povećanja obnovljivih izvora energije u Hrvatskoj, Sloveniji i Slovačkoj – drveni peleti

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ABSTRACT • Energy from renewable sources is globally a very important issue. In order to reduce pollution and greenhouse gas emissions, many countries enact laws for enhancing the consumption of renewable energy sources. Sooner or later traditional non-renewable energy sources would have to be replaced with alternative energy sources that are already used in developed countries. According to the European Commission (2018), the EU is already a global leader in the sustainable use of natural resources within an efficient bio-economy. The wood pellet industry is becoming more important and the use of wood pellets is increasing as one of the most important contributors to the renewable energy goals of the EU. Wood pellet is an environmentally acceptable product and its production contributes to desirable rural development and sustainable approach to the management of timber resources. This paper focuses on the market of wood pellets used for heating, pinpointing differences in consumers point of view, and drafting the possibilities of future consumption enhancement. Results revealed a relatively low use of wood pellets in all the three surveyed markets. The highest share of consumers of wood pellets came from the areas with less than 5,000 inhabitants. Such households were mostly over 20 years old. The most important factors to decide to use such source of energy were space (required for the heating system) followed by price of woode pellets.

Key words: wood industry; wood pellets; renewable energy source; Croatia; Slovenia; Slovakia; households

SAŽETAK • Energija iz obnovljivih izvora globalno je vrlo važno pitanje. Radi smanjenja onečišćenja i emisij stakleničkih plinova, države promiču zakone o poticanju potrošnje obnovljivih izvora energije. Prije ili kasnije tradicionalne neobnovljive izvore energije bit će potrebno zamijeniti alternativnima, koji se već koriste u razvijenim zemljama. Prema Europskoj komisiji, Europska unija (EU) lider je u održivom iskorištavanju prirodnih resursa

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u sklopu učinkovite bioekonomije. U tom kontekstu industrija drvnih peleta, kao i njihova upotreba, iz dana u dan postaju sve nezaobilazni. U dijelu koji se odnosi na obnovljive izvore energije drveni su peleti jedan od važnijih elemenata koji pridonose ciljevima EU-a. Riječ je o ekološki prihvatljivom proizvodu, a njegova proizvodnja znatno pridonosi ruralnom razvoju i održivom pristupu gospodarenju prirodnim resursima. Ovim se radom želi potaknuti promišljanje kako proizvođača, tako i potrošača drvnih peleta o izrazitom tržišnom potencijalu drvnog peleta za grijanje u hrvatskim, slovenskim i slovačkim kućanstvima. Nadalje, u radu su prikazane razlike u demografskim profilima ispitanika, njihovo znanje o drvenim peletima općenito te o mogućnostima budućeg poticanja potrošnje drvnih peleta u Hrvatskoj, Sloveniji i Slovačkoj. Rezultati su pokazali da je uporaba peleta na sva tri istraživana tržišta relativno niska. Najveći udio potrošnje peleta zabilježen je među potrošačima iz manjih područja (do 5000 stanovnika), a većina stambenih objekata ispitanika stariji su od 20 godina. Najvažniji razlozi zbog kojih se potrošači odlučuju na upotrebu peleta kao izvora grijanja jest prostor potreban za instalaciju opreme za grijanje na pelete te cijena peleta.

Ključne riječi: drvna industrija; drveni pelet; obnovljivi izvori energije; Hrvatska; Slovenija; Slovačka; kućanstva

1 INTRODUCTION

1. UVOD

Energy from renewable sources is globally a very important issue. In order to reduce pollution and greenhouse gas emissions, many countries enact laws for enhancing the consumption of renewable energy sources. For many years, the European Union has been one of the world leaders in the promotion of renewable energy trying to change the relations in energy, favoring renewable energy through applicable laws and active implementation of incentive programs, simultaneously providing generous subsidies. More precisely, the aim of the European Union (EU) as a whole is to provide 20 % of energy from renewable energy sources for its gross energy consumption by 2020 and 32.5 % by 2030 (Annual activity reports, 2019). Sooner or later, traditional non-renewable energy sources would have to be replaced with alternative energy sources that are already used in developed countries. According to the European Commission Report (2018), the EU is already a global leader in the sustainable use of natural resources within an efficient bio-economy. The bio-economy covers all sectors and systems that rely on biological resources, their functions and principles. It includes and interlinks: land and marine ecosystems and the services they provide; all primary production sectors that use and produce biological resources (agriculture, forestry, fisheries and aquaculture); and all economic and industrial sectors that use biological resources and processes to produce food, feed, bio-based products, energy and services. In other words, it implies a shift from fossil resources (oil) to renewable resources (biomass) with an accent on the development and production of new products from biomass that must be implemented in a sustainable manner (Šupin and Dzian, 2018). A lot of studies from central and southern Europe dealing with forest-based sector emphasize the role of wood and wood products within the European Green Deal (Dudík *et al.*, 2019; Glavonjić *et al.*, 2015; Kaputa *et al.*, 2017; Mařová and Kaputa, 2018; Olřiaková *et al.*, 2016; Paluš *et al.*, 2014; Paluš *et al.*, 2018; Parobek *et al.*, 2016; Pirc Barčić *et al.*, 2015; Pirc Barčić *et al.*, 2019; Potkány and Debnár, 2018; Šupin, 2015).

The majority of demand for pellets originates from the European Union (EU) (precisely 30.3 % of the total world production, according to the Calderón and Colla, 2019) in response to its greenhouse gas (GHG) (NREL, 2013) and emission mitigation policy, as a result of the EU objective to increase the share of renewable energy. The wood pellet industry and the use of wood pellets is now becoming more and more important. Moreover, wood pellets are emerging as one of the most important contributors to the renewable energy goals of the EU. Flinkman *et al.* (2018) stated that wood pellets represent the best international and dynamic character of the European renewable energy market. Furthermore, when talking about ecological and ecotoxicological aspects, the potential role of wood-pellets in a sustainable biofuel system is an important issue (Olsson *et al.*, 2011).

1.1 Wood pellets as eco-acceptable source

1.1. Drvni peleti kao ekološki prihvatljiv izvor energije

Wood-pellet is a renewable fuel with no carbon dioxide emissions that would contribute to global warming, and with the highest potential to reduce carbon dioxide (Wahlund *et al.*, 2004). Additionally, as defined in ENplus standard (2015), wood pellets are a woody biofuel shaped in a cylindrical form with random length, typically 3.15 to 40 mm, with a diameter of about 6 or 8 mm, and broken ends. The advantage of wood pellets, compared to the original biomass, lies in a higher energy density, homogeneous quality, improved handling and storage properties, and better applicability for different end uses. According to Sikkema *et al.* (2011) and Flinkman *et al.* (2018), two main categories and related markets can be identified: i) industrial grade pellets for large scale power production and ii) residential grade (or non-industrial pellets for small-scale to medium-scale production) pellets. The production of wood pellets started in the 1970s in the United States and Canada, while the first large scale production took off in the 1990s, also in the US and Canada (Peksa-Blanchar *et al.*, 2007; Sikkema *et al.*, 2011; Thrän *et al.*, 2018). In Europe, the first developments were recorded in Sweden in the 1980s as a result of the second oil price/energy crisis. However, in Sweden in 1992, the wood pellets market started to be com-

petitive almost overnight, after the introduction of fiscal measures in taxing fossil fuels. The wood pellets markets started to develop in Austria, Denmark, Italy, and Germany in the late 1990s (Peksa-Blanchar *et al.*, 2007). Since that time, wood pellets markets have been expanded and transformed (Thrän *et al.*, 2018). In 2011, Cocchi *et al.* presented the first compilation of the global production and trading of wood pellets for energy with data from 31 countries in the Americas, Europe, and Asia, showing an estimated increase in consumption of about 110 % between 2006 and 2010, reaching 13.5 million tones. The major import originates from North America but the increasing demands have stimulated advances in Russia, Africa, South America and Asia (Verhoest and Ryckmans, 2012). Since that time, markets have been further expanded and diversified. Experts from the International Energy Agency (IEA) Bioenergy Task 40 have collected and analyzed the market situation in all wood pellet related countries. IEA Bioenergy Task 40 focuses on sustainable biomass markets and international trade to support the biobased economy. As both production and consumption increase, trade in pellets is becoming more significant and the market for this new fuel is becoming increasingly global, with imports to Europe from as far as western Canada and China.

Besides the development of the countries' policies, demands, and supply patterns (Thrän *et al.*, 2018), papers mostly deal with trade flow trends, apparent consumption (including industrial and non-industrial wood pellets consumers), and pellets producers in the context of facility capacities. There is, however, a lack of information about the profiles of non-industrial wood pellet consumers. Flinkman *et al.* (2018) noted that a questionnaire sent to wood pellet companies indicates that specific state subsidies could be a driver for the purchase of pellet stoves and boilers, resulting in a basic level of consumption of non-industrial pellets. Further, light heating oil and natural gas are considered the main heating sources replaced by wood pellets.

The question is how to describe the profiles of wood pellet consumers and types of their households. Given that the development of wood pellets market has been very country-specific, also driven by national fiscal and financial incentives to influence their own domestic market (Dicken, 2008), the scope of this paper was to explore how much Croatian, Slovenian and Slovak households know about wood pellets in general and what the possibilities of their future consumption enhancement are. By signing the Kyoto Protocol, Croatia, Slovenia and Slovakia have committed themselves to reduce greenhouse gas emissions by five percent by 2020 and to promote the use of wood biomass, especially wood pellets, this being one of the activities required to meet these obligations. This paper sheds light on the situation and answers the questions about the wood pellets market potential for heating, pinpointing differences in the demographic profiles of the respondents, their knowledge about wood pellets in general and the possibilities of their future consumption enhancement.

2 MATERIALS AND METHODS

2. MATERIJALI I METODE

For this research, the following non-industrial pellets markets were selected: Slovenia, Croatia and Slovakia. These countries have a high potential of renewable energy sources. In order to collect consumer data for this research, a telephone survey was used, with a total of 1916 respondents. The first survey was conducted in Croatia in 2015 (preliminary research done by Pirc Barčić *et al.*, 2015), the second in 2017 (Slovenia and Croatia market), and the third one in 2018 for the Slovak market. Regarding the samples by countries, 915 respondents were from Slovenia, 887 from Croatia, and 225 from Slovakia. In all the three markets, identical questions were used. This non-specific population was targeted because there were no records on consumer consumption of renewable sources, which could narrow down the target population.

A telephone survey was used for surveying respondents for this study. This approach was selected because, according to Roster *et al.* (2004), it is possible to obtain a representative national sample by telephone surveys. The relative advantages of telephone surveys, like lower cost, less risk of interviewer bias, and avoidance of cluster sampling, were additional elements in making decision about the method of data collection (Berrens *et al.*, 2003).

Based on research objectives, a questionnaire was developed, pre-tested, and finalized based on pre-tested inputs. Straightforward questions and Yes/No items were used. Furthermore, multi choice item measure was used because, according to Thorndike (1967) cited by Lewis-Beck *et al.* (2004), it can be superior to a single, straightforward question. At the beginning of the phone interview, the researcher gives an introductory statement presenting the research study, introduces himself and explains the respondent's role emphasizing that his/her participation in research is essential (Dillman *et al.*, 1976) was presented to respondent.

The questionnaire consisted of twenty-one open questions, asking respondents about their household monthly income, types of their households, heating sources in their households, reasons for using wood pellets, availability of pellets price and consumption, other possible factors that could influence the pellet consumption, etc. Data were analyzed using descriptive statistics, χ^2 -test, Fisher's Exact Test, Shapiro-Wilk normality tests, with the use of the SPSS statistical packages.

3 RESULTS AND DISCUSSION

3. REZULTATI I RASPRAVA

3.1 Demographic profile of respondents

3.1. Profil ispitanika

Among the considered market population, in all the three countries, households with two (2) and one (1) employees (50.0 % and 22.0 %, respectively) dominate. Observing the population in the area where the households are located, survey results showed that

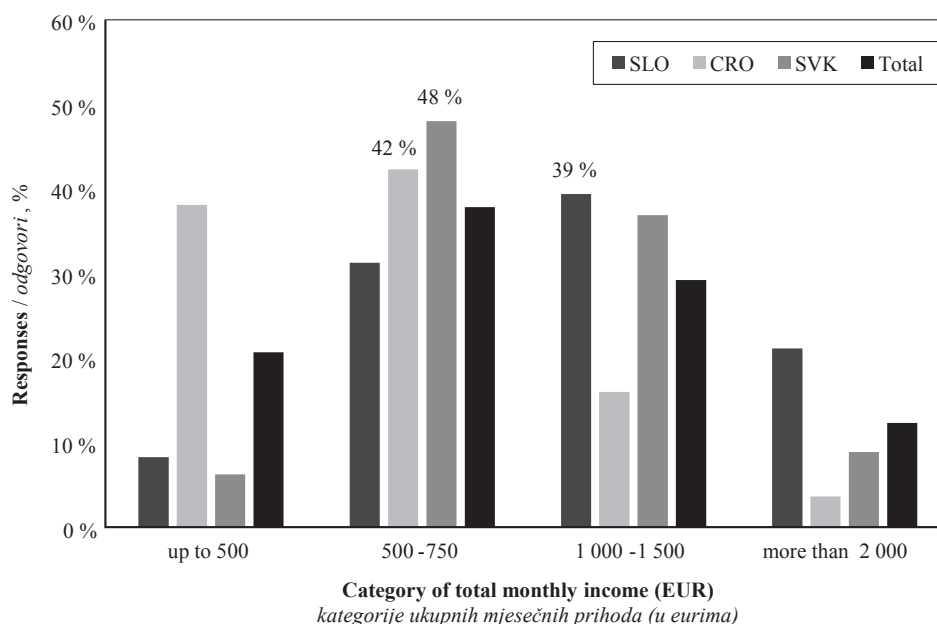


Figure 1 Total monthly household income per person
Slika 1. Ukupni mjesečni prihodi kućanstva po osobi

most households are located in the area with less than 5,000 inhabitants (48.5 %) and from 500,000 to 1,000,000 inhabitants (20.0 %). Regarding their monthly household income per person (Figure 1.), for instance, in Slovenia, the highest percentage (39%) of the observed population have an income of 1,000 to 1,500 EUR. In case of Croatia and Slovakia, most respondents stated to have from 500 to 700 EUR (42.0 % and 48.0 %, respectively). Regarding the education level, most respondents declared to have high school graduate and college or university level (61.2 % and 24.5 %, respectively).

Such description needs a few comments. Considering the location of respondents, all the three countries belong to the group of central and south EU countries with rather smaller population (from 2 up to 5.5 million of inhabitants) and no bigger cities (except their capitals). At this point of view, they are comparable. The differences in monthly household income are much more robust – especially in the case of Slovenia with prevalently higher income categories. Comparative reflections on Slovakian and Croatian economies

and wood sector can be found in the study of Kaputa *et al.* (2018).

3.2 Household characteristics

3.2. Obilježja kućanstava

In this research, households more than 20 years old (61.3 %) mostly dominated, followed by those between 10 and 20 years old (24.7 %). It is interesting to note that just 4.5 %, (mainly in Slovenia – 7.1 %) are newer houses, meaning that they are less than 5-year-old.

The characteristics discerning the markets from one another were investigated applying Chi-Square statistic. Tests showed that there is a statistically significant difference between the countries mean values of almost all heating sources, ($\chi^2(12) = 720,505, p < 0.001$). As shown in Table 1, on average, the use of firewood as a heating source is the highest (46.4 %, especially in Croatia and Slovenia). Furthermore, there is a light difference when observing the countries individually; for example the Slovak household, where a

Table 1 Heating sources and heating area of households observed ($n = 1966$)

Tablica 1. Izvori grijanja i grijana površina promatranih kućanstava ($n = 1966$)

Energy source used for heating, % / Izvor energije za grijanje, %							
Market Tržište	Gas Plin	Oil Ulje	Electricity Struja	Firewood Ogrjevno drvo	Solar Solarni izvori	Heating plant Toplinske pumpe	Other Drugo
SLO	12.1	15.3	13.8	43.3	4.1	3.1	8.3
CRO	25.2	2.5	13.5	55.1	0.3	2.5	0.9
SVK	23.6	0.0	6.2	28.9	0.4	38.2	2.7
Total / Ukupno	18.2	8.9	13.0	46.4	6.0	2.5	4.9
Heating area in households, % / Grijana površina, %							
	Up to 50 m ²		50-100 m ²	100-200 m ²	>200 m ²		
SLO	7.8		32.6	46.0	13.6		
CRO	28.6		51.5	18.1	1.8		
SVK	6.7		61.3	24.9	7.1		
Total / Ukupno	16.4		43.9	31.8	7.9		

*SLO – Slovenia / Slovenija; CRO – Croatia / Hrvatska; SVK – Slovakia / Slovačka

heating plant is most frequently the energy source, accounting for 38.2 %. At the other end of the spectrum lie other sources (like heat pump, biomass, briquettes, etc.) and heating plant, only accounting for 3.1 % (Slovenia) and 2.5 % (Croatia). Chi-Square test also showed statistically significant differences in all the three above mentioned cases ($\chi^2(6) = 371,460$, $p < 0.001$). Consequently, in most cases, the results show that the heating area covers 50 to 100 and 100 to 200 square meters (Table 1). Regarding the question about annual heating costs, for testing the differences in the markets, besides χ^2 test, a post-hoc test was made by pairwise comparisons of countries, as well as the applied Bonferroni correction for multiple tests. The tests showed that there is a statistically significant difference between Slovenia and Croatia ($p < 0.001$, Fisher exact test) and between Slovenia and Slovakia in annual heating costs ($p < 0.001$, Fisher exact test). However, the difference between Croatia and Slovakia were not significant ($p = 0.022$, Fisher exact test). Expenses in all the three countries were mostly up to 700 EUR (48.2 %) and ranged between 700 and 1,300 EUR per year (41.1 %). However, when comparing the expenses of heating with the energy source used for heating on annual basis, individually per market, then Slovenian householders pay the highest price, more than 1,300 EUR, for plant heating. On the Croatian and Slovak market, this was the case for oil heating.

3.3 Pellet users in Slovenia, Croatia and Slovakia

3.3. Korisnici peleta u Sloveniji, Hrvatskoj i Slovačkoj

As already mentioned, wood pellets have an important role for the renewable EU energy goals, in the transformation of the energy system from fossil fuels, which is required to meet the EU 2030 and COP21 targets. To this end, a set of open questions was used to explore how much Slovenian, Croatian, and Slovak households know about wood pellets in general, and what the possibilities of their future consumption enhancement are. The Fisher exact test proved that there is a statistically significant difference between the Slovenian and Croatian population in their familiarity with the term wood pellet ($p < 0.001$), more precisely 83.2 % of respondents from Slovenia and 65.3 % from Croatia declared to know about it. The same answer came to the question on their familiarity about lower price of pellets versus other heating sources, such as oil.

Several tests were done to investigate the use of pellets as a main source of heating in households of the observed markets – Slovenia, Croatia and Slovakia. Chi-square test has shown that there is a significant difference between pellets users and non-pellets users, generally ($\chi^2(4) = 18,435$, $p < 0.05$, Pearson Chi-Square). Considering the whole sample ($n = 1,973$ respondents) only 6.0 % of respondents stated to use wood pellets as a heating source. Dealing with individual countries, the highest share of (pellets) users were in Slovenia (11.2 %). The data shows a relatively low use of pellets in all the three markets. Among the considered population, the highest percentage of pel-

lets users came from an area with less than 5,000 inhabitants (52.9 %) and with households more than 20 years old (45.4 %). Heating surface mostly (43.7 %) covers from 50 to 100 and from 100 to 200 square meters. Furthermore, such households mainly have 4 persons, where usually only 2 persons work (63.0 %). Monthly household income per person differs among countries. In Slovenia, pellets users receive over 2,001 EUR (38.8 %), in Croatia from 500 to 1,000 EUR, and in Slovakia from 1,001 to 2,000 EUR (30.8 %). These findings point at different respondents' living standards. The majority of respondents (>80 % of answers) are familiar with wood pellets producers in their country, as well as with the price of wood-pellets and government subventions.

Furthermore, the following set of variables was applied to explore the reasons for using pellets: *price, government subventions, ecological aspects, space, decrease of energy, higher heat emission, and long-term cost effectiveness* (Table 2). Fisher's Exact test has shown that there is a statistical difference between respondents across the three markets and regarding the variable *price* ($p = 0.005$). To see the difference between groups, further post hoc tests were done. A Bonferroni correction has been applied for Chi square test on comparison of groups. With four pairwise comparisons, p-value must be less than $0.05/6 = 0.008$ to be significant at $p < 0.05$ level. The results indicated a higher share of Slovak respondents, who marked price as the reason for using wood-pellets (Cramer's $V = 0.322$, $p < 0.001$). Even though there were no statistically significant differences between other variables, when observing the results of descriptive analysis (Table 2), it can be seen that the most important reasons for the use of pellets are *space* and then *price* (66.3 % and 33.7 %, respectively). At the end of the spectrum was a government subvention (4.2 %). There are no differences among the individual markets. For instance, in case of Slovenian users, the most important reason was *space* (67.5 %), while in case of Slovakian users, it was *price* (77.8 %).

To explore the benefits of pellets, the participants were asked to estimate annual heating costs and their satisfaction with the amount of produced heat. The Fisher's Exact Test was applied to investigate the characteristics discerning the three markets from one another. The results showed that there are 3 statistically significant differences between respondents and annual wood-pellet costs ($p = 0.040$) across all the three markets. The annual heating costs for pellets mostly ranged around 1,000 EUR in case of Slovenian users (75.6 %) and Slovak users (66.7 %). The majority of Croatian users (66.7 %) pay the price between 1,000 and 2,000 EUR. Comparing this result with non-pellets users, the costs are slightly lower for pellets users. Their satisfaction with the amount of produced heat is not statistically significant ($p > 0.05$), but generally almost all the pellets users (94.6 %) expressed satisfaction with this heating option.

The research also focused on the source of information about pellets. Respondents indicated **media**

Table 2 Reasons for using wood-pellets and annual wood-pellets costs (in EUR) on observed markets (*n* = 119)

Tablica 2. Razlozi odabira peleta i godišnja cijena takvoga grijanja na promatranom tržištu (*n* = 119)

Market <i>Tržište</i>	Reasons for using wood-pellets, % / Razlozi odabira peleta, %						
	Price <i>Cijena</i>	Government subventions <i>Državne subvencije</i>	Ecological aspects <i>Ekološki aspekti</i>	Space <i>Prostor</i>	Decrease of energy use <i>Smanjenje potrošnje energije</i>	Higher heat emission <i>Veća toplinska energija</i>	Long-term cost effectiveness <i>Dugoročna isplativost</i>
SLO	30.1	4.8	27.7	67.5	26.5	22.9	7.2
CRO	0.0	0.0	0.0	100.0	0.0	0.0	0.0
SVK	77.8	0.0	11.1	44.4	0.0	11.1	0.0
Total YES <i>Ukupno DA</i>	33.7	4.2	25.3	66.3	23.2	21.1	6.3
Annual pellets costs (in EUR), % / Godišnji troškovi peleta (u eurima), %							
Up to 1 000 /do 1 000		1 000-2 000		>2 000			
SLO	62.2		19.4		0.0		
CRO	0.0		33.3		0.00		
SVK	38.5		23.1		7.7		
Total / <i>Ukupno</i>	57.1		21.0		0.8		

*SLO – Slovenia / Slovenija; CRO – Croatia / Hrvatska; SVK – Slovakia / Slovačka

(33.7 %) as the main source of information about wood pellets, followed by some other communication channels (25.3 % of responses). Recommendation was of low importance. To determine the difference between markets, a set of Fisher’s exact tests were run. These tests showed that there is a statistically significant difference only among respondents across all the three markets and media ($p=0.005$, Cramer’s $V=0.322$, $p<0.001$).

3.4. Potential pellets users in Slovenia, Croatia and Slovakia

3.4. Potencijalni korisnici peleta u Sloveniji, Hrvatskoj i Slovačkoj

To explore the possibilities of enhancement of wood pellets future consumption, a list of 7 variables was introduced to respondents for evaluation. Table 3 summarizes respondents’ statements, validated by chi-square and post hoc tests. The tests showed a statistically significant difference among countries and their intention to use wood-pellets in the future - *within 1 year* ($\chi^2(2) = 10.887$, $p<0.05$, Pearson Chi-square test).

Also, statistically significant difference was revealed among countries and their intention to use wood-pellets in the future - *within 3 years* ($\chi^2(2) = 17.744$, $p<0.05$, Pearson Chi-square test). The Bonferroni correction has been applied for chi-square test in comparison of groups for these question. With four pairwise comparisons, p -value must be less than 0.008 ($0.05/6=0.008$) to be significant at the $p<0.05$ level. The results showed a statistically significant difference indicating a higher proportion of Slovenian and Croatian respondents (>94.0 %) who missed to express intention to use pellets within three years (Cramer’s $V=0.098$, $p<0.001$). As shown in Table 3, most of respondents (11.1 %) stated the possibility to move to start using pellets heating within five years. On other side, no possibility to install wood pellets heating system in household was seen as the most important barrier (27.8 %) for non-pellets users. This finding is contrary to the response of pellets users since they consider price as a positive characteristic.

Table 3 Intention to use pellets in future (*n* = 1598)

Tablica 3. Namjera o budućoj uporabi peleta (*n* = 1598)

Market <i>Tržište</i>	Intention to use pellets in future – YES, % <i>Namjera o budućoj uporabi peleta – DA, %</i>			Intention to use pellets in future – NO, % <i>Namjera o budućoj uporabi peleta – NE, %</i>			
	YES – within 1 year <i>DA – za 1 god.</i>	YES – within 3 years <i>DA – za 3 god.</i>	YES – within 5 years <i>DA – za 5 god.</i>	NO – high price <i>NE – visoka cijena</i>	NO – insufficient information <i>NE – nedovoljno informacija</i>	NO – there is no possibility to install wood pellets heating system in my haousehold <i>NE – u mojem kućanstvu ne postoji mogućnost instalacije grijanja na pelete</i>	NE – other <i>NE – drugi razlozi</i>
SLO	4.2	5.2	12.8	16.1	17.5	21.2	22.4
CRO	2.2	1.9	9.5	10.4	30.1	25.7	21.4
SVK	0.5	0.9	12.0	0.0	23.5	56.3	6.6
Total <i>Ukupno</i>	2.9	3.2	11.1	11.3	24.2	27.8	19.9

*SLO – Slovenia / Slovenija; CRO – Croatia / Hrvatska; SVK – Slovakia / Slovačka

Chi-square test also proved statistically significant differences among the observed markets for non-user subgroup that gave a negative answer about the future use of pellets, as presented in Table 3. Statistically significant differences showed that the reasons were *price* ($\chi^2(2) = 36.787, p < 0.05$, Pearson Chi-square test), *insufficient information* ($\chi^2(2) = 26.868, p < 0.05$, Pearson Chi-square test) and *inadequate technical prerequisites* ($\chi^2(2) = 88.183, p < 0.05$, Pearson Chi-square test).

4 CONCLUSION 4 ZAKLJUČAK

Wood pellets require to be observed from the economic, environmental and social point of view due to the pronounced advantages and volume of raw material resources in Croatia, Slovenia and Slovakia. In many cases, they represent the fuel of the future.

In Croatia, Slovenia and Slovakia, the observed households (48.5 %) are mainly located in the area with less than 5,000 inhabitants, usually generating monthly household income from 500 to 750 EUR. Around 61 percent of households are more than 20 years old and the majority of them use wood as the heating source (46.4 %, especially in case of Croatia and Slovenia). Further, there were some differences when the countries were observed separately. In Slovakia, the most frequent source of heat comes from heating plants (38.2 %), while up to 29.0 % of households use firewood for this purpose. This fact has a historical explanation since most of urban blocks, built during the socialist period, were heated centrally. On the other side, households in rural areas used firewood or gas, or a mix of these two. Such Slovakian households have the biggest potential to become the users of wood pellets.

Heating costs in all the three countries achieved either up to 700 EUR (48.2 %) or between 700 and 1 300 EUR per year (41.1 %). Slovenian householders pay the highest price, more than 1,300 EUR. A statistically significant difference was found between Slovenian and Croatian population in their familiarity with the term wood pellets ($p < 0.001$) (83.2 % respondents from Slovenia and 65.3 % from Croatia declared to know about it), but the results revealed a relatively low use of pellets in all the three markets. Additionally, among the considered population, the highest percentage of pellets users came from areas with less than 5,000 inhabitants and with households more than 20 years old. The majority of respondents in all the three countries stated that they are familiar with subventions and government programs that encourage the use of renewable energy sources, but the most important reasons for the use of wood pellets were *space* and then *price*, while at the end of the spectrum was a government subvention (only 4.2 %). This study also showed statistically significant differences between countries and their positive intention to use wood-pellets in the future - *within 1 years* and *within 3 years*. The most frequent reason not to plan to use wood pellets was *no possibility to install wood pellets heating system* in household (27.8 %).

Croatian consumers (public institutions and private persons), similarly as Slovenian and Slovakian consumers, are not informed enough about the scope of use of wood pellets and their advances within the Green Deal. In many cases, the market price, which seems to be perceived as high by consumers, plays the main role. Over all, European Union bioenergy policies, oil prices and sales of heating appliances can have an important effect on wood pellets consumption market. Additionally, segments related to energy efficiency in flats, houses and other buildings can also influence the wood pellets demand, as well as the development of wood-pellets production technologies. Finally, the authors hope that this study will support decision making of wood pellets producers, wood-pellets consumers as well as policy makers to strengthen the development of this wood-based sector in all the surveyed countries.

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