Mario Šercer, mag. oec.

J. J. Strossmayer University of Osijek Faculty of Economics Gajev trg 7, 31000 Osijek, Croatia Phone: 091/1656066 E-mail address:bioplam@ck.t-com.hr

Zlatica Kavić, mag. oec. J. J. Strossmayer University of Osijek Faculty of Economics Gajev trg 7, 31000 Osijek, Croatia Phone number: 098/268842 E-mail address: zlatica.kavic@gmail.com

THE ROLE AND IMPORTANCE OF WOOD BIOMASS IN CROATIAN ENERGETICS

ULOGA I VAŽNOST DRVNE BIOMASE U HRVATSKOJ ENERGETICI

ABSTRACT

Renewable sources, regenerative or alternative energy sources are sources which are within the human horizon practically inexhaustible or they are relatively quickly restored. Today, they are increasingly in use for its safety for environment. With wind, solar and geothermal energy, one source of this kind is biomass consisting of various products of flora and fauna, such as wood waste in forestry, manufacturing remains in wood industry, various vegetable oils, straw, corn stalks, animal faeces and residues from livestock, municipal and industrial waste, etc. Of all forms of biomass, the widest use occupies wood biomass. In this work is briefly explained the concept of biomass with a detailed focus on wood biomass as one of renewable source of energy. Aim of this work is to present the role and importance of wood biomass in Croatia as one of the most important energy sources in the near future. Use of wood biomass (in the form of firewood) has a long tradition in the Republic of Croatia. The Republic of Croatia has significant potential of wood biomass for energy production, which confirms the fact that forest and woodlands cover 47% of Croatian land surface. The role of wood biomass is multiply, both in environmental protection and in terms of sustainable development. Besides, it is important to highlight social and economic contribution of biomass whose exploitation creates independence from imported energy, creates new working positions, and opens the chances to export, strengthen the regions and promote environmental protection. These are important factors because of which biomass in the energy strategy of Republic of Croatia represents an important role as evidenced by international collaboration in this field as well as organizing traditional international scientific meetings. Croatian Ministry of Economy is on of the key subjects that with its not just short-term but also longterm energy policy and energy development strategy can greatly contribute that biomass in the Croatian energy sector according to its potential take the place in the politics of sustainable which belongs to her.

Key words: renewable energy sources, wood chips, wood biomass, sustainable development, ecology

SAŽETAK

Obnovljivi izvori, regenerativni ili alternativni izvori energije su takvi izvori koji u okviru ljudskog horizonta praktički neiscrpni ili pak se razmjerno brzo obnavljaju. U današnje se vrijeme sve više koriste zbog svoje neškodljivosti prema okolišu. Uz vjetar, sunčevu i geotermalnu energiju, jedan od takvih izvora je i biomasa koju čine različiti proizvodi biljnog i životiniskog svijeta kao što su drvni otpad u šumarstvu, proizvodni ostaci u drvnoj industriji, razna biljna ulja, slama, kukuruzovina, životinjski izmet i ostaci iz stočarstva, komunalni i industrijski otpad i drugo. Od svih navedenih oblika biomase najširu primjenu zauzima drvna biomasa. U radu je ukratko pojašnjen pojam biomase s detalinijim naglaskom na drvnu biomasu kao jednog od obnovljivih izvora energije. Cilj rada je prikazati ulogu i važnost drvne biomase u Hrvatskoj kao jednog od važnijih energenata u skoroj budućnosti. Korištenje drvne biomase (u obliku drva za ogrijev) ima u Republici Hrvatskoj dugu tradiciju. Republika Hrvatska raspolaže s značajnim potencijalom drvne biomase za proizvodnju energije što potvrđuje podatak da je 47% kopnenih površina Republike Hrvatske pokriveno je šumom i šumskim zemljištima. Uloga drvne biomase višestruko je očita; kako u zaštiti okoliša tako i u funkciji održivog razvoja. Uz to svakako valja istaknuti i socijalno-ekonomski doprinos biomase čija eksploatacija stvara neovisnost o uvoznoj energiji, otvara nova radna mjesta, otvara šanse izvozu, jača regije i unapređuje zaštitu okoliša. To su važni čimbenici zbog kojih biomasa u Energetskoj strategiji Republike Hrvatske predstavlja važnu ulogu što dokazuju međunarodna poslovna suradnja na tom području kao i organiziranje tradicionalnih međunarodnih znanstveno-stručnih skupova. Ministarstvo gospodarstva Republike Hrvatske jedan je od ključnih subjekata koji svojom ne samo kratkoročnom već i dugoročnom energetskom politikom te strategijom energetskog razvoja uvelike može doprinijeti da biomasa u hrvatskoj energetici sukladno svom potencijalu zauzme ono mjesto koje joj u politici održivog i pripada.

Ključne riječi: obnovljivi izvori energije, peleti, sječka, drvna biomasa, održivi razvoj, ekologija

1. Introduction

Today, for a number of reasons, because of environmental, economic and political nature an increasing attention is focused on the renewable energy sources. Some of these reasons are placed for the reduction of the carbon dioxide emissions, the independence of the generating energy system, the limited reserves and the day after day rising costs of the fossil fuels, competitive prices and others. On a long – term period, the electric energy policy will be more focused on the energy that is obtained from renewable sources, and one of them is the wood biomass, which from all the available forms of biomass has the widest usage. The wood biomass (in the form of a firewood corn wood) in our country has a long tradition of use. The Republic of Croatia has considerable potential for the wood biomass production, for the production of energy as evidenced by the fact that nearly half of the Croatia's land area is covered by the forests and the forest lands. This work is structured of the five chapters. The first chapter contains a brief introduction. In the second chapter were sets out the basic information's about renewable energy, and of the biomass in general. The third section discusses the wood biomass in the Republic of Croatia and its share in the primary energy production. In the fourth chapter, the comparison of production and consumption of energy derived from renewable energy sources in Croatia, Slovenia, Germany, Sweden and countries EU-28 was drawn upon. The fifth chapter brings to a conclusion.

2. Renewable energy sources

Renewable energy sources are such sources that in a given period of time are subjected to a self – renewable process, during human exploitation they cannot be exhausted, but it is possible to completely deplete their resources. Reproducibility of individual energy sources for us is the easiest way to perceive, if we say that the renewable source is such whose average reproducibility has repeated each year, without reducing its capacity - at least for the human perception of time. They are increasingly being used because of their safety to the environment. In the renewable energy sources are included: hydro power, biomass (and the biogas, including wood and the waste matters), solar energy and wind energy.

Part of the renewable energy sources cannot be stored or transport by any means in natural form (such as the wind and the sun radiation), and the part of such sources can be stored (watercourses, river water and accumulations, biomass and biogas) The energy sources that cannot be stored as such, it should be used at a time when they appear, or to convert them into another form of energy. The obvious advantages of the non-renewable resources are: permanency, they are better suited to adapt to our needs, the advantage of being storage and transport in natural form, less needs for the investment to build a processing plant for their production, conversion and usage, and also maintenance of the plant in a view of the installed power (Šljivac, Šimić, 2009, 5).

In the Republic of Croatia, renewable energy sources, in the case when the hydropower has not been included, gives only an inconsiderable part of the total energy required (only 1%). That share in the future should be significantly increased because, we found the existence of the non-renewable sources even in a lesser extent, and their harmful impact has significantly increased (Sušnik, Benković, 2007, 12)

The Government of the Republic of Croatia has recognized the importance and on the many ways encourages the use of biomass and other renewable sources. According to Sinčić (2011) the tangible aim in terms of replacing fossil fuels was set first by the European Directive 2003/30/EC, and by the Directive 2009/28 / EC, which were set on the promotion and use of renewable energy, has definitely changed the situation in the area, since it's moved away from the previous recommendations. Specifically, it referred to mandatory targets and they require from the each country the specific plan for their implementation. These are popularly called 20-20-20 order that requires:

- To increase energy efficiency and save 20% of energy,
- To reach 20% of the produced renewable energy in total energy consumption,
- Reduce the greenhouse gas emissions by 20%,

and, in particular to reach the goal of replacing 10% of the fuel consumption in transport by the same amount of biofuels (Sinčić, 2011, 331)

2.1. About biomass in general

When mentioned in broader terms, the biomass includes all the organic substances (i.e. those substances containing carbon). Accordingly, the biomass includes all the living world found in nature (plants and animals), the remnants of plants and animal world, extinct (but not yet fossilised) plants and animals, in further terms, all of the matters that were made by the use of the technological processes or the materials usage (for example, paper and cellulose pulp, slaughter – houses waste, organic garbage, vegetable oil, alcohol).

The border line between biomass and fossil fuels makes the peat¹⁸⁷, the secondary product that occurs during the putrefaction process (Kaltschmitt, 2009, 2)

¹⁸⁷ Peat - the youngest fossil fuel, formed during a long process of decomposition of marsh plants.

Biomass in the strict sense is a renewable energy source that includes firewood, branches and wood waste from forestry and also the sawdust, bark and wood waste, chips from the wood industry, as well as the straw, corn stalks, sunflower stalks, remnants as a result of the pruning of vines and olives, cherries pits and apples peel from the agriculture production, animal dung and remains from livestock, municipal and industrial waste. It's the only renewable energy source that can be used for unlimited production of electricity and heat, and as liquid fuels for the vehicles. The main advantage of biomass when compared to the fossil fuels, is its renewability and sustainability. Lately, more and more it becomes obvious that the current approach to the energy consumption is unsustainable. From all the renewable energy sources, the largest contribution in the near future is expected from the biomass itself. Biomass and its products - liquid biofuels and biogas are not only potentially renewable, but also sufficiently similar to fossil fuels that can directly substitute (Working Group on Biomass, 2005, 5) There are two main modes of biomass distribution:

1. In accordance to their origin:

а

c.

- Forest or wood biomass
 - i. Residues and waste from forestry and wood processing industry
 - ii. Products that resulted from targeted breeding (fast-growing trees and so-called energy crops)
- b. Non-wood biomass
 - i. Products of targeted breeding (fast-growing algae and grasses)
 - ii. Residues and waste from the agriculture production
 - Biomass of animal origin
 - i. Animal waste and scrap
 - ii. Animal waste and scrap
- 2. In accordance to the final manifestation of the matter
 - i. Solid biomass
 - ii. Biogas
 - iii. Liquid biofuels (alcohol, biodiesel)

The final forms of biomass those were generated by different processes of transformation and processing from the initial raw materials: plants, residues from forestry, wood processing and agricultural production and waste (Labudović, 2012, 36)

Biomass can be viewed as the most complex form of a renewable energy source with several aspects: it forms all three states of matter, it covers a wide range of raw material, from the biomass can be produced all three forms of useful energy, usable wide range of the conversion technologies, from the same types of biomass can be produced various forms of useful energy using different conversion technologies, and others. In comparison to other renewable energy sources, biomass has several significant advantages, its use is limited by the criteria of sustainability, energy from the biomass can be stored, the primary energy obtained from biomass can be used on a distance from the place of its production, the production of energy from the biomass enables continuous process similar as with the conventional energy (for instance, the cogeneration plants), and also bring the multiple benefits to the local community (Vorkapić, 2010, 11).

2.2. Obtaining energy from biomass

Energy from the biomass can be obtained in different ways. Biomass is the only renewable energy source that can be used for unlimited production of electrical and heat energy, and for the purpose as the liquid fuels for vehicles (Working Group on Biomass, 2005, 4)

The most common processing method of directly converting biomass into energy is simply combustion, when the superheated steam for heating in industry and households is produced, or to generate electricity in small thermo - power plants. Oilseed rape and some other oilseeds provide biodiesel, which can be directly used in diesel engines. Biogas methane is produced using an anaerobic fermentation process from the biomass. Biogas is produced by the use of fermentation in the atmosphere without the presence of oxygen, and contains methane and carbon and therefore can be used as a fuel. So far, the biomass fermentation into alcohol is the most advanced chemical conversion of biomass matter. Such treatment consists of raw materials preparation, fermentation and distillation of ethanol. Ethanol can be produced from sugar (sugar cane), starch (corn) and cellulose (from wood and agricultural residues) (Šljivac, 2008, 9).

The most cost-effective way of producing electricity from the biomass is done in the cogeneration plants (when simultaneously combined heat and power), for which there are plentiful of examples that can be found in various countries. As a typical example of the possibilities for a successful cogeneration of biomass material, we can take the wood industry - wood processing companies have a need for heat (drying and steaming of wood, rooms central heating) and for the electrical energy, and by the process of wood processing occurs sufficient quantity of wood waste and chips that can be used as a fuel.

2.3. The advantages of biomass usage

The advantage of using wood chips when compared to the fossil fuels is in less CO_2 emissions and other air pollutants, and it's convenient from the standpoint of a CO_2 balance in nature, since the forest during growth has accumulated carbon dioxide (the so-called biomass circular cycle) During the combustion process of the wood chips, results solid residues (slag and ash) and flue gases containing combustion products (nitrogen and sulphur oxides, and solid particles) Emissions of sulphur oxides during combustion of biomass are very small (<0.01% of sulphur in the total wood weight), while the emissions of solid particles can be reduced by installing a flue gases purification system (Lovrić, 2013, 281)

Except for the environmental reasons, Gotovac and Dundović (2013) also recognize the economic and social benefits of biomass. The economic benefits of biomass from the forestry, wood and agriculture industry are reducing the imports of fossil fuels and the security of energy supply, which is one of the strategic problems of every country. According to forecasts, the dependence of the Republic of Croatia on energy imports will rise from the current 55% of imports to over 70% in 2030. Social benefits of using biomass will generate opportunities for the creating a large number of new jobs, which shall contribute to the rural development and that, is an imperative of the Croatian economic and social policy. In accordance to the European recommendations and empirical data, in the production of 1 MWh of thermal energy from the renewable biomass, works on average six people (Čikić, 2012, 42), while according to the data of the Austrian Biomass Association¹⁸⁸ there are 15 times more jobs provided by the use of wood as an energy source, when compared to the fossil fuels, because the biomass usage, except its production, involves creating the need for a new jobs in the plant production, production equipment and various supporting activities.

3. Wood biomass in Croatia

Energy utilization from the forest biomass, mainly fuel wood, has a long tradition in the Republic of Croatia, especially in rural parts of the country, so in 1965, from the forest biomass had been satisfied nearly a quarter of a then total energy needs. Although Croatia today has significant potential of biomass for the energy production (heat, electricity,

¹⁸⁸ Österreichischer Biomasseverband, Franz Josefs-Kai 13, 1010 Vienna, Ausria

biofuels), because of a lack of market and replacement with the other energy sources that are imported (gas, oil-fuel oil, electricity) as well as the lack of the environmental awareness on the benefits of renewable energy sources, the usage of such sources has come down to as low as 4,3% (Sušnik, Benković, 2007, 13).

For a long-term forest management program (2006 - 2015) it is estimated that only Croatian Forests Ltd. could dispose of 2,6 million m^3 of forest biomass for energy, which would double the current share of biomass as an energy source (Dundović, 2010, 1)

The annual cut of 6,5 million m^3 constitutes 30% of logs, 10% of pulpwood, 20% of firewood and the remaining 40% represents the thinner wood, that as a waste remains unused in the woods. Today, from the aforementioned waste, 62,5% could be used for energy production, but 37% of a waste would remain in the forest. If that amount will join the amount of firewood, we'll get the total amount of a wood for generating the energy that today could be placed on the energy market, i.e. 45% share of the total annual harvest (Pašičko, Kajba, Domac, 2009, 426).

It is worth mentioning that in the Republic of Croatia the beech is not only the most widespread species, but also the first wood species per share in the fund. The growing stock of Croatian beech accounts for approximately 36% (Potočić, et al, 2009, 289).

Nearly 47% of the total territory covered with forests is the great Croatian potential for the biomass usage. Total annual increment amounted to total of 9,6 million m³, together with the developed wood industry and a significant share of agriculture and animal husbandry in the economy are also an excellent basis for the production of energy from biomass, particularly in Slavonia and Gorski Kotar regions, where is especially pronounced the potential for using agricultural biomass. When considered geographically, the continental part of Croatia has a much higher biological potentials than the seaside, because a large part of the coast is consisted of a very rocky and a poor soil. Total consumption of energy derived from biomass is still used on the most ineffective way - for home heating (Šljivac, 2008, 19). The fact is that the wood sector export is positive because it's more export oriented than focused on imports, but the structure of exported goods shows that are exported mainly products of a lower values. An export encompasses only 3% of furniture, and even 63% of fuel and untreated wood (Čupin, 2012, 158).

3.1. The share of biomass in primary energy production

The structure of primary energy production in the Republic of Croatia highlights the constant increase of fuel wood and other renewable energy sources in the total production, so in 2002 the firewood was involved with 6,7% in the total primary energy production.

This value is constantly growing and in 2011 has reached 14,3%. The same trend was observed in the total energy consumption in the Republic of Croatia. The share of consumption of firewood in total energy consumption during 2002 was 3,3%, and by the 2011 it has reached 19,23% (Statistical Yearbook, 2013, 313)

Total production of primary energy in the 2012 was reduced by 5,6%, when compared to the previous year. Production of energy from the fuel wood and other solid biomass has been increased by 9,1%. The largest increase in production was achieved for the other renewable energy sources (wind and solar energy, biogas, liquid biofuels and geothermal energy) what amounted to 90,7%, as shown in Table 1.

	2007.	2008.	2009.	2010.	2011.	2012.		2012./11.	200712.
		PJ						%	
Fuel wood and Biomass	15,42	17,01	17,97	19,96	26,74	29,17		9,1	13,6
Crude Oil	37,27	35,42	33,07	30,69	38,37	25,62		-9,7	-7,2
Natural Gas	100,12	94,05	93,50	93,88	85,02	69,19		-18,6	-7,1
Hydro Power	42,21	50,19	65,77	79,71	42,59	45,45		6,7	1,5
Heat	1,01	1,25	1,48	1,76	1,68	1,71		2,1	11,2
Renewables	0,82	1,01	1,30	2,63	2,97	5,66		90,7	47,0
Total	196,86	198,93	213,09	228,62	187,36	176,79		-5,6	-2,1

Table 1 Primary energy production in the Republic of Croatia

Source: Energy in Croatia 2012 Annual Energy Review, the Ministry of Economy, p. 41

During the six year period, from 2007 to 2012, the primary energy production in Croatia decreased at an average annual rate of 2,1 %. Also, the trend of reduction was achieved in the production of crude oil and natural gas, while the production of other primary energy sources has achieved an upward trend. Production of crude oil and natural gas have been decreasing at an average annual rate of 7,2 % and 7,1 %, respectively. Hydrological conditions in the 2012 were such that during the six-year period, an increase was realised at an average annual rate of 1,5 %. The fastest growing energy production was from the renewable sources and annual growth rate of as much as 47 % has been achieved. Thermal energy from the heat pumps, during the observed time interval has recorded an increase an average annual rate of 11,2 %, while the production of fuel wood and other solid biomass grew at an average annual rate of 13,6 %. (Energy in Croatia, 2012, 2013, 42)

3.2. The realization of the project for energy use of forest biomass in Croatia

In their presentation that was held on the Eight Days of Biomass in Croatia in Našice, Pavelić and Kurić (2013) has quoted that during September of 2013, in the Register of projects run by the Ministry of Economy, was reported 97 projects with plants for biomass utilization of total power of approximately 240 MW. From those, for the 32 projects has received energy approval and are entering the phase of realization.

Up today, several smaller plants and several power plants have been realised to meet the needs of technological processes for thermal energy, which uses wood biomass as a fuel, as well as numerous small sources of heat (fireplaces, furnaces and boilers) by which it's covered the heat demand for heating and preparation of hot water in buildings intended for different purposes. Some of the completed projects of biomass plants in the Republic of Croatia are the following (Labudović, 2012, 262):

- Strizivojna Hrast Ltd cogeneration plant.
- Đuro Đaković Elektromont joint stock company, cogeneration plant.
- Centrometal Macinec heating of the production halls.
- Heating plant in Ogulin, built in 1995.
- Heating plant in Gospić, built in 2002 and others.
- Lika Energo Eko cogeneration plant, in active operation since of May 2012.

4. Comparison of the production and consumption of energy derived from the renewable energy sources in Croatia and the EU

The consumption of energy derived from the renewable sources is constantly increasing and it is approaching the target values as shown in Table 2.

	2008	2009	2010	2011	2012	Target value			
	%								
EU-28	10.5	11.9	12.5	12	14.1	20			
Croatia	12.1	13.1	14.3	15.4	16.8	20			
Slovenia	15.0	18.9	19.2	19.4	20.2	25			
Germany	8.5	9.9	10.7	11.6	12.4	20			
Sweden	45.0	48.2	47.2	48.8	51	49			

Table 2 Display of energy derived from the renewable energy sources in total energy consumption

Source: Own data preparation (data downloaded from Eurostat March 28, 2014)

The primary energy production from the renewable sources from one year to another maintains constant growth, what is represented by the data shown in Table 3. However, in the 2011, when compared to the previous year (in all countries except in Germany) there was a noticeable slight decrease in the production, resulting from unfavourable economic situation.

	2007	2008	2009	2010	2011	2012					
		2007 = 100									
EU-28	100	106.0	112.2	125.3	124.7	136.4					
Croatia	100	116.7	139.0	166.5	144.4	159.5					
Slovenia	100	115.1	135.6	138.0	131.1	136.3					
Germany	100	99.0	104.2	122.1	128.2	141.4					
Sweden	100	102.1	103.4	111.1	108.2	121.0					

Table 3 Primary energy production from the renewable sources

Source: Own data preparation (data downloaded from Eurostat April 3, 2014)

The trend of primary energy production from the solid biomass is similar to the trend of primary energy production from the renewable sources. This means that the constant annual growth was observed, with a slight decline during the 2011, when compared to the previous year. It is worth noting that Croatia and Slovenia did not record this fall; energy production from the solid biomass in Croatia almost doubled in the 2012, when compared to 2007.

	2 071			· · · · · · · · · · · · · · · · · · ·	/				
	2007	2008	2009	2010	2011	2012			
	2007 = 100								
EU-28	100	103.5	108.4	120.7	118.3	125.7			
Croatia	100	109.7	118.5	131.1	176.9	192.1			
Slovenia	100	109.3	125.1	123.8	131.9	130.6			
Germany	100	98.9	109.2	133.7	125.7	134.3			
Sweden	100	98.4	102.1	112.5	105.8	113.3			

Table 4 Primary energy production from the solid biomass (without charcoal)

Source: Own data preparation (data downloaded from Eurostat April 3, 2014)

5. Conclusion

Bearing in mind the fact that almost half of the entire of the land area of the Republic of Croatia is covered by forests, which represents a huge potential for energy recovery from the forest biomass, it could replace more expensive and less accessible fossil fuels. Renewable energy still lacks a significant role in the energy policy of the country, and because they cover only a small part of the needs for energy. Apart from the fact that we do not use our own available resources, the non-use of biomass leads to the direct environmental burdening with permanently damaging consequences. For the greater and wider use of biomass matter, there

are still many obstacles, one of which is still low environmental awareness of the population, which will give priority to the 'contemporary' (and often more expensive) solutions - natural gas or the fuel oil. In addition, in the Republic of Croatia there is still no significant support for the implementation of small heat sources for the single family houses, residential, public and commercial buildings, small plants, etc. that were fuelled on renewable sources, as it is the case in some other European countries. An increased interest in such energy solutions confirms that forest, i.e. wood biomass certainly represents a significant potential for energy usage. As it was noted in previous considerations, 97 projects with a total capacity of about 240 MW, that were registered in the Register of projects, and plants for the use of renewable energy sources and cogeneration and also the privileged producers by the Ministry of Economy - are the best proof for this claim. Nevertheless, it is still a relatively small number of projects active so far, that on one hand shows how these projects are technically demanding and relatively expensive, and on the other hand how much still a complex the whole administrative procedure is for their achievement, and obtaining an approval for acquiring the status of the privileged energy producer. It is reasonable to expect that the wood biomass in the Croatian energy sector in the coming years shall take place that it deserves, as was the case in the past, but this time with the use of the utterly modern and efficient technology solutions, and that the use of biomass as an energy source in the future achieve significant universal benefits, in terms of sustainable development.

REFERENCES

Čikić, A., Radić, A., (2013.): Analiza i izbor najpovoljnijeg energenta za toplinske potrebe proizvodnog pogona, Tehnički glasnik, Vol. 7, No. 3, pp. 221-224

Čikić, A., (2012.): **Obnovljivi izvori energije u funkciji intenzivne proizvodnje povrća**, Radovi Zavoda za znanstvenoistraživački i umjetnički rad u Bjelovaru, October 2012, No.6, pp. 33-45

Čupin, N., (2012.), **Obnovljivi izvori energije u Bjelovarsko-bilogorskoj županiji**, Radovi Zavoda za znanstvenoistraživački i umjetnički rad u Bjelovaru, October 2012, No.6, pp. 147-166

Dundović, J., (2010.): Sekcija za biomasu, http://www.sumari.hr/biomasa/, (accessed 25. March 2013)

Gotovac, A., Dundović, J., (2013.): Uloga energetskog korištenja šumske biomase kroz povećanje novostvorene vrijednosti drva na primjeru Ciprijanović d.o.o.Orahovica, http://www.sumari.hr/biomasa/osmidanibiomase/07.ppt, (accessed 25. March 2013)

Group of Authors, (2013.); **Statistički ljetopis Republike Hrvatske**, Državni zavod za statistiku Republike Hrvatske, Zagreb

Group of Authors, (2012.): Energija u Hrvatskoj - godišnji energetski pregled, Ministarstvo gospodarstva Republike Hrvatske, Zagreb

Hrvatski državni sabor, (2001.): Zakon o energiji, NN 68/01, 177/04, 76/07, 152/08, 127/10, Zagreb

Kaltschmitt, M., Hartmann, H., Hofbauer, H., (2009.), Energie aus Biomasse - Grundlagen, Techniken und Verfahren, 2. Auflage, Springer, Berlin

Labudović, B. (2012.): Osnove primjene biomase, Energetika marketing, Zagreb

Lovrić, M., Lovrić, D., (2013.): **Obnovljivi izvori energije u Hrvatskoj, prednosti i nedostatci,** Kemija u industriji, Vol.62, No.7-8, pp. 279-282

Pašičko, R., Kajba, D., Domac, J., (2009.): Konkurentnost šumske biomase u Hrvatskoj u uvjetima tržišta CO2 emisija, Šumarski list, Vol.133, No.7-8, pp. 425-438 Pavelić, I., Kurić, D., (2013.): Realizacija projekata i investicija u energetska postrojenja na drvnu biomasu, http://www.sumari.hr/biomasa/osmidanibiomase/06.pdf, (accessed 25. March 2013)

Potočić, N. i drugi autori, (2009.): **Ekofiziološki odziv suncu izloženih sadnica obične bukve (Fagus sylvatica l.) pri različitim razinama gnojidbe**, Šumarski list, Vol.133, No.5-6, pp. 289-300

Sušnik, H., Benković, Z., (2007.), Energetska strategija Republike Hrvatske u kontekstu održivog razvitka šumarstva i poljoprivrede, Zbornik radova Obnovljivi izvori energije u Republici Hrvatskoj, Hrvatska gospodarska komora, Sektor za industriju, May 27-29. 2007., pp. 11-18

Sinčić, (2011.), **Obnovljivi izvori energije – proklamacije i stvarnost**, Kemija u industriji, Vol.60. No.6, pp. 331-333

Šljivac, D., (2008.): **Obnovljivi izvori energije – energija biomase**, http://oie.mingorp.hr/UserDocsImages/OIE%20Tekst.pdf, (accessed 25. March 2013)

Šljivac, D., Šimić, Z., (2009.), **Obnovljivi izvori energije, Najvažnije vrste, potencijal i tehnologija**, http://oie.mingo.hr/UserDocsImages/OIE%20Tekst.pdf, (accessed 26. March 2013)

Šturc, M., (2014.): Share of renewables in energy consumption up to 14% in 2012, http://epp.eurostat.ec.europa.eu/cache/ITY_PUBLIC/8-10032014-AP/EN/8-10032014-AP-EN.PDF, (accessed 29. March 2013)

Vorkapić, (2010.), **Energija iz biomase**, http://www.menea.hr/wp-content/uploads/2013/12/7_biomasa.pdf, (accessed 26. March 2013)

Working Group on Biomass, (2005.): Biomasa kao obnovljivi izvor energije, Energetski institut Hrvoje Požar i Šumarski fakultet u Zagrebu, Zagreb