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Production of Bioenergy in the Posavina Region

Veljko Vorkapić[1], Ana Kojaković[1], Gordana Đurić[2,3], Stoja Jotanović[3], Danijela Kondić[3], Borut Bosančić[2,3], Duška Šaša[1]

[1]*Energy Institute Hrvoje Požar, Zagreb, Croatia*
[2]*Genetic Resources Institute, University of Banja Luka, Republic of Srpska, BiH*
[3]*Faculty of Agriculture, University of Banja Luka, Republic of Srpska, BiH*

Abstract

This paper presents the results of the project titled "*Agricultural Biomass Cross-border Development of Energy in Posavina" - ABCDE Posavina* implemented within the IPA Cross-border Programme between Croatia and Bosnia and Herzegovina. Its main objective is to promote agro-bioenergy in rural economies by including utilisation of agricultural biomass for energy purposes in the Posavina region. The region includes Vukovar-Srijem County (VSC) in Croatia and four municipalities (Odžak, Domaljevac-Šamac, Orašje, Šamac) and Brčko District in Bosnia and Herzegovina (BiH). These areas represent valuable agricultural land with a good potential for economic utilisation. The analysis of agricultural biomass potential includes production of biogas in co-digestion of manure (cattle, pigs and poultry manure) and maize silage (input of maize silage is limited at 30% of feedstock mass) as well as biodiesel from oilseed rape and bioethanol from maize. Potential GHG savings are estimated for the biogas and biofuels use. Theoretical biogas energy potential is estimated at 1,386 TJ/yr for VSC and 574 TJ/yr for BiH. Based on the theoretical potential for generation of electricity and heat from biogas, total installed capacity in VSC would be 19.8 MW_e while 8.2 MW_e in BiH. The corresponding theoretical potentials for biodiesel production are 4,258 TJ/yr (VSC) and 1,415 (BiH) while for bioethanol these are 6,140 TJ/yr and 1,689 TJ/yr, respectively. It is assumed that 50% of total theoretical biogas potential and 30% of total theoretical biofuel potential are achievable. Annual GHG savings for biogas use are estimated at 31.30 ktCO2-eq (VSC) and 26.84 ktCO2-eq (BiH). Annual GHG savings due to biodiesel use are estimated at 37.46-64.22 ktCO2-eq (VSC) and 12.45-21.34 ktCO2-eq (BiH) and for bioethanol use at 54.02-92.61 ktCO2-eq (VSC) and 14.86-25.48 ktCO2-eq (BiH).

Key words: biomass, potential, cross-border development, Posavina region.

Introduction

This paper presents the results of *Agricultural Biomass Cross-border Development of Energy in Posavina* - ABCDE Posavina project that is being carried out within the IPA Cross-border Programme between Croatia and Bosnia and Herzegovina. The project aims to promote use of agricultural biomass for energy generation in Posavina. Target area spreads across 3,494 km^2 (~ 350.000 inhabitants) and includes Vukovar-Srijem County (VSC) in the Republic of Croatia (RC) and municipalities of Šamac, Domaljevac-Šamac, Orašje, Odžak as well as Brčko District in Bosnia and Herzegovina (BiH) (Figure 1).

Fig. 1. Project target area – the Posavina region
Projektom ciljano područje - područje Posavine

The total arable area in BiH amounts to 51,002 ha, whilst in Vukovar-Srijem County it covers around 154,856 ha (CORINE Land Cover Croatia). Quality agricultural land along with the tradition of field crop and animal production represent significant development resource of the region, but on the other hand, inadequate and fragmented production of low productivity does not allow full-scale development of economic potentials.

Using agricultural biomass for generation of electrical energy has various advantages in comparison with the use of fossil fuels, such as no greenhouse gas emissions, solving the issue of stable manure disposal, diversification of agricultural production, exploitation of degraded, less productive agricultural land, inducing rural development, using domestic energy resources, diversification of supply and reducing dependence on import, etc.[8,1]

Furthermore, it is important to underline that the European Union (EU) has defined the following objectives regarding renewable sources of energy (RSE) by *Directive 2009/28/EC*:

- The share of gross final consumption of energy from renewable sources in gross final consumption of energy shall amount to 20 percent by 2020
- The share of energy from renewable sources in all types of transport shall amount to at least 10 percent of the total energy in transport by 2020

Having laid down the *Energy Sector Development Strategy of the Republic of Croatia (NN 130/09)*, the RC adopted the said objectives. Moreover, the RC has established an incentive system for generation of electrical energy from RSE and the use of biofuels and other renewable fuels for transport purposes. In BiH, the *Law on Electrical Energy of the Republic of Srpska (The Official Gazette of the RS 66/02, 29/3, 86/03, 111/04)* and the *Law on Electrical Energy of the Federation of BiH (The Official Gazette of FBiH 41/02, 24/05, 38/05)* view generation of electrical energy from RSE in a positive way.

In regards with the reduction of greenhouse gas emissions, the EU set a target to reduce emissions by 20 percent in comparison to 1990, thus making it possible to achieve reductions by 30 percent providing that other countries (especially China, India, Brazil)[6,15] have accepted certain obligations. The RC and BiH have ratified the *United Nations Framework Convention on Climate Change (UNFCCC)* which aims to establish stable concentration of greenhouse gases in the atmosphere at a level that will prevent anthropogenic interference with the climate system. As one of the parties to Annex B of the Kyoto Protocol, the RC has committed to reduce greenhouse gas emissions by 5 percent during the first commitment period 2008-2012 in comparison with the 1990 baseline emissions.

Methodology

The analysis of agricultural production in Posavina has been carried out with the aim to evaluate the state and potentials for energy production (biogas, liquid biofuels) from agricultural raw materials.

Availability of agricultural land

To determine the area that can be used to grow biomass for production of energy, sustainability criteria have been applied. In addition, it was assumed that food and animal feed production still has to remain the primary use of agricultural land and that neither meadows and pastures nor environmentally valuable areas were to be used for energy crops.

On the basis of experience and literature data, to provide food for humans, including field crop and animal production, 0.16 ha of agricultural land is needed per capita.[17] When determining arable land available for energy crops in the region under study, the fact that Posavina is "a granary" both for the RC and BiH was also taken into account. Therefore, an assumption has been made that for food production it is necessary to ensure the area that corresponds to the share of agricultural land in the region concerned with the total agricultural land in each country.

To calculate available agricultural land for each target region, the following formula has been used:

$$P_{en} = \frac{(P_{Pos} - \frac{P_{Pos}}{P_{uk}} \times B_{st} \times 0{,}16) \times (P_{Pos} - P_{lp})}{P_{Pos}} \text{ [ha]}$$

Where:

P_{en} – available agricultural land for energy crops in the region under study [ha]
P_{Pos}– total agricultural land in the region under study [ha]
P_{uk}– total agricultural land in RC/BiH [ha]
P_{lp} – total meadows and pastures in the region under study [ha]
B_{st} – RC/BiH population
0.16 – agricultural area needed for production of food and animal feed in order to provide sustenance for one person [ha/cap]

Availability of raw materials

Availability of raw materials has been estimated based on the agricultural production and average values of biomass production suitable for energy purposes. In animal husbandry sector, amounts of stable manure produced on cattle, pig and poultry farms have been considered. The focus in field crop production is on growing maize (silage and grain) and oilseed rape. Also, for VSC, the estimate has been made in regards with biodegradable waste produced in slaughterhouses.

The priority was given to the disposal of manure. Thus, when calculating technical potential, it was assumed that part of the land available for energy crops (Pen) would be primarily used for silage maize needed for co-digestion i.e. biogas production, whereas the remaining land could have technical potential for biodiesel production using oilseed rape as well as bioethanol from maize.

Biogas production

The technical potential for biogas production implies biogas production by means of anaerobic digestion:

a) co-digestion of stable manure and silage maize
b) monodigestion of slaughterhouse waste

When calculations were made, a 30 percent silage mass share was estimated in the feedstock. The 30 percent share of silage will contribute to the increase in biogas yield, whereas at the same time it will not require too high land allocation for its production, thus it will add to sustainable use of the land.

Biogas/methane yields used to calculate energy potential are given in the table below.

Tab. 1. Feedstock properties for biogas production[19]
Karakteristike supstrata za proizvodnju bioplina

Feedstock	Share of organic dry matter in fresh matter (oDM)	Methane yield per unit of organic dry matter (p) [m^3CH_4/t oDM]
Pig manure(liquid)	0.22	250
Cattle manure (solid)	0.0595	280
Poultry manure (solid)	0.33	300
Maize silage	0.32	234
Slaughterhouse waste	0.15	500

To calculate the biogas production potential, the following formula has been used:

$$BP = m \times oST \times p \times k \quad \text{[kWh/g]}$$

Where:

BP – energy potential of produced biogas [kWh]
m – feedstock mass (biomass) for production of biogas at annual level in the region under study [t/yr]
oST– share of volatile dry matter in dry matter of the feedstock concerned
p – methane yield (CH_4) per mass unit of organic dry matter [m^3/t oDM]
k=10 – energy value of biomethane [kWh/Nm^3]

The above given formula is used to calculate production potential of single feedstock. In the case of co-digestion, it is necessary to sum the potentials of particular raw materials.

Biogas can be used as a fuel for generation of heat and/ or electrical energy. In the estimate of technical potential, generation of electrical and heat energy in cogeneration has been envisaged with efficiency factors at 36 percent for electrical and at 30 percent for heat energy.

Production of liquid biofuels – biodiesel and bioethanol

Oilseed rape has been considered as a raw material for production of biodiesel, and maize for production of bioethanol.

The potential for production of biodiesel and bioethanol was calculated according to the formula:

$$BG = \frac{P_{en} - P_{bp} \times p}{f} \times OV_{BD} \quad \text{[J/yr)}$$

Where:
BG – potential for biodiesel/ bioethanol production [J]

P_{en} – available agricultural land for energy crops for production of liquid biofuels in the region under study [ha]
P_{bp} – agricultural area needed for growing silage maize to be used for production of biogas in the region under study [ha]
p – annual yield of the raw material being considered [t/ha]
f – conversion factor for the raw material being considered
OV_{BD}– lower heating value of biodiesel/ bioethanol [GJ/t]

Values of conversion factors f for particular crops, i.e. quantities of particular types of raw materials needed for the production of 1 tonne of liquid biofuel are given in the table below:

Tab. 1. Quantities of raw materials needed for production of 1 tonne of biofuel
Količine sirovine potrebne za proizvodnju 1 tone biogoriva

Biodiesel (1t)[12] *Biodizel*	Bioethanol (1t)[13] *Bioetanol*
Oilseed rape (t) (wet 10%) *Uljana repica (t) (mokrina 10%)*	Maize (t) (dry process) *Kukuruz (t) (suhi postupak)*
2.45	3.26

It needs to be emphasised that in order to calculate the potential of liquid biofuel production it was assumed that the land available for production of liquid biofuels was to be used to grow a single crop (either oilseed rape or maize). Therefore, the biodiesel or bioethanol potential given herein using a single crop at the same time represents the total potential for the region concerned. The purpose of such a presentation is to provide indicators on possibilities without prejudice regarding crop selection or type of fuel to be produced.

Greenhouse gas emissions savings

The methodology used to calculate GHG savings during production and use of biogas is given below.

Methane emissions savings

The calculation is based on IPCC methodology for calculation of emissions in stable manure management sector.[11]

$$Emissions\ (kt\ CO_2\text{-}eq/yr) = Livestock\ number \times EF\ (kg\ (CH_4)/livestock\ unit\ annually) \times GWP \times 0.5 / 10^6$$

Emission factors, EF (kg (CH_4)/livestock unit annually), from National Greenhouse Gas Inventories RC[14] were used (Table 3). Global warming potential for

methane is 23, whilst it is assumed that it is possible to reduce methane emissions by 50 percent in case of biogas production from manure.[3]

Tab. 2. Emission factors for methane from stable manure management sector
Emisijski faktori za metan iz sektora upravljanje stajskim gnojem

	Dairy cows *Mliječne krave*	Other cattle *Ostala goveda*	Pigs *Svinje*	Poultry *Perad*
EF kg(CH_4)/livestock unit annually	6	4	4	0.012

Emissions of N_2O in stable manure management are not included in the calculation due to their considerable variability.[2,4]

Reduction of emissions due to generation of electrical and heat energy

The estimate is based on an assumption that electrical and heat energy generated from biogas with zero greenhouse gas emissions replaces the energy generated from other sources.

$$\textit{Emissions (kt } CO_2\textit{-eq/yr)} = \textit{Generated energy (kWh/yr) x EF (kg } CO_2\textit{/kWh)} / 10^6$$

Emission factors by kWh of electrical and heat energy are given in the table below.

Tab. 3. CO_2 emission factors in generation of electrical and heat energy[9]
Faktori emisija CO_2 u proizvodnji električne i toplinske energije

	RH	BiH
EF (kg CO_2/kWh)	0.349	0.887

Reduction of emissions caused by decrease in synthetic fertiliser production

The estimate is based on an assumption that up to 20 percent more efficient use of nitrogen is achieved when using digestate than when using fresh stable manure, which causes reduction of use i.e. production of fertilisers.[1]

$$\textit{Emissions (kt } CO_2\textit{-eq/god)} = \textit{Livestock unit number x Nitrogen emission (kg/LU annually) x 0.2 x EF (3.3 kg}CO_2\textit{-eq/kgN)} / 10^6$$

The emission factor used for production of synthetic fertilisers amounts to 3.3 $kgCO_2$-eq/kgN.[5]

Greenhouse gas emissions savings can be achieved by using biofuels in transport. *Directive 2009/28/EC* has also set out sustainability criteria in order to enable alleviation of adverse social and environmental effects. These criteria, inter alia,

include minimal reduction of greenhouse gas emissions when using biofuels in comparison with corresponding fossil fuels. Currently, reductions must be at least 35 percent, whereas the percentage shall go up to 50 percent in 2017 or 60 percent in 2018 for biofuels produced in facilities that will have started production in 2017 or later. In terms of motor biofuels, the Directive has set reference emissions for fuels at 83.8 g CO_2-eq/MJ.

Results

Input data for animal and field crop production in the region of Posavina are shown in the following tables.[7]

Tab. 4. Livestock unit (LU) number and quantities of manure at an annual level
Broj uvjetnih grla i količina stajskog gnoja na godišnjoj razini

Region *Područje*	Category *Kategorija*	LU number *Broj UG*	Production of stable manure (t/yr) *Proizvodnja stajskog gnoja (t/god)*
VSC	Cattle	32,283	306,366
	Pigs	14,080	113,062
	Poultry	511	4,849
Total		*46,874*	*424,277*
BiH	Cattle	5,884	55,849
	Pigs	7,441	59,752
	Poultry	4,957	47,042
Total		*18,282*	*162,643*

Tab. 5. Average annual yields of energy crops
Prosječni godišnji prinosi energetskih usjeva

Crop / *Usjev*	Municipality / *Općina*	Yield (t/ha) / *Prinos*
Oilseed rape *Uljana repica*	VSC	2.7
	BiH	2.3
Maize *Kukuruz*	VSC	7.1
	Domaljevac	5.0
	Odžak	5.5
	Orašje	4.6
	Šamac	5.8
	Brčko	4.6
Silage maize *Silažni kukuruz*	VSC	33.6
	Domaljevac	22.8
	Odžak	22.8
	Orašje	22.8
	Šamac	22.2
	Brčko	12.5

Theoretical potential for the production and use of biogas and liquid biofuels in the region is shown in the tables below.

Tab. 6. Theoretical potential for the production of biogas from agricultural biomass in Posavina
Teoretski potencijal proizvodnje bioplina iz poljoprivredne biomase u Posavini

Region *Područje*	Theoretical energy potential for biogas production *Teoretski energetski potencijal proizvodnje bioplina*		Theoretical energy potential for generation of electrical and heat energy using biogas *Teoretski energetski potencijal proizvodnje električne i toplinske energije iz bioplina*	
	Co-digestion (TJ/yr.) *Kodigestija*	Agricultural land needed for maize silage growing (ha) *Poljoprivredne površine potrebne za uzgoj kukuruzne silaže*	Cogeneration (GWh/yr) *Kogeneracija*	Total installed capacity (MW_e) *Ukupna instalirana snaga*
VSŽ	1,370.39	5,408	138.61 el. en. 115.51 heat en.	19.80
BiH	574.25	4,527	57.43 el. en. 47.86 el. en.	8.20

Tab. 7. Theoretical potential for the production of liquid biofuels from agricultural biomass in Posavina
Teoretski potencijal proizvodnje tekućih biogoriva iz poljoprivredne biomase u Posavini

Region *Područje*	Biodiesel from oilseed rape *Biodizel iz uljane repice*		Bioethanol from maize (dry process) *Bioetanol iz kukuruza (suhi postupak)*		Agric. land for growing raw material (ha) *Polj. površina za uzgoj sirovine (ha)*
	t/yr	TJ/yr	t/ yr	TJ/ yr	
VSŽ	115,067	4,257.50	227,402	6,139.86	104,413
BiH	38,243	1,415.02	62,633	1,689.07	41,101

It is important to underline that to make use of animal husbandry waste for energy purposes it is necessary to dispose of with adequate infrastructure and that cost-effectiveness of such use depends on waste volumes produced at individual farms (i.e. livestock unit number). As in Vukovar-Srijem County around 50 percent of the total livestock unit number of cattle, pigs and poultry are bred at larger farms, we can assume that 50 percent of the total available animal husbandry waste could be used for generation of energy. Accordingly, the total installed capacity in biogas cogeneration facilities would be 9.90 MW_e. Animal production in Bosnian Posavina is characterised by small farms, thus it is realistic to assume that a number of centralised biogas

facilities would be built (that would be provided with raw materials by a bigger number of farms). In this case, alongside well-organised centralised facilities and farmers, it would be possible to make use of 50 percent of available stable manure. Then, the installed capacity of biogas cogeneration facilities would be 4.10 MW_e.

As far as biofuel production is concerned, it is realistic to expect that available agricultural land will also be used for other purposes, besides energy use. Therefore, we can conclude that real potential for liquid biofuel production in Posavina could amount to 30 percent of the theoretical potential (Tab. 8).

Tab. 8. Achievable potential for liquid biofuel production from agricultural biomass in Posavina
Ostvarivi potencijal proizvodnje tekućih biogoriva iz poljoprivredne biomase u Posavini

Region *Područje*	Biodiesel from oilseed rape *Biodizel iz uljane repice*		Bioethanol from maize (dry process) *Bioetanol iz kukuruza (suhi postupak)*		Agric. land for growing raw material (ha) *Polj. površina za uzgoj sirovine (ha)*
	t/yr	TJ/ yr	t/ yr	TJ/ yr	
VSŽ	34,520	1,277.25	68,221	1,841.96	31,324
BiH	11,473	424.51	18,790	506.72	12,330

The total potential greenhouse gas emission reductions achieved by using biogas are shown in the table below.

Tab. 9. Greenhouse gas emission reductions when producing and using biogas
Uštede emisija stakleničkih plinova pri proizvodnji i korištenju bioplina

Region *Područje*	Emission reductions ($ktCO_2$-eq yr) *Uštede emisija*
VSŽ	31.30
BiH	26.84

Table 11. shows potential greenhouse gas emission reductions when using liquid biofuels.

Discussion and conclusion

There is a legal framework in the RC that encourages the use of electrical energy generated from RSE or use of RSE in transport, hence objectives have been set in accordance with the EU Directive 2009/28/EC. U BiH, as far as the use of RSE is considered laws have been laid down that view generation of electrical energy from RSE in a positive way, although bylaw acts that are to encourage its use are still to be laid down.

Tab. 10. Potential greenhouse gas emission reductions achieved by using biofuel in transport
Potencijalne uštede emisija stakleničkih plinova ostvarene korištenjem biogoriva u prijevozu

Minimal reductions *Minimalne uštede*	Biodiesel ($ktCO_2$-eq yr) *Biodizel*		Bioethanol ($ktCO_2$-eq yr) *Bioetanol*	
	VSŽ	BiH	VSŽ	BiH
35%	37,46	12,45	54,02	14,86
50%	53,52	17,79	77,18	21,23
60%	64,22	21,34	92,61	25,48

The region of Posavina disposes with abundant and quality agricultural land. However, inappropriate and fragmented production of low productivity does not allow the economic exploitation of these potentials. Moreover, the region is characterised by migrating and ageing population which hinders further development of agriculture. In VSC, owing to development of agricultural policies, land consolidation has been taking place throughout the last ten years, but the yields are still lower than in the Western Europe. The aforementioned points to the fact that there are significant capacities for enhancement of the field crop production in the region.

In Posavina, even though there are all prerequisites and the tradition of animal production, it is mainly small-scale and potentials are not sufficiently used for various reasons, such as constant change in animal feed prices, disorganised market and lack of selection work as well as insufficient farmers' knowledge on modern production, market, consumer requirements and environmental protection measures being imposed. Processing industry is rather underdeveloped in BiH, so the production under contracts does not exist, whilst farmers' associations, cooperatives or companies do not exist or are not particularly involved. In the area of VSC, there are slightly more favourable conditions both in terms of legal and financial support available to farmers and farm size in comparison with BiH. In VSC, animal husbandry production is characterised by the increase in number and quality of livestock unites per individual farms, this trend being especially evident in dairy cattle farms. It is worth noting that the field crop production has become hardly sustainable in Posavina, therefore one of the solutions is to integrate its forage base with livestock farming, which shall lead to the increase in total number of livestock units.

Envisaging the biogas production in co-digestion (manure and maize silage) and use of 50 percent of manure in the current production in VSC, the installed capacity of biogas cogeneration facilities is estimated at 9.90 MW_e. This estimate for BiH is at 4.10 MW_e. Based on the state of livestock production and results obtained on potential for biogas use, the construction of biogas facilities near bigger farms is recommended in VSC, whereas in BiH, due to farm size, it would be realistic to envisage the construction of a few centralised biogas facilities that would be supplied with feedstock by a number of farms.

Taking into account the current energy crops yields and utilisation of 30 percent of theoretical potential, the potential of biodiesel production using oilseed rape in VSC is estimated at 34,520 t/yr or bioethanol production using maize at 68,221 t/yr. The potential for the area under study in BiH is as follows: 11,473 t/yr for biodiesel and 18,790 t/yr for bioethanol.

Possible greenhouse gas emissions reductions regarding the production and use of biogas have been estimated at 31.30 $ktCO_2$-eq annually in VSC, whereas at 26.84 $ktCO_2$-eq annually in BiH. Depending on minimal emission savings, these reductions, which can be made by producing biofuels, range between 37.46-64.22 $ktCO_2$-eq annually for biodiesel or 54.02-92.61 $ktCO_2$-eq annually for bioethanol in VSC, whereas in BiH area under study they range between 12.45-21.34 $ktCO_2$-eq annually for biodiesel or 14.86-25.48 $ktCO_2$-eq annually for bioethanol.

To compare the above given emission savings, it is important to mention that the total greenhouse gas emissions in 1990 amounted to 31,440 $ktCO_2$-eq in RC[14] and 34,043.49 $ktCO_2$-eq in BiH[10], without taking into account forestry sector, land use and changing the land purpose. Moreover, the price of a tonne of CO_2 at the EU market of greenhouse gas emission units was 7.57 €[20] in December 2011. Having ratified the Kyoto Protocol, the RC committed to reduce greenhouse gas emissions by 5 percent in comparison with 1990 in the first commitment period 2008-2012, whereas BiH has not yet committed to reduce greenhouse gas emissions.

Sustainable production of biofuels, in line with sustainability criteria of the *EU Directive 2009/28/EC*, requires reduction of greenhouse gas emissions in transport, but on the other hand, it is necessary to pay attention to adverse effects primarily related to the use of agricultural land, increase in food and forage prices, different use of land and use of fertilisers, pesticides and water resources.[18,16]

Besides reducing greenhouse gas emissions, biogas use leads to other positive environmental effects such as waste use, reduction of foul odour, production of quality fertilisers and decrease in synthetic fertiliser use.[1] On the other hand, it is important to say that in the case when maize silage is used for production of biogas, attention should also be paid to adverse effects similar to those when growing energy crops for biofuel production.

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Proizvodnja bioenergije u Posavini

Veljko Vorkapić[1], Ana Kojaković[1], Gordana Đurić[2,3], Stoja Jotanović[3], Danijela Kondić[3], Borut Bosančić[2,3], Duška Šaša[1]

[1]*Energetski institut Hrvoje Požar, Zagreb, Hrvatska*
[2]*Institut za genetičke resurse Univerziteta u Banjoj Luci, BiH*
[3]*Poljoprivredni fakultet Univerziteta u Banjoj Luci, BiH*

Sažetak

Prikazani su rezultati projekta ABCDE Posavina (*Agricultural Biomass Cross-border Development of Energy in Posavina)* koji se provodi u okviru Programa prekogranične suradnje Hrvatska - Bosna i Hercegovina 2007.-2013. Glavni cilj projekta je promocija korištenja poljoprivredne biomase za proizvodnju energije u ruralnim područjima. Ciljanu regiju predstavlja Vukovarsko-srijemska županija (VSŽ) u Hrvatskoj te općine Odžak, Domaljevac-Šamac, Orašje, Šamac i distrikt Brčko u Bosni i Hercegovini. Područje karakterizira veliki potencijal za poljoprivrednu proizvodnju (raspoložive poljoprivredne površine, klimatski uvjeti, tradicija poljoprivredne proizvodnje i drugo). Provedena je analiza mogućnosti korištenja poljoprivredne biomase za proizvodnju energije u ciljanoj regiji. Procjena potencijala uključuje proizvodnju bioplina iz stajskog gnoja (goveda, svinje i perad) i kukuruzne silaže (udio kukuruzne silaže je ograničen na 30% ukupne mase sirovine) te biodizela iz uljane repice i bioetanola iz kukuruza. Na osnovu dobivenih rezultata su procijenjene uštede emisija stakleničkih plinova. Procjena teoretskog potencijala proizvodnje bioplina iznosi 1.386 TJ/god. za VSŽ i 574 TJ/god. za područje u BiH. Na osnovu procijenjenog teoretskog potencijala, ukupna instalirana snaga za bioplinska postrojenja iznosi 19,8 MW_e za VSŽ te 8,2 MW_e za područje u BiH. Za VSŽ teoretski potencijal proizvodnje biodizela iznosi 4.258 TJ/god. dok bioetanola iznosi 6.140 TJ/god. Za područje u BiH, teoretski potencijal iznosi 1.415 TJ/god. za biodizel odnosno 1.689 TJ/god. za bioetanol. Pretpostavlja se da je u regiji ostvarivo 50% teoretskog potencijala proizvodnje bioplina te 30% teoretskog potencijala proizvodnje biogoriva. Godišnje uštede emisija stakleničkih plinova za proizvodnju i korištenje bioplina su procijenjene na 31,30 $ktCO_2$-eq (VSŽ) i 26,84 $ktCO_2$-eq (BiH). Procjena godišnjih ušteda pri korištenju biodizela iznosi 37,46-64,22 $ktCO_2$-eq (VSŽ) i 12,45-21,34 $ktCO_2$-eq (BiH) odnosno 54,02-92,61 $ktCO_2$-eq (VSŽ) i 14,86-25,48 $ktCO_2$-eq (BiH) pri korištenju bioetanola.

Ključne riječi: biomasa, potencijal, prekogranična suradnja, regija Posavina.

Gordana Đurić
E-mail Address:
gordanadju@gmail.com