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SOLID BIOMASS AS RENEWABLE ENERGY SOURCE
Case study for Becej Community

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Summary

The study has been provided to evaluate possibilities of solid biomass – crop residues use as energy source in community in agricultural area in Pannonia plane. The energy needs and biomass potentials have been elaborated separately for stock holding company having 14,000 ha and private farmers. The energy needs for household heating, heating of company rooms and drying have been assessed. It has been found that biomass of private farmers can cover about 37% of total energy need for household heating in the community. This is approximately 244 TJ/a, while the potential of the available biomass is 312 TJ/a. Almost the same share of heating and drying energy needs in the company can be covered using biomass, 40%. This will be covered using approximately 2,390 t/a of available 5,950 t/a.

Economy of biomass use as a fuel has been provided for one 400 kW facility that should be used for heating of administration room, laboratory and central workshop of company. The price of effective energy of biomass is considerably lower than that of natural gas, but facility – boiler with equipment – costs much more for biomass. Final energy price is lower for biomass, but not considerably. The other indirect economic and non economic influences have been considered and commented. It was concluded that implementation of biomass as energy source can contribute to the development of rural area. However, proper development requires support of the whole society. Implementation of biomass has economic, environmental and societal effects.

Key words: solid biomass, heating, processing heat

INTRODUCTION

Serbia and Montenegro shell, like other countries, follow the worldwide declared efforts to reduce consumption of fossil fuels and contribute to solution of environmental problems. In this regard, the EU members and access countries have a goal declared in the White book to substitute 12% of fossil fuels by 2010 (Anonym 3, 1997). Serbia and Montenegro set up the objective to increase the use of renewables from current 1,5% to 3% by 2010 (Ilic et al, 2004, Martinov et all, 2004, Martinov et all, 2005). The use of renewable energy sources, especially solid biomass, is followed with legislation aimed at limitation of emission of pollutants (Brkic et al, 2002, Hartmann, Strehler, 1995, Kaltschmitt, Hartmann, 2001, Laundhardt 1998).

Most renewables sources are located in rural areas. This follows to the conclusion to use them, primarily, there. Focus is placed on a typical agricultural region, the Province of Vojvodina, part of Serbia situated in Pannonia plane. For the study, community Becej was selected, that has been found to be post typical (Martinov, Tesic, Brkic, 2005). The objectives were:

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1. To analyze energy needs in the community.
2. To identify biomass potentials.
3. To select most appropriate use of solid biomass.
4. To evaluate economic and non economic effects of biomass use.
5. To propose future activities aimed at implementation of biomass use as energy source.

MATERIAL AND METHODS

Community Becej has population of 41,440. It covers 48,649 ha, therefrom 42,538 ha is arable land. It is estimated that agricultural production and food processing make up about 70% of income. About 14,000 of arable land is in possession of big farm, stock holding company PIK "Becej" while the rest is privately owned. Industry is mostly oriented toward processing of agricultural products.

The needs for energy have been estimated according to data on consumption of diverse sources, but was mostly focused on energy needs for household heating, business and administration premises, and energy for primary processing, e.g. drying.

The household heating needs has been calculated based on study done for community Becej (Bogner, 1989) and heating energy requirement defined in Germany (Anonym 1 1966, Anonym 2 1994). The local specific conditions concerning climate, house construction and living conditions have been respected.

The resources of biomass, crop residues, have been estimated based on produced crops, common and possible practice of their harvesting, and long term average yield. The future changes in farming technology have been considered and respected.

The economic evaluation has been done using market prices of facilities and biomass. The prices of biomass were take from the official calculation done by company PIK "Becej" and free market prices in villages. Price of straw bales was taken to be 2,5 din/kg (1 Euro = 80 din). It is based on average harvesting price 2.1 din/kg with minimal material price 0.4 din/kg. For all calculation 0.5 din/kg of straw has been added for the costs of manipulation and storage – total price 3 din/kg. The price of maize cobs was 2 din/kg, whereby 0,3 din/kg has been added as a manipulation and storage (maize cobs are often available in the users' yards) – total price 2.3 din/kg.

The price of natural gas, net heating value 33 MJ/m^3_n, was 13 din/m^3_n.

Economic evaluation of biomass use has been done based on facilities and fuels prices. Non economic evaluation was the result of inquiry conducted in village Backo Petrovo Selo. This also resulted in knowledge about current practice in household heating in villages, and estimation of inhabitants' readiness to use biomass – crop residues for household heating.

RESULTS AND DISCUSSION

Energy needs

For community Becej

The data given is study of Bogner (1989) and community authorities were the base for estimation of number of households and fuels used in settlements, Tab. 1.

The average living area in the city of Becej has been estimated (Bogner 1989, community authorities 2005) to 65 m^2 per household. Taking into account commercial and offices (administration and business) premises the average heated area is 77 m^2. Taking into account the data given in literature (Bogner 1989, Anonym 1, 1966, Anonym 2, 1994), dominant type of house construction, insulation and climatic conditions the average heating power has been estimated to be 140 W/m^2, or 10,8 kW per household.

In the countryside average heated living area has been estimated to be 56 m^2 per household, and wasn't extrapolated by commercial premises while they are there neglected. The specific heating power has been assessed to be 160 W/m^2, or average heating power 9 kW per household.

Tab. 1 Number of inhabitants, households and fuels used for heating in community Becej

Settlement	Number of inhabitants	Number of households	Fuels used
Becej	25,700	9,180	Gas (central and individual), coal, wood, biomass[1]
Backo Petrovo Selo	7,270	2,600	Biomass, coal/wood, heavy heating oil
Backo Gradiste	5,450	1,950	Biomass, coal/wood, gas
Radicevic	1,320	470	Biomass, coal/wood
Milesevo	1,120	400	Biomass, coal/wood
Poljanice	280	98	Biomass, coal/wood
Total	41,440	14,698	

[1] Biomass means here crop residues

For estimation of annual consumption of heating energy were used data given in Anonym 2 (1994), 220 kWh/m^2, and new 80-190 kWh/m^2, and long term data related to annual energy consumption, given by authorities in Becej central heating company, average value is 3.9 GJ/a for every kW of heating system power. Based on this data and respecting local conditions, average annual heating energy consumption has been estimated to be 180 kWh/m^2, i.e. 650 MJ/m^2. This is for average household in Becej city round 50 GJ/a, and for other settlements 36 GJ/a.

The heating energy need for all settlements of the community, assessed share of biomass use as a fuel and needed amount of biomass are given in Tab. 2.

Tab. 2 Data on biomass share for household heating and needed amounts

Settlement	Annual energy need, TJ/a	Share of biomass, %	Useful biomass energy[3], TJ/a	Needed amount of biomass, t/a
Becej	459.0	20[1]	91.8	10,200
Bačko Petrovo Selo	93.6	95	88.9	9,900
Bačko Gradište	70.2	40[2]	28.1	3,100
Radičević	16.9	100	16.9	1,900
Milesevo	14.4	100	14.4	1,600
Poljanice	3.5	100	3.5	400
TOTAL			243.6	27,100

[1] It has been supposed that biomass will be used in suburbs as a cheaper energy source; there are also citizens involved in farming.
[2] It has been supposed that the families doing farming will use crop residues as the cheaper fuel for household heating.
[3] Calculation based on effective heating energy 9 MJ/kg of crop residues (net heating value for 14% moisture content is 15 MJ/kg, facility efficiency 60%).

According to the Tab. 2 energy needs for household heating (commercial, business and administration premises in city Becej included) are around 657 TJ/a. Biomass energy could cover about 244 TJ/a, i.e. 37%. Heating energy for industry is not included here.

Stock holding company PIK "Becej"

Calculation of effective energy used for heating and drying, according to the data from company documentation shows 63 TJ/a. This is about 47% of total energy consumption. Energy for vegetables and fruits processing unit is not included. Company uses only 1.6 TJ/a energy of biomass now, but there are plans to extend it considerably.

The list of current and possible uses of biomass as energy source for heating and drying, with thermal power of units and annual biomass needs are given in Tab. 3.

Tab. 3 List of current and possible biomass facilities for heating and drying with thermal power and needed biomass per year

No.	Unit	Purpose	Thermal power, MW	Annual biomass need, t/a
1	Center for seed processing	Hot air generator for seed corn drying	2x1,3 1x2,5	650
2	Center for seed processing	Heating of workshops and offices	0.3	120
3	Administration and central workshop	Heating of offices, laboratory and workshop	0,4	160
4	«Novo Selo» BP Selo	Heating of green house	2x2 MW	1,200
5	«Novo Selo» BP Selo	Heating of offices and workshop	0.18	50
6	«Zalivno polje»	Heating of offices and workshop	0.2	60
7	«Breg»	Heating of offices and workshop	0.25	75
8	«Breg» new unit	Drying and heating	0.25	75
TOTAL				2,390

Calculating biomass energy based on value of net heating energy 15 MJ/kg and average efficiency of facilities 65% (advanced new facilities) useful energy of this amount of biomass is 23,3 TJ/a. This is about 37,6% of total energy needs for heating and drying purposes within the whole company.

BIOMASS POTENTIALS

Energy potential of biomass is product of the mass and effective energy. Effective energy of biomass is product of net heating value and average efficiency. The net heating value of cereal and soybean straw having moisture content 15% is about 15 MJ/kg (Martinov, 1980). The same value can be taken for maize cobs (Martinov, Topalov, 1984). Taking into account relatively high average value of efficiency, for different working conditions and facilities, of 60%, the effective energy, energy output for heating, of one kg of biomass is 9 MJ/kg.

Almost all biomass available for energy purposes in community Becej are crop residues. Due to difference in production technique there are differences in biomass effective yield available on private farms and company PIK “Becej”. Therefore these two sources have been calculated separately.

Private farms

The maize is grown on about 50% of 28,500 ha, around 14,000 ha. Average share of cereals is about 28%, i.e. 8,000 ha, and soybean about 3,000 ha.

Average yield of cereal straw is 2,5 t/ha, and soybean straw 3 t/ha. About 80% of maize is traditionally harvested with picker–huskers and dried naturally in drying bins. After drying the corn is shelled and maize cobs are available in farmers' yards. The yield of maize cobs is in average 1,4 t/ha (Ilic, 2003, Martinov, 1980, Martinov, Topalov, 1984). The biomass yield is, for given data:

- Cereal straw, 19,600 t/a
- Soybean straw, 9,000 t/a
- Maize cobs 15,700 t/a

If the half of cereal straw were taken into calculation, the reduction due to conservation tillage and use for animal beading, the available amount of cereal straw would be approximately 10,000 t/a. The total available biomass from private farms is 34,700 t/a. This offers effective heating energy of 312 TJ/a. Comparing the data in Tab. 2, realistic estimation of biomass needed for household heating, it is clear that all presumed needs can be covered. This means, covering of 37% of household hating energy needs.

Stock holding company PIK "Becej"

Within about 8,000 ha of field production about 5,000 ha is covered with cereals and soybean. The conservation tillage is practiced on about 30% of fields. Calculating average straw yield for cereals and soybean 2.5 t/ha i.e. 3 t/ha, not harvested straw in conservation tillage and use certain amount for animal beading, the available straw for energy purposes is about 5.000 t/a.

The company also has a 60 ha orchard, with an average yield of about 300 t/a of pruning residues (5 t/ha,a).

The production of seed corn also yields 650 t/a of dry maize cobs as processing residue. The total potential of biomass is shown in Tab. 4, as well as equivalent of light heating oil, i.e. natural gas. Here used is the average efficiency of biomass combustion facilities 65%, i.e. 9.75 MJ/kg of biomass. Light heating oil has net heating value of 42 MJ/kg, and efficiency of 85%; natural gas 33 MJ/m^3_n and efficiency of good facilities 90%.

Tab. 4 Potentials of biomass as energy source in stock holding company PIK «Becej»

Biomass	Annual yield t/a	Useful energy, TJ	Equivalent of light heating oil, t	Equivalent of natural gas, 10^3 Nm^3_n
Straw	5,000	48.7	1,370	1,667
Pruning residues	300	2.9	82	100
Maize cobs	650	6.3	178	220
TOTAL	5,950	57.9	1,630	1,987

The realistic need of biomass for heating and drying in the company (2.390 t, tab. 3) is about 40% of available biomass – crop residues.

Analysis of economy

The energy unit price can be calculated from fuel price and effective energy content:

Cereal and soybean straw, price, including manipulation and storage, 3 din/kg. Effective energy for efficiency 60% 9 MJ/kg. Result is 0.33 din/MJ.

Maize cobs, price 2,3 din/kg including manipulation and storage. Effective energy 9 MJ/kg. Result 0.26 din/MJ

Natural gas 13 din/m^3_n. Effective energy for efficiency 85% is 26.4 MJ/m^3_n. Result 0.49 din/MJ.

The analysis of economy of biomass use is complex and has been done for few cases, here is presented one example for company PIK "Becej". In Tab. 5 have been compared fuel costs, natural gas and biomass, based on prices calculated for units described in Tab. 3. Due to much higher energy price light heating oil hasn't been considered.

It can be concluded that there is a clear advantage in using biomass instead of natural gas, and even more instead of light heating oil. But, the fuel price isn't the only cost of final energy. To demonstrate other influences the rough calculation has been done for facility no. 3 in Tab. 5.

For this purpose a boiler of 400 kW thermal power should be used. The price of the boiler using natural gas is about 950,000 din, and additional 100,000 din is needed. The price for facility for light or heavy heating oil are even cheaper than this for natural gas, but the price of fuel is three, i.e. two times higher. This is why here has not been included for the comparison.

Tab. 5 Annual fuel consumption and possible fuel cost savings, comparison natural gas – biomass for facilities described in Tab. 3

No.	Unit	Natural gas		Biomass		Savings
		Amount, 10^3 Nm^3_n	Costs, 10^3 din	Amount, t	Costs, 10^3 din	10^3 din/a
1	Center for seed processing, drying	217	2.817	650	1.430	1,387
2	Center for seed processing, heating	40	520	120	264	256
3	Administration and central workshop	53	693	160	480	213
4	«Novo Selo» BP Selo 1	400	5,200	1,200	3,600	1,600
5	«Novo Selo» BP Selo 2	16.7	217	50	150	67
6	«Zalivno polje»	20	260	60	180	80
7	«Breg»	25	325	75	225	100
8	«Breg» new purpose	25	325	75	225	100
TOTAL		796.7		2,390		3,803

Biomass boiler with manual fueling, heat accumulator and simple dust facility costs about 1.950.000 din. The difference in price is 900,000 din, and annual saving in fuel costs 213,000 din. Taking into account annual interest for capital investment of 8% the compensation of higher investment takes ten years of facility use. Fueling costs should be added, as well as the costs for ash removal, cleaning of heat exchanger and chimney. Positive is that most of these services can be performed by the employees of the company, and this is needed out of season. The list of costs is given in Tab. 6.

Tab. 6 Costs of investment and use of heating facility 400 kW for administration, laboratory and central workshop hating, comparison of using natural gas and straw as a fuel

	Natural gas	Straw
Investment		
Facility price with montage, din	950,000	1.950,000
Additional installation, din	100,000	–
Total price of facility, din	1.050,000	1.950,000
Annual costs		
Anuitets[1], din	47,250	87,750
Relatively fixed maintenance costs, din	10,000[2]	39,000[3]
Chimney cleaning, din	500	2,000
Fuel costs, din	693,000	480,000
Fuel feeding, ash removal, cleaning of heat exchanger and monitoring[5], din	2,000[4]	60,000
Total per year, din	752,750	668,750
Total net energy delivery, net, MJ/a	1.440,000	
Total costs for delivered energy		
din/MJ	0.523	0.464
din/kWh	1.88	1.67

[1] Payback 10 years, 8% annual interest. [2] Presumed 1%. [3] Presumed 2%.
[4] Means two controls during heating season. [5] This includes not full salary of the person working on fuel feeding, but supplement for additional activity.

Comments: The price per MJ i.e. kWh for use of natural gas and straw are similar. The salary for the worker doing fuelling isn't included in the calculation, while lots of them are free for this service out of farming season. It is taken only additional payment, some kind of stimulation for this job. The price of facility for biomass includes simple devices for exhaust gas cleaning. The price will be much higher for the advanced one. If the loan conditions were less convenient, the energy price for straw would be higher than for the natural gas

Other economic and non economic issues

Following demerits and merits should be considered as well:

Gas is paid according to the consumed amount, monthly. The straw has been collected in the summer, and stored until use in winter. All the costs are paid many months before use. This means some financial costs and disadvantages in a case of using straw. They should be calculated too, and with these the total costs of will be higher by using straw than natural gas.

In the costs of straw, 3 din/kg, are also included costs for workers doing straw harvesting, around 1din/kg. This is 180.000 din per year of straw total costs 480.000, given in tab. 5. It is additional job for company employees and this amount is not paid to others, about 27% of total annual costs.

Use of biomass is permanent solution of energy supply, and with adequate equipment (control of exhaust gases) contribution to the environmental issues.

Regarding comfort is the use of natural gas more favorable. This is also more reliable technique.

On society and community level there are clear advantages of biomass use:

Better import–export balance.

Fulfilling of demands concerning replacement of fossil fuels and reduction of CO_2 imbalance.

Lower dependence on imported energy, important especially for crises periods.

Contribution to the employment, especially in economically week rural areas.

There are clear interests of the company and society to implement biomass as energy source. Proper and stimulate use needs adequate planning and management, but also good policy and supporting measures on the level of society.

CONCLUSIONS

The biomass potentials in agricultural region of Serbia and Montenegro are considerable in agricultural rural areas. They can cover about 45% of energy needs for heating and special drying, like maize seed production. Crop residues can cover all, or almost all needs for heating in villages.

Energy of crop residues used as a fuel is cheaper than the energy of natural gas, but the energy conversion facilities for biomass cost more. The economy of biomass use should be studied in detail before making any final conclusions. There are lots of direct and indirect influences on economical characteristics.

Biomass from own sources contributes to use of local resources, both material and human. Development of new, economic and environmentally better solutions needs RTD activities, which can also support development of economically weak rural areas. New solutions should follow internationally declared demands, especially concerning the rise of efficiency and reduction of pollutants emission.

There are clear societal, economic and environmental benefits of biomass use. This is why clear international and national policy on biomass use should be developed and realized.

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