BIOMASS FOR HOUSEHOLD HEATING IN RURAL AREAS
Case study for province of Vojvodina

M. Martinov, M. Konstantinovic, B. Stepanov

Abstract: *The social, economic and environmental needs of biomass using for household heating in the region of Southeastern Europe have been identified using a case study for Province of Vojvodina, in a form of pre study.*

The potential of biomass in the Province has been estimated, based on published data, measured harvest yield and practice. Interests of the society and private interests have been discussed, as well as conflicts. The adequate policy for biomass use for household heating has been stipulated as a necessary tool for supporting the implementation and solving the problem of interest conflict. The necessity of national legislation, based on existing standards in the EU for biomass facilities, has been declared.

The types of users, regarding social status, comfort expectation, family status and other influences are defined, and possible facility types proposed. The proposed types have been discussed.

It was concluded that implementation of contemporary biomass use for household heating in rural areas needs a clear policy and innovative and research activities. All activities shell be aimed at developing of low-cost solutions of all of three proposed facility types. This also offers local business opportunities.

Key words: *biomass, household heating, rural areas*

INTRODUCTION

Countries of Southeastern Europe are faced with diverse problems in agriculture and rural areas. Beside many economic problems, the problem of migration from rural areas to the cities has significant social, demographic and environmental impacts. At the doorstep of the EU, some further reduction of food production and usage of renewable energy sources are expected. In this case study, the example of Province of Vojvodina is taken as the most important agricultural region of Serbia and Montenegro.

The whole region of Southeastern Europe is depending on imported fossil fuels. This is a heavy burden for national budget and economy. Any increase of use of domestic energy sources will have a positive economic impact. In the strategic documents and discussed Energy Law a rise of use of renewable energies until 2010, from today's 1,5% to 5% of total energy consumption is foreseen. The strategy is also in accordance with trends in the World and in Europe related to Kyoto declaration and other environmental and economic-oriented policies. The policy about renewables is unfortunately missing, and it is still not clear what is to be expected regarding the new proposed law. Concerning worldwide situation in energy supply and the shape of national economy, this issue is expected to be stressed very soon. The special task in the near future will be to follow EU policies about renewables and to declare a goal: 12% of renewable energy source of total energy consumption after year 2010.

Other significant economic, social and demographic problem in the country is migration of population from rural to urban areas. The reason for migration is very clear: aspiration for better living conditions. Beside better employment possibilities, the quality of living in the cities is potentially better. From the point of view of regional development, urban organization and environmental sustainability this trend is unfavorable, not only in Serbia and Montenegro, but throughout the Europe. Some strategic decisions regarding this are expected, e.g. support for industrial and other activities in rural areas. Electricity network, reliable infrastructure – roads and telecommunication, should be also improved. Know-how in the field of entrepreneurship is needed to accelerate general development of these areas. One of problems is a lack of comfortable household heating, where the investment and fuel costs are of great importance. Traditional autarchic approach of inhabitants of rural areas indicates that it is possible to expect a certain amount of produced renewables from own sources. This is a very certain pre condition and a base for wider acceptance of renewables.

ESTIMATION OF BIOMASS POTENTIAL

Estimation of biomass potential has been an issue of many investigations, but all of them have some kind of inconsistencies, first of all regarding common practical obstacles and limitations. The Tab. 1 shows the newest data presented in the National Study of renewables.

Tab. 1 Crop production in Serbia, the data for Vojvodina are shaded (Ilic et al, 2003)

Crop	Central Serbia, ha		Vojvodina, ha		Kosovo, ha	
	1	2	1	2	1	2
Wheat	16.600	324.200	157.900	208.700	3.740	83.800
Rye	290	5.300	360	640	58	1.800
Barley	4.800	45.800	37.100	29.400	4.600	8.500
Maize	9.600	591.900	122.400	537.700	270	91.400
Sunflower	6.100	9.000	67.900	75.100	1.350	950
Soybean	3.200	3.900	51.200	24.351	-	-
Rape seed	350	350	240	390	83	-

1– Company farms and cooperatives, 2– Private farms

According to this data, the most of arable fields are covered by maize, followed by wheat. Due to climatic conditions and market demands this will be kept in the future.

The authors of the Study have evaluated crop residues, considering the common average yield and relation between the main product and residues. Based on experimentally confirmed results, other use of residues, e.g. animal production – bedding have been evaluated. The potential of available biomass has been calculated. The results showed that about 3 million tons of biomass are available for energy use in Serbia and Montenegro, whereby at least one million is in Vojvodina, due to higher yields and better harvesting technique. This amount is pretty realistic and it can be taken into calculations.

The real potential should be considered according to the crop groups. The first group is cereal straw, primarily wheat. The data about grain-straw ratio is usually calculated for all overground mass. Fig. 1 shows measured stubble losses depending on cutting height used in climatic conditions of Vojvodina. Considering this and common harvesting losses, the average available straw yield would be from 2,5 to 3 t/ha, for grain yield of 6 t/ha. The yield is in many cases lower, and for more reliable calculation 1,8 t/ha of available straw could be calculated. According to this assumption, about 880.000 t of straw would be available in Vojvodina, i.e. about 500.000 t per year for energy purposes.

The second crop is maize, covering about 650.000 ha in Vojvodina. Fig. 2 shows relative yield of maize residues related to the corn yield (100%). Usable maize straw is a group 2, with the relative yield of 60-90%, and group 3, maize cobs, with the relative yield of 10-21%. The problem is that the straw is usually moist in harvesting time and not usable for combustion and for storage. Here could be used up to 20% of available biomass, i.e. early ripening hybrids. With average yield of maize in Vojvodina of 7 t/ha, and harvesting efficiency of 50%, the total available biomass should be 300.000 t.

Maize cobs are better material. The cobs are available after threshing of naturally dried maize, typical for dominant small and medium farms. If the average yield of grain were 7 t/ha with the share of 15% of maize cobs, it would be 525.000 t for maize production on about 500.000 ha. This is the most promising biomass source for heating.

Biomass residues of other field crops, orchard and vineyard can be estimated at 200.000 – 300.000 t per year in Vojvodina. In total, in Vojvodina about 1,5 million tons of biomass could be used as a solid fuel. This is about 10 t per farmer/farmer's family.

Heating value of biomass with 15% moisture content is comparable with domestic coal, or the substitution of some 380.000 t of oil could be calculated, considering lower thermal efficiency of solid fuel facilities.

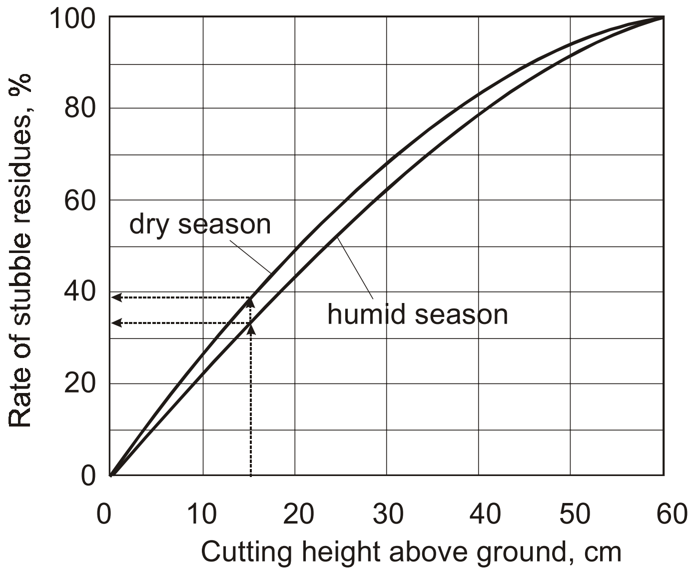

Fig. 1 Rate of stubble residues versa cutting height for wheat, curves for minimum and maximum, example for cutting height 15 cm given, (Martinov, 1980)

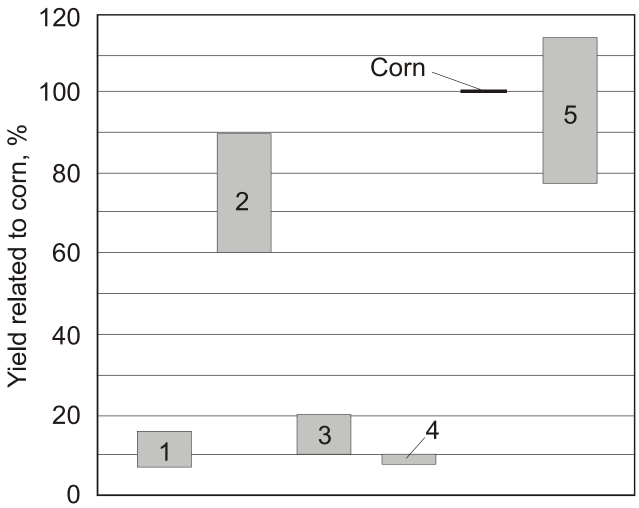

Fig. 2 Ranges of maize plant residual parts relative yields, (Martinov, Topalov, 1984) 1– first 20 cm of stalk above the ground, 2– stalk without first 20 cm above ground, 3– cobs, 4– husks, 5– residual parts, total

There are some other restrictions of biomass use as a fuel. Some agronomists are strongly against the removal of crop residues from the field, as needed for soil fertility. Nowadays, the use conservation tillage and "no till", aimed at reducing the production costs, are in expansion. It is assumed that these techniques will be extended to at least 30% of total field production. These procedures comprise incorporation of crop residues into soil.

PUBLIC–PRIVATE INTERESTS, CONFLICTS AND SOLUTIONS

Regarding biomass use for household heating, the interests of farmers and other inhabitants are:

1. To have reliable facility that fulfills all heating needs all over the year.
2. That investment for facility is as low as possible and efficiency highest possible.
3. The system should be as comfortable as possible.
4. To get financial support from government for purchasing of facility.

Implementation of renewables has important impacts, proclaimed and planned, due to following interests of the society:

1. To replace energy import by usage of domestic energy sources.
2. To reduce consumption of fossil fuels, and to contribute international efforts.
3. To enable acceptable, inexpensive and comfortable heating for households in rural area in order to make these areas more attractive for people to stay there.
4. To have facilities with the highest possible efficiency and low pollutants emission and to contribute environment protection as much as possible.
5. To obtain all former with as low as possible subsidies or without any.

Institutions and companies that can be involved in dissemination of biomass use for household and other heating facilities are the third interested party. They are:

- Institutes engaged in energy sector, as partner involved in international and national demonstration projects.
- Institutions authorized for testing and certification of equipment.
- Institutions and companies involved in planning and design of heating units.
- Producers of boilers and furnaces.

All three parties have own interests, but there is a clear unanimous statement: to have an official policy regarding biomass usage for household and other heating in rural areas. There are also conflicts of interests of farmers and government, last points in both lists. Some instruments included in this policy should bring positive long-term results and overcome conflict of interests. This must be carefully planned and conducted. Very important prerequisite for realization the policy is enacting of appropriate legislation on facilities for biomass combustion (Brkic et al, 2002, Laundhardt, 1998).

DEFINITION OF USER GROUPS

Estimation of users population and social groups

Autonomous province of Vojvodina has the highest level of agricultural production within Serbia and Montenegro. It is faced with all typical problems of agriculture today, from technological, economic, and environmental points of view. For a long period 2/3 of land was private, but ownership was limited to 10 ha. Nowadays is privatization of big farms in progress and it is expected that the agricultural land will be soon completely private. In general, there will be soon three groups of agricultural producers:

1. Farmers with small farms, up to 50 ha, and medium farms, up to 300 ha.
2. Big farms, enterprises, or joint stock companies.
3. Extremely small farms, mostly under 5 ha, owned by old farmers or by people who practice farming as additional job.

The fist group is emerging with expectation to rise in the future, the second one will be, depending on management, more or less successful, and the third one is socially jeopardized. Almost all of them will be in the future inhabitants of villages and other countryside social units, but number of farmers, including workers at big farms, is expected to be reduced to approximately 150.000. It represents 1,500.000 ha in total in Vojvodina, calculating the average of 10 ha per farmer.

Proposal for household heating biomass facilities – type and use prerequisites

Selection of possible heating facilities should be based on different users group, different approach to this issue, available biomass type, and even personal attitude and family situation. The groups of users are:

1. Multi users of district heating system – e.g. school with administration offices and surrounding houses.
2. The most prosperous framers with high investment capability and high comfort demands.
3. Prosperous farmers with lower investment capability and comfort demands.
4. "Smaller" farmers, workers that live in villages and old farmers.

Approach to the way of heating, farmer's vision and wishes can be divided in the following groups:

1. Highest comfort demands, low labor input, heating for new house. High responsibility for environment and top hygienic level.
2. Medium to high comfort demands, readiness for manual work and lower investment potential.
3. Capability for minimal investment and high personal engagement in feeding and maintenance of the facility.

Typical biomass types and forms are:

1. Straw in a form of conventional small bales.
2. Straw in a form of round and big bales.
3. Maize cobs.
4. Other forms, e.g. maize straw bundles, diverse pruning residues.

Personal attitude and family situation influences the selection of facility depending on number of family members, their time spent in house, person/s available for operating the heating facility, etc. Needed heating power of facility depends primarily on house surface area and insulation. There is a question of planned temperature, if additional heating is available e.g. additional furnace or fireplace.

Potential facilities given here are listed from the simplest one to the most complex.

<u>*Redesigned traditional biomass furnace – Type 1*</u>

Traditional biomass furnace is shown in Fig. 3. It is a common facility used almost all over the Pannonia plane. It is made of clay and chaff mixture. The room for feeding was typical; it was used also as a buffer storage for maize straw bundles and for ash removal. Same furnaces were used as bakery stoves. It was the most popular place in the house and the center of family gatherings in the evening.

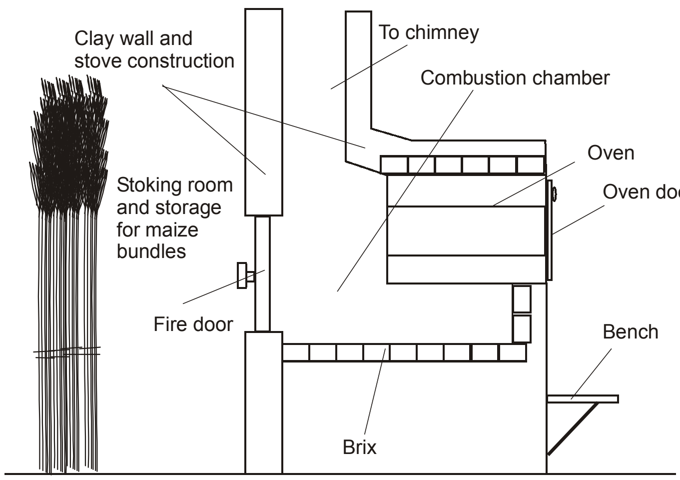

Fig. 3 Traditional furnace for biomass, (Martinov et al, 2003)

The furnace has at least two demerits: there is no grate and air regulation. The volatile rich biomass causes improper combustion, with efficiency of 10-40% and high emission of CO and other pollutants. The design of traditional furnace was limited by the lack of firebricks and cast iron grates. New design solutions could improve the furnace. That can be also the job for handicraftsman. Big volume firebox type should be aimed at combusting of small bales, and maize straw bundles, if available. Improved furnace – light or semi heavy design can also have a heat exchanger that enables heating of additional rooms and "tempering" of bedrooms, with additional pump and expansion vessel. Diverse modifications are of course possible.

The furnace must be redesigned, as it has been done in some EU countries for wood logs furnaces. The efficiency should be at least 60%, and CO, C_nH_m and other gasses emission less than maximal permitted by regulations. This type of facility would be used by group of "small" and old farmers, but it can be also used as additional heating facility for other groups in the period of mild or extremely low temperatures.

The same problem and development approach should be applied for traditional cooker, that can also have integrated heat exchanger, as for wood log cookers in Austria and Bavaria in order to enable heating of other rooms and/or household water.

Big volume straw bale boiler – Type 2

A big volume boiler for conventional or round bales with additional heat accumulator is the second type of here-proposed facilities. The facility is presented in Fig. 4. It is well known that the efficiency of solid biomass is much lower by partial thermal power. The emission of pollutants is also higher in the case of partial power. The big volume boiler enables use of full power and accumulation of energy by heating water in the buffer vessel, i.e. heat accumulator. This enables also good regulation of room temperature and starting of heating according to the user's need, e.g. early in the morning. Additional insulated vessel, circulation pump and temperature and water flow regulators, are making this system much more expensive. In the other hand, it is easier to control pollution and gain much higher comfort.

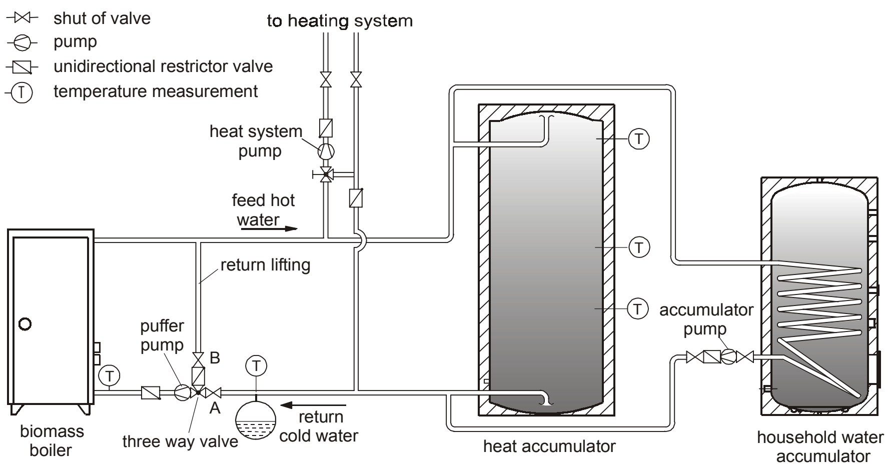

Fig. 4 Example of heating plant with big volume combustion chamber boiler and heat accumulator (Kaltschmitt, Hartmann, 2001)

The power of such facility is always higher as nominally needed, but depending on ambient temperature it can be used only partially during the day or few hours during more days. The installation is fully automated and provides a high comfort for user.

There are also facility designs for big bales, e.g. Fig. 10. It can be used for large-scale farms, but it is more suitable for multi-user district heating. Similar system aimed at combusting of round bales has been developed and used in Denmark (A1 1998).

Continuous feeding facility for maize cobs – Type 3

Continuous stoking-feeding boilers are widely used for wood chips combustion in many countries. This facility offers comfort heating and regulation of combustion process. The example of this facility with pre-furnace is shown in Fig. 5.

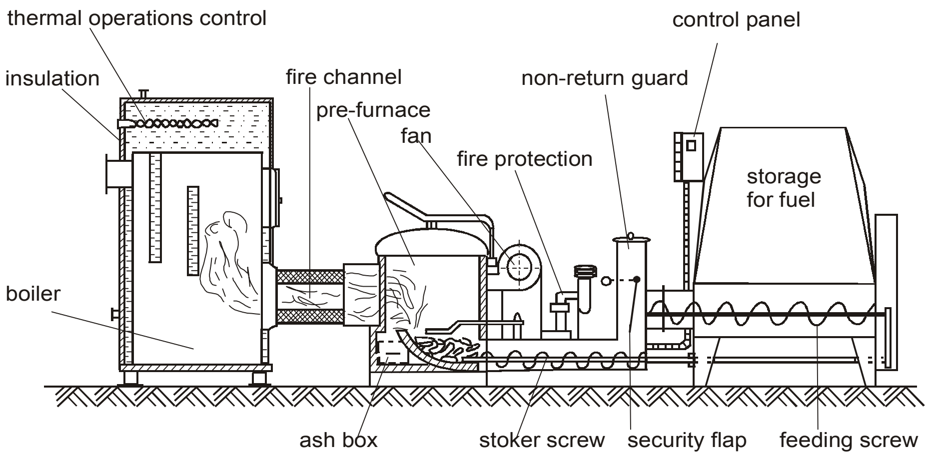

Fig. 5 Continuous feeding boiler for chopped biomass with pre-furnace, (Strehler, 1988)

There are no experiences with market-ready products for maize cobs combustion of this facility type. The maize cobs should be cracked into smaller pieces with length from 1 to 1,5 of diameter to be suitable for auger feeding. Further problem are ash-softening characteristics of maize cobs, with its low "yield point", what can cause different problems by combustion. There is also a problem of high potassium content and insulation layer generated on the tubes of heat exchanger.

This facility is more expensive than other two, and it is expected to be used by the group of the most prosperous farmers.

CONCLUSIONS

There are very clear social, economic, environmental and private benefits of biomass using for household heating in rural areas of Vojvodina. For its implementation on proper technical, social, economic and environmental level an adequate policy is needed, well balanced between all interests. The common policy and practice used in some EU countries can be a good background for its application in the region of South-eastern Europe, but local conditions must be highly considered. Development of an appropriate legislation on biomass combustion facilities is also prerequisite for program implementation.

The identified three types of facilities should be considered and properly designed, whereby international cooperation and technology transfer from developed countries would be of great importance. Development of low costs solutions should be underlined, according to regional conditions. This pre study can be a good background for development of innovation and research strategy on this issue.

Development, testing, manufacturing, assembling and maintaining of biomass facilities for household heating could be a considerable support for economic activities in rural areas by offering many new business possibilities for SMEs.

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ABOUT THE AUTORS

Prof. Dr. Milan Martinov, MSc Miodrag Konstantinovic, Borivoj Stepanov, dipl.ing., Faculty of Engineering, Novi Sad, Serbia and Montenegro, mmartog@uns.ns.ac.yu

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