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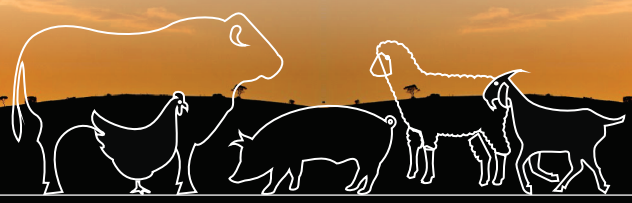

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BIOMASS UTILIZATION SYSTEMS FOR SERBIAN LIVESTOCK FARMERS – POTENTIALS AND REALITY

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Invited paper

Abstract: The paper analyses the availability and energy potential of biomass originating from agriculture and animal husbandry in Serbia, and generally recommends the necessary changes in order to increase the use of biomass as an energy source in Serbia. Also, detailed analysis of a simple example of the possible applications of biomass to livestock farms is presented.

Key words: biomass, energy, livestock farms, Serbia

Introduction

Three key resources to focus on are water, food and energy, and our most important goal and a pledge for the future must be to ensure them in sufficient quantities in a sustainable manner at both the local and global level. Agriculture and livestock are of great importance for the production, consumption and conservation of these three resources (*Lukić et al., 2013*). Serbia is unfortunately already late with the introduction of changes in production methods in order to preserve resources and increase production. It is indicative that despite the great relevance and urgency, there is relatively little published research in this field in our country, especially those relating to the energy aspect of livestock farms.

When we speak of energy and its production and consumption in a sustainable manner in agriculture and animal husbandry, we are really talking about biomass, which is becoming increasingly important and desirable energy source. The fact is that the use of biomass in the production of thermal and/or electrical energy does not adversely affect the environment, it is locally available in agricultural regions and farms and unused, and as such it represents a cost-effective solution (*Yamashiro et al., 2013; Iwasaki et al., 2013*). On the other hand, the use of biomass cannot completely replace other energy sources, but can significantly contribute to reducing energy needs and increase energy security both at local and global levels, while reducing emissions of greenhouse gases.

The aim of this study is to analyze and briefly show the current availability and biomass energy potential in Serbia, and generally recommend the necessary and feasible changes that would increase the use of biomass in Serbia. Also, in details will be presented and a simple example of possible changes in energy sources, or the application of biomass as an energy source in livestock farms analysed.

Biomass as energy resource

There are many definitions of biomass. Basically, biomass is organics, which is produced by the activities of living creatures, and can be used as energy and material. It is therefore understandable why the main sources of biomass in all countries of the world, although not the only sources, agriculture and forestry. Often the production of biomass for energy purposes is identified with these two production as its integral part, which is increasingly gaining in importance.

With the use of biomass as fuel, the three key aspects are to be analysed:

- Resources - assessment of the potential and actual biomass availability in terms of quantity and energy value, taking all factors into account;
- Conversion - choosing the most appropriate process/technology specific use of biomass for energy in the concrete case;
- System - the development, analysis and elaboration of models and concrete project, which should in practice facilitate the applicability, sustainability and cost-effectiveness of the use of biomass as fuel.

If we analyse the biomass as a resource in our country, it is well known that biomass is considered individually the most important potential source of renewable energy in Serbia. It is estimated that biomass represents 55%, and by some estimates up to 64% of the total potential of all renewable energy sources in Serbia. It is also well known that this potential is not nearly enough utilized. Total biomass energy potential in Serbia is estimated at 3.4 Mtoe (wood biomass, 1.5 Mtoe; agricultural biomass, 1.7 Mtoe; biodegradable waste, 0.2 Mtoe) and currently about 1 Mtoe is being used, almost exclusively of wood biomass.

Table 1 shows estimates of the total annual production potential and unexploited biomass in Serbia.

Table 1. Total amount of unused biomass in Serbia (rough estimation)

Biomass type and remarks	Amount (million tons per year)
• Crop byproducts (field remains from cca. 2.3 million ha)	**15 Mt/y**
• Fruit and grapes byproducts (0.35 mil ha, pruning remains)	**0.6 Mt/y**
• Wood byproducts (without firewood)	**1 Mt/y**
• Livestock manure	**20 Mt/y**

Source: Statistical Office of the Republic of Serbia

From the estimated total annual production, it is evident that the greatest untapped potential in Serbia is biomass from agricultural production, primarily from the fields of corn and wheat, extremely dominant field crops in our country. Also, a significant potential in terms of total annual production is manure from livestock production. However, this biomass potential should be accepted with great reserve, due to a number of factors that have a crucial impact on the availability of biomass. Soil fertility protection is a very important issue, as well as livestock production - animal feeding and bedding, mechanization losses in the collecting process, too big collecting and transport costs or other unfavourable economic aspects. Therefore all the biomass potential cannot be used as an energy source. In order to obtain more realistic data on the availability of these resources and their energy levels further analysis and calculations are required, and one of the possible calculations is given in Table 2. The present calculation is based on average annual areas under maize and wheat, and the expected average annual number of cattle, pigs and poultry in Serbia in the future (*Lukić et al., 2009; Lukić, 2012; Lukić et al., 2013).*

Table 2. Potential and availability of main unused biomass in Serbia (estimation)

Crop field remains (corn and wheat)
Corn remains - potential Yearly production of corn (from 1.2 mil. ha): 6 million tons of grain *Ratio of waste production for corn: 1.0 t/t* (6Mt grain/year)(1.0t/t) = 6Mt corn remains/year *Coefficient of energy conversion for corn: 17.7GJ/t* (6Mt/year)(17.7GJ/t)= 177PJ/year Corn remains – availability *Availability ratio for energy production in case of agricultural waste (including corn remains and wheat straw) is 25%.*

(177PJ/year)(0.25) = **44PJ/year**

Wheat straw - potential
Yearly production of wheat (from 0.5 mil. ha): 2 million tons of grain
Ratio of waste production for wheat: 1.3t/t
(2Mt grain/year)(1.3t/t) = 2.6Mt wheat straw/year
Coefficient of energy conversion for wheat: 17.5GJ/t
(2.6Mt/year)(17.5GJ/t)= 45.5PJ/year
Wheat straw – availability
(45.5PJ/year)(0.25) = **11.4PJ/year**

Livestock manure

Cattle
900.000 heads (number of cattle) x 1.1t/y/head = 1Mt of dry manure per year
(1Mt/year)(15GJ/t) = 15PJ/year (potential)
(15PJ/year)(0.125) = **1.9PJ/year (available)**
Pig
3 million heads (number of pigs) x 0.22t/y/head = 0.7Mt dry manure/year
(0.7Mt/year)(17GJ/t) = 12PJ/year (potential)
(12PJ/year)(0.125) = **1.5PJ/year (available)**
Poultry
23 million (poultry number) x 0.037t/y/head = 0.85Mt dry manure/year
(0.85Mt/year)(13.5GJ/t) = 11.5PJ/year (potential)
(11.5PJ/year)(0.125) = **1.4PJ/year (available)**

Sources for statistics: Agriculture in Serbia in 2013, Green book, Ministry of Agriculture RS
Source for used calculations coefficients: The Asian Biomass Handbook, Japan Institute of Energy

Because of obviously great potential of biomass in Serbia, currently there are many ongoing international projects, aimed at greater use of biomass in our country and of whom much is expected. The most detailed analysis of the potential and availability of biomass for energy in Serbia, so far, was created and recently released as a part of one of the projects (DBFZ, 2015). However, the availability of significant volumes of biomass in a certain area does not necessarily lead to the realization of the objectives of these projects (*Inoue et al., 2009*). In each case, it is necessary to individually carefully and thoroughly consider all three key aspects of using biomass as a fuel, as has already been pointed out in this paper.

Another major disadvantage is the dominance of small farms and landholdings, and biomass is often spread over a large area in relatively small quantities. Thus, in the planning and construction of larger plants and systems it is necessary to ensure a strong and economically cost-effective logistic support for the collection of biomass and its storage. At the same time, in Serbia, it is important to focus on increasing the use of biomass for energy in small and medium-sized farms, or where it is produced, whereby one should aim at simpler and more cost-effective ways of implementation. Also, in the system using biomass as an energy source, it is necessary to ensure continuous collection of biomass

during the period of several years and thus ensuring the security of supply of biomass, especially in our conditions where there is still no developed market for biomass.

The analysis of the current situation, i.e. the real potential, needs and opportunities for increased use of biomass in farms in Serbia, can result in practical recommendations to farmers, experts and lawmakers that could serve as a basis for the development of models and concrete systems using biomass as fuel in individual farms. Possible scenario for growth in the use of biomass as an energy source on farms is shown in Table 3.

Table 3. Possible scenario of better use of biomass resource on farms in Serbia

Target: main unused biomass (estimation):
– Corn field remains: 6 mil.t (potential) (25%)=1.5 mil.t (available) – Wheat straw: 2.6 mil.t (potential) (25%)= 0.7 mil.t (available) – Livestock manure (cattle, pig, poultry): 2.5 mil.t dry (12.5%)= 0.3 mil.t (av.) *How to collect: existing mechanization (small farms) and/or big baler machines (middle and big farms) for field residues; small scale digester (middle farms) and plants for biogas production and cogeneration (big farms) for manure.*
Conversion method, products and distributions:
– For field residue: physical (production of pellets or briquettes) and/or combustion (for small farms only combustion in small scale boilers – heat production for households and farms in winter time). Products: pellets or briquettes (small scale production or bigger facilities/plants baying corn or straw big bales from farmers). – For manure: middle farms – anaerobic digestion and heat production for farm self-usage. Big farms: anaerobic digestion for methane/hydrogen production and cogeneration systems for heat and electric power production.
What we need for success:
– A lot of education for farmers and pilot plant/training facility establishment (from bottom to top approach). – A lot of research and investment/subsidies support (from top to bottom approach).

Biomass utilization system on livestock farm – one simple and effective model

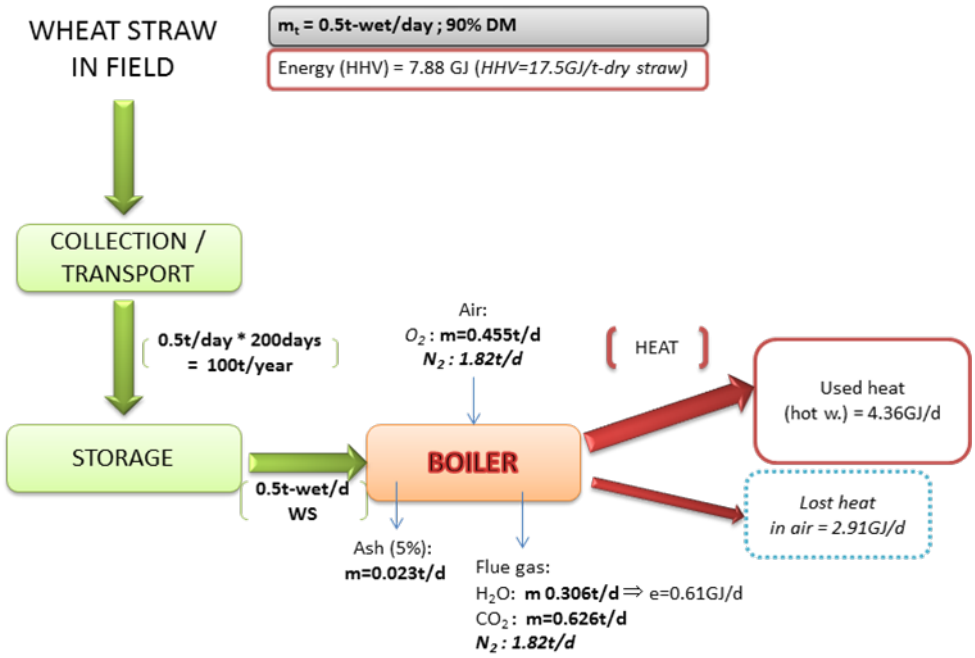
System for using wheat straw for heating pig/poultry farm in winter time (and optional - drying corn grain after harvest)

As an illustration of the possible examples of simple and effective application of biomass as an energy source in pig farms (or poultry), we will consider the effects of substitution of the electric boiler (or fossil fuels) with boiler using the straw as fuel in the existing heating system with hot water. Analysis and development of the system is not made for a real farm, the model and simulation are used, so the results can be used with a certain reserve. Each farm requires a careful consideration of all three key aspects of the use of biomass for energy, including the development and analysis of the relevant final project.

The initial elements for the development and analysis of this example of a very simple system are:

- ***Goal:*** *To develop model of system for using unused wheat straw (or corn remains) from own production which can be replacement for existing heating system on pig farm with electric power boiler (or oil/natural gas boiler).*
- ***Users:*** *Middle scale farms with combined crop and livestock production (with pigs or poultry farm).*
- ***Some boundary and parameters used (suitable) for development/implementation of system:*** *Volume of own production of biomass: ≥ 100t wheat straw per year; Pig farm capacity (for heat consumption): ≥ 200 sows (or broiler farm with equivalent capacity/heat consumption need) with hot water heating system; Heating system running 200 days in year; Collection, transport and labour needs covered by existing farm mechanization and workers.*

A simplified and shortened version of the results of the system analysis shown in this work included three main components of the analysis with graphics and text explanations of the most important indicators. Figure 1 schematically shows the flow of all processes in the planned new system, the use of wheat straw as a fuel, including mass and energy balance of the system.



(Remarks: assumed boiler efficiency 60%)

Graph 1. Flow scheme, mass balance and energy balance of the system

Energy efficiency (Ef) and Energy Profit Ratio (EPR) of the system are 0.55 and 4.36, respectively.

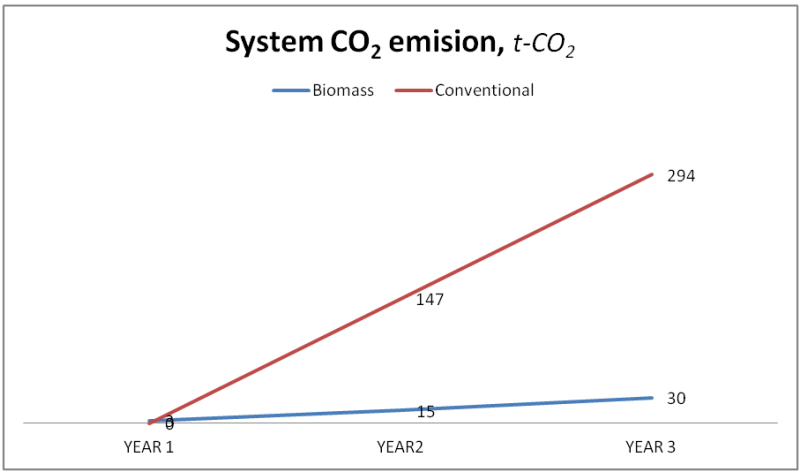
Basic parameters of economic analysis and assessment of the cost-effectiveness of the proposed system in relation to the previous are given in Table 4.

Table 4. Economical evaluation of the system

Cost type, ***way for calculation, formula, explanations …***	**Overall price (€)**
CAPITAL COST ***(estimation based on price of existing similar plants/systems)***	**30,000**
OPERATIONAL COSTS ***(per year):***	
Feedstock *Wheat straw from own production, not purchased. Cost of collecting & transport within farm for 100t wheat straw per year* *(estimate cost for 1t = 20*€)	2,000
Electric power *For running pumps - boiler, hot water heating system* *(100kWh/d *200d*0.05€/kWh)*	1,000
Labor (*covered by existing farm workers)*	0
Maintenance *(estimation, 3% of capital cost)*	900
Unforeseen *(estimation, 1% of capital cost)*	300
OPERATIONAL COST $\sum$ =	**4,200**
INCOME (*saving money for electric power needed for pig farm heating per year)* *Calculation: 4.36GJ/day * 200days = 872GJ heat energy per year* *1kWh = 3.6MJ ⇒ 876GJ = 242,000kWh* *242,000kWh * 0.05€/kWh =*	**12,200**

The obtained data indicate that in the market conditions and system parameters used in this example, the annual savings of 8,000 € can be expected with the use of planned new heating system compared to the existing one, and that the investment would be returned in less than 4 years.

Using Life Cycle Assessment (LCA) method, the CO_2 emissions of the old and new systems are established (Graph 2). Using the new system, lower annual CO_2 emissions can be expected by 132.5t, compared to the existing conventional system, i.e. the CO_2 recovery payback time is already in the first year of implementing the new system.



Graph 2. System CO_2 emission, t- CO_2

Finally, it should be noted that already on our farms, especially pig farms, there are very successful examples of the application of such or similar ways of using biomass as fuel. The implementation of such models is expanding mainly due to their simplicity and efficiency, relatively small investments and relatively quick return on investment. The system, depending on the needs and opportunities farms, can also be significantly upgraded and improved.

Conclusion

Serbia has significant energy potential in produced and available biomass, whose efficient use as energy has been current topic for long time, but in reality and practice it is still at the beginning. Considering numerous specificities, primarily large number of small and medium-sized farms that have unused biomass, primarily crop residues and manure, it is important to focus on the increasing application of biomass for energy in these farms, or where it is produced, with tendencies towards more cost-effective ways of implementation. Perhaps in the case of Serbia to plan for increased use of biomass, if we consider the smaller but numerous, as a result we get more.

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Sistemi korišćenja biomase za srpske stočare – potencijali i realnost

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Rezime

U radu se analizira raspoloživost i energetski potencijal biomase u Srbiji poreklom iz poljoprivrede i stočarstva i generalno predlažu potrebne promene kojima bi se povećala upotreba biomase kao energenta u Srbiji. Takođe, detaljnije se analizira jednostavan primer moguće primene biomase na stočarskoj farmi.

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