TECHNICAL AND ECONOMICAL ANALYSIS OF BIOENERGY PRODUCTION

Ghereș M. I., V. Roș, Teodora Chira, L. V. Fechete, A. Molnar, O. Ranta

Technical University of Cluj Napoca, Department of Automotives and Agricultural Machinery,
Bd. Muncii, 103-105, Cluj Napoca 400641. Romania, Tel/Fax. +40 264 401677,
E-mail: marius.gheres@arma.utcluj.ro

Key words: bioenergy, biomass, environmental protection, economical analysis

Abstract. In the paper is presented a study regarding the bio-energetic potential of agricultural crops and the evaluation possibilities of agricultural wastes for energetic proposes. In the study is analyzed, from technical and economical point of view, the phases of energy from solid biomass conversion. The authors proposed an agricultural farm for the evaluation of energetic potential of agricultural solid biomass as a fuel.

INTRODUCTION

The biomass is an important alternative energy sources to the conventional energy sources. The biomass is uniform distributed in the world and it have a renewable characters. So, the biomass, is a viable energy sources for all the countries (industrialized and developing countries).

In the last decade the consumption of biomass was continue increase. For example, in USA, in 1970, the consume of the biomass was 850.000 (BOE – Barrels of oil equivalent) BOE/day, and increased at 1,4 billions/day in 1990 and the specialists estimate continue increase in the next years. Today, in Canada, the biomass consume for energetic propose covers 5% from the total energetic necessity.

The objectives of EU White Paper – 1997 showed the energetic importance of biomass. The main objective is increasing the energy production from biomass, up to 12% from total energy consume, until 2010 years.

The International Energy Agency (IEA) showed the increasing of the quantity of energy from biomass in Europe at 1,1 billion tones oil equivalent per year. The increase annual level proposed by the European Commission for next period, is about 8 – 9 billion tones oil equivalent per year.

Because environment and geographical conditions allow, Romania is estimated, in present, like a country with a high energetic potential of solid biomass (around 8.000 BOE/year). From the total surface of Romania (237,500 Km²), the agricultural area represents about 40% and the forest areas represents about 28%.

In year 1998, the production of biomass reached 126.3 PJ and participated with 10.94% in the total energy production.
The main biomasses are firewood and agricultural waste (which account about 95% of the total) and wood waste from industrial processes (about 5%).

From the total firewood & agriculture waste, it is estimated that only a share of 30% is commercial biomass and the share of 70% represents the contribution of the biomass harvested by the owners from the private forests and gardens and of the agriculture waste resulted in the rural household.

Regarding the crop production structure, area under grain cereals has the highest share (66%). The rest of surfaces are under fodder crops (14%) and technical (industrial) crops (13%). Taken together, these groups account for 93% of the entire cultivated area. This reflects the poor diversification of agricultural crops, requiring measures for the enlargement of agricultural crops, especially of those incorporating a high rate of technicality.

The elaboration of efficient biomass uses technology

The main important research of the study regarding to the elaboration of efficient biomass uses technology are: determination of technical and economical possibilities for energetic production. The study was realized in accordance with the specific condition from our country. The main proposed of the study is the elaboration of the agro-energetic projects for agricultural farms.

A systemic analysis of the obtain agriculture biomass process (Fig. 1) was realized for to prepare the qualitative and quantitative energetic balance.

The energetic consume $W_i$ is composed by:

- The energetic consume of the tillage for each type of crops;
- The energetic consume of the fertilizers and pesticides used;
- The mechanical energy embodied in the agricultural machines used for the tillage of the cultivated unit area per year;

The external factors $F_m$ is represented by:

- The impact factors on the energetic consume (soil characteristics);
- The environmental factors which can determine the biomass production (the environmental condition favorable for the agricultural crops).

The biomass production $W_0$ was evaluated after the results regarding to energetic potential of the mass unit for the agricultural products, of the cultivated areas in Romania and the annual medium productions per total country area. Statistical dates were taken from the Statistical National Institute.

The energetic consume of the different agricultural production is showed in Table 1. The dates are in accordance with the specific tillage systems.
The energetic potential of solid biomass from agriculture, in our country, is showed in Table 2.

**Table 1. Energetic consume/ha**

<table>
<thead>
<tr>
<th>Crop systems</th>
<th>Energetic consume MJ/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clasic</td>
<td>2200</td>
</tr>
<tr>
<td>Minimum tillage</td>
<td>1000</td>
</tr>
<tr>
<td>No-tillage</td>
<td>450</td>
</tr>
</tbody>
</table>

**Table 2. The energetic potential of the biomass from agriculture**

<table>
<thead>
<tr>
<th>Crops type</th>
<th>Surface area, [ha]</th>
<th>Production [t/ha]</th>
<th>Energy $\times 10^6$ GJ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>415,5</td>
<td>2,77</td>
<td>3,01</td>
</tr>
<tr>
<td>Maize</td>
<td>3013,4</td>
<td>3,83</td>
<td>87,44</td>
</tr>
<tr>
<td>Sun flower</td>
<td>1043</td>
<td>1,24</td>
<td>8,81</td>
</tr>
<tr>
<td>Fruit trees</td>
<td></td>
<td></td>
<td>0,80</td>
</tr>
<tr>
<td>Wine twigs</td>
<td></td>
<td></td>
<td>37,68</td>
</tr>
</tbody>
</table>

The practice of the minimum tillage technologies and no-tillage technologies is necessary for to increase the energetic efficiency of agricultural tillage. The comparative study between the energetic consume and the biomass potential (Table 1 and 2) showed this situation.

The solid biomass is converted in other energy forms using two main methods: thermo-chemical methods and bio-chemical methods (figure 2). In the both methods, the conversion have two main phases: **physical conversion** (the pre-treatment operation of biomass) and the **secondary conversion** (the energy embodied in solid biomass is converted in final energy form – mechanical energy, thermal energy, electrical energy etc.).

The phase of physical conversion (or primary conversion) is composed by the few operations: drying operation, resize of biomass dimensions, increasing of biomass density or the biomass compactation and the separation process. The main propose of the psychical conversion is the increase of the conversion efficiency.

**Drying operation**: is realized in two phases. In the first phases the moisture content is decrease by the water eliminated in liquid forms and in the second phase, the water is eliminated in gaseous form. The drying operations propose are increases of thermal conversion efficiency by decreasing calorific energy consumed for water evaporation during the combustion process. The direct resulted of the biomass drying from 40 – 60% moisture content less than 30% is an increase of flame temperature from $980^\circ$C until $1260 – 1370^\circ$C, in the same burn conditions.

Regarding to economical consideration, the optimal drying methods of the raw agricultural waste (40 – 60% moisture content) is solar drying, chemical flocculation methods and the high or low temperature of treatments.

**Resize of biomass dimensions**: the resize of particles biomass dimensions is a preparation phases (reduce of psychical dimensions of biomass). The resulted products can be as directly as fuel. The resulted products are used for pellets, briquettes manufacturing. The direct resulted is the useful handling and reduction of storage space. Usually, the resize operation is realized by the cutting operation, hammering or milling operations.
Solid biomass compactation: is the phase of increasing biomass density. The final products of compactation phases have highest density and can be easy handling during the transportation and storage.

In the first phase the compactation of solid biomass can be realized by the balling of the agricultural wastes. The balling is a specific operation for wheat crops. The result of the methods is the density of the balls about 70 – 90 kg/m³. The second method used is the pelleting operation. The density of wheat pellets is about 300 – 1200 kg/m³.

![Diagram of biomass processing and conversion](attachment:image.png)

Fig. 2. Proposition for an efficient technology for solid biomass
The separation activities: is used for the harvesting agricultural production separation in different components. An clear example is the animal forage and the agricultural waste for energetic porposes.

The secondary conversion of solid biomass: is the final phase of biomass conversion. In this phase the energy embodied in the final products resulted in the finals separation phase is converted in other energy forms: thermal energy, electrical energy or mechanical energy. The thermal conversion is the most important final conversion method of solid
ium. The thermal conversion of solid biomass can be realized from the direct combustion, pyrolysis and liquefying, gasification etc.

The necessary conditions for efficient use of solid biomass as fuels are:

- a strong exothermic reaction;
- a high speed and high temperature of the exothermic reaction;
- a non-polluting burn products;
- a non-corrosive burn products;
- a low costs.

Fig. 3. The efficient uses technology of the maize production and wastes for energetic propose.
An efficient technology for solid biomass uses is presented. The proposed technology was created for a rural community from our country with a total agricultural surface about 1000 – 2000 ha (figure 3).

The efficient technology was realized for a maize crop because the maize crop is specific for Transylvania area (up to 50% from agricultural surface). The main purposes for rural community proposed is the efficient uses of main production (the consume necessity and alcohol production) and the efficient uses of agricultural wastes (maize cobs) for energetic purposes.

The phases of the technological solution proposed is the resize of agricultural wastes, wastes dry operation (the operation is necessary to decrease of moisture content to obtain a high thermal efficiency) and pelleting operation. The economical efficiency of wastes uses as a fuel is demonstrated by the researches study presented in the specific literature.

CONCLUSIONS

Romania is a country with a high renewable energy potential. The agricultural waste is an important energetic source for our country because the solid biomass from agriculture has a renewable character and non-polluting proprieties. The uses of the agricultural wastes and the wood wastes from the siliculture, for thermal energy generation in rural areas, have a positive impact on the living condition and on the environmental protection.

The results of the implementation of new conversion technology of the energy embodied in agricultural wastes in thermal energy (with high thermal efficiency) is the decreasing of the fuel consume and of the thermal energy generation costs.

The results of utilization of renewable energy sources (agricultural wastes) as a fuels in agricultural farms is the energetic independence of farm and the decreasing of thermal energy costs.

BIBLIOGRAPHY