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THE BIOENERGY POTENTIAL OF AGRICULTURAL RESIDUES IN ROMANIA

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Abstract

One of the main concerns worldwide is the production of renewable energy based on agricultural waste, in most countries the agricultural sector is the basis of the national economy. The most important amount of biomass residues is generated by agricultural crops. The energy potential of biomass residues from agricultural crops depends to a large extent on the amount of resources available and their characteristics. The purpose of this paper was to evaluate the energic and theoretical potential of biomass result. A mathematical calculation model for all indicators was defined in the paper. Maximum total amounts of biomass residues obtained from the studied crops are estimated at 9,985.18 kilotons, 11,105.04 kilotons, 2,542.03 kilotons and 1,564.56 kilotons. Due to the pedoclimatic conditions and the agricultural production, Romania has a high biomass potential, having a great diversity of types of crops that can be found in the field.

Key words**:** *biomass, agricultural residues, potential*

INTRODUCTION

The framework for climate and energy policy for 2030 aimed at setting the following targets for all EU member states: "reducing GHG emissions by 40% from 1990 levels, using at least 27% of total renewable energy consumption and at least 27% of stored energy [6]. Both the European Parliament and the European Council jointly agreed in June 2018 that a mandatory target should be renewable energy production, with a percentage of 32% by 2030". "By the end of 2019, each Member State had to presents an integrated national energy and climate plan for a period of 10 years, containing objectives, contributions, policies and national measures".
In the case of bioenergy, it is estimated that it will contribute in 2020, by about 140 Mtoe to the final consumption of raw energy, being 20.6% higher than in 2016 (116 Mtoe) [7].
For 2030, the estimated values of bioenergy may vary between 160-180Mtoe, which represents 14% -16% of GFEC [8].
Among the main major concerns of policy development and implementation of bioenergy are the availability of biomass, the alternative use of biomass and sustainability issues. At EU level, the biomass potential estimated by the EEA (European Environment Agency) has been estimated for 2020 at 235 Mtoe, of which: 100 Mtoe goes to waste, 96 Mtoe to agriculture and 39 Mtoe to forestry [5, 10].
To achieve the target it is necessary to increase substantially the level of biomass in the EU and for this you can use waste resources (agricultural residues, manure, municipal solid waste, etc.) that can effectively contribute to energy supply.
The main potential raw materials for obtaining organic energy are agricultural and crop residues. Agricultural waste is an opportunity to increase bioenergy production, without the need to apply for land to obtain raw materials for biomass [19].

MATERIALS AND METHODS

The quantities of agricultural residues resulting from crop production, as well as their characteristics vary depending on different factors such as: climatic conditions, differences between appling good agricultural practices, type of crop, yield per hectare and production [12, 15]. Thus, the properties and

quantities of agricultural crops may differed depending on the region, country.
In this paper, the authors determined the theoretical potential of biomass obtained from agricultural residues, the theoretical energy potential and energy potential available at national level for the period 2007-2018, highlighting the minimum, maximum and average values for this period.
The data used to determine these parameters were obtained from the INSSE site and analysed taking into account the following characteristics: production obtained, type of residue resulting (stem, straw, leaves, etc.), humidity, residue ratio, and lower heating values of dry matter of residue.
Table 1 shows the characteristics of agricultural residues for the following crops: wheat, corn, sunflower, oats and rapeseed.

Table 1. Characteristics of agricultural crop residues

Crop	Agricultural residue	Humidity (%)	Residual Report	LHV (Heating Lower value) (MJ/kg)	Availability (%)
Wheat	Straw	12.5	1.12	18.50	40
Maize	Cobs	15	0.70	17.40	50
Maize	Stalks	40	1.29	15.70	50
Sunflower	Stalks	17	1	16.55	50
Rapeseed	Stalks	45	1.7	17.10	50

Source: [4, 13,14,17].

The theoretical potential of biomass indicates the total annual amount of biomass obtained from agricultural residues. The following formula was used to determine the theoretical biomass potential (TBP):

$$TBP = \sum_{i=1}^{n} CP(i) * RPR(i) * \left[\frac{100 - M(i)}{100}\right]$$

where:
CP (i) - annual crop production (tonnes);
RPR (i) - the ratio of residue to production;
M (i) - relative humidity content (%).
The following formula was used to calculate the theoretical energy potential (TEP) of the dry mass of biomass:

$$TEP = \sum_{i=1}^{n} TBP(i) * LHV(i)$$

where:
LHV (i) is the lower heating value of plant (MJ/kg).
The available energy potential is determined by the formula:

$$AEP = \sum_{i=1}^{n} TEP(i) * A(i)$$

where:
A (i) is the ratio of available residues (%) [1].

RESULTS AND DISCUSSIONS

Biomass is that biodegradable part of products and residues that can be transformed by various processes into energy. It can be composed of various plant and animal elements (agriculture, animals, forestry, other industries) but also industrial and urban waste [9, 3].
In Romania, biomass is a source of raw materials for all energy sectors: electricity, heat, biofuels and bioliquids [16]. It comes from:
-plant products from agriculture or forestry activities, which can be used as fuel in order to recover their energy content;
-wastes from agriculture, forestry and food industry (if the thermal energy generated is recovered), from the production process of primary pulp and pulp, cork waste, construction and demolition waste wood).
Depending on the origin, biomass can be classified into: primary, secondary and residual biomass and fossil.
Residual biomass is produced in human activities: straw, sawdust, slaughterhouse waste, urban waste, etc. From the point of view of biomass residues can be classified into:
-*primary residues* - are produced from energy plans, agricultural crops or forest products, are found in the field and must be collected for later use;
-*secondary residues* - generated following the processing of biomass for the production of agri-food products or other wood products, being available in the food industry, at paper mills, etc.;
-*tertiary residues* - various wastes, with variations of the organic fraction, these being available after a biomass product has been used.
Romania has varied and rich renewable energy resources. These resources are distributed throughout the country and can be

widely exploited depending on the performance potential of the technologies and equipment used [2].

For Romania, biomass is a promising source of renewable energy, given its high potential and its varied use.

In Romania, the technical energy potential of biomass is approx. 518,400 TJ and includes the distribution in the territory of energy values (TJ) expected to be obtained by energy recovery of plant biomass [9].

The areas with the highest technical energy potential of biomass are: Southern Plain (126 639 TJ), Subcarpathians (110,198 TJ) and Moldova (81,357 TJ).

The biomass resources that can be used to produce energy are very diverse. At the national level, biomass resources consist of agricultural crops, plant residues, forest resources and special energy plants.

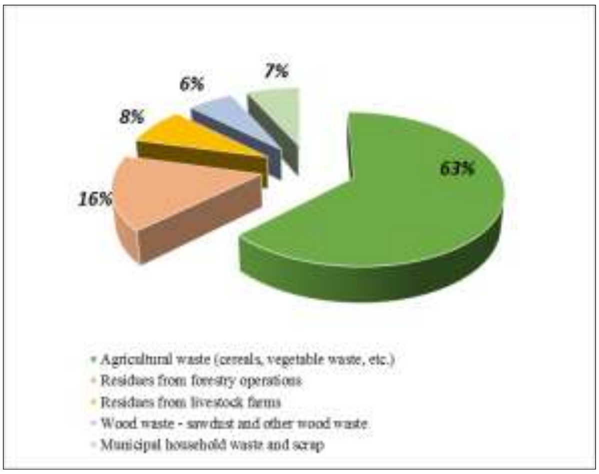

Fig. 2. Percentage distribution of residues in Romania, Source: [18].

The biomass resources that can be used to produce energy are very diverse. At the national level, biomass resources consist of crops, plant residues, forest resources and special energy plants.

In this context, the distribution of the agricultural area according to crop is analyzed in the first phase (Fig. 1). The total agricultural area cultivated with cereals in 2018 was 8.5 million ha, of which the largest share was occupied by maize cultivation of 29% (2.43 million ha), followed by wheat cultivation, with 25% (2.1 million ha) and 12% sunflower (1 million ha).

At the level of 2018, the total production of cereals harvested from the agricultural area of Romania was 31.55 kilotons.

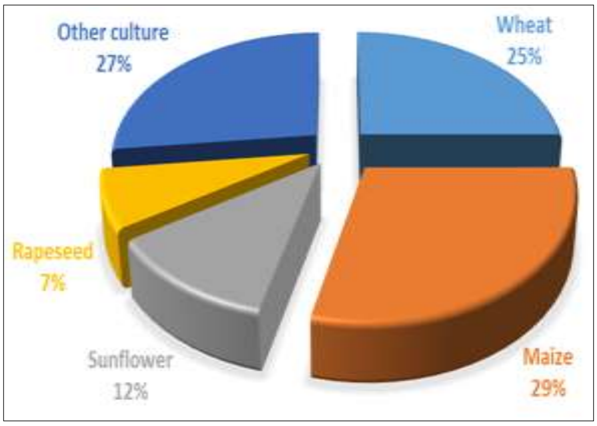

Fig. 1. Distribution of agricultural area by crops at national level

Source: INSSE processed data, Accessed on 14.06.2020 [11].

Evaluating the production situation for different types of agricultural crops for the period 2007-2018, it can be seen in Fig. 2, that the wheat crop registered the minimum production 3,044.47 kilotons, while the maximum of the period was of 10,143.67 kilotons. In the case of corn cultivation, the maximum production was 18,663.94 kilotons, and the minimum 3,853.92 kilotons. The sunflower and rapeseed crop recorded an average production in the period 2007-2018 of 178.53 kilotons and, respectively, 888.78 kilotons, while the tobacco crop recorded 1.66 kilotons.

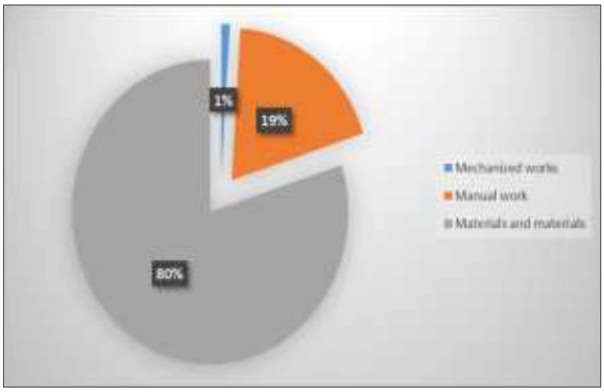

Fig. 3. Production of agricultural products (kilotons) 2007-2018

Source: calculations based on INSSE statistical data [11].

Using the calculation methodology described above, the value of the energy potential of biomass, theoretical energy potential and AEP, from Romania, was obtained for all 5 agricultural crops studied, depending on the type of residue obtained during 2007-2018 (Table 2).

Table 2. Theoretical biomass, energy and available energy potential

Specification		TBP (Theoretical potential of biomass) kilotons	TEP (Theoretical energy potential) TJ	AEP (Available energy potential) TJ
Wheat	min	2,996.90	55,442.56	22,177.02
	max	9,985.18	184,725.76	73,890.30
	average	6,982.70	129,180.03	51,672.01
Maize (Cobs)	min	2,293.08	39,899.61	19,949.81
	max	11,105.04	19,3227.76	96,613.88
	average	6,071.02	95,314.99	47,657.49
Maize (Stalks)	min	34,68.53	54,455.86	27,227.93
	max	14,501.88	227,679.53	113,839.76
	average	7,928.04	124,470.16	62,235.08
Sunflower	min	453.95	7,512.79	3,756.40
	max	2,542.03	42,070.64	2,1035.32
	average	1,479.50	24,485.65	12,242.83
Rapeseed	min	1,47.27	2,518.36	1,259.18
	max	1,564.56	26,753.99	13,376.99
	average	831.01	14,210.26	7,105.13

Source: own calculations.

Determining the theoretical potential of dry biomass for wheat and corn cultivation, it can be seen in figure no1. the fact that for wheat there was an average value of 6,982.7 kilotons, for corn (cobs), 6,071.01 kilotons and corn (stem) 7,928.08

kilotons. Wheat and corn are the most important crops that produce significant amounts of residues. The theoretical energy potential is estimated for the two crops at maximum values of the period of 129,180.03 TJ, 95,314.99 TJ and 227,679 TJ respectively (maize-residue stem).

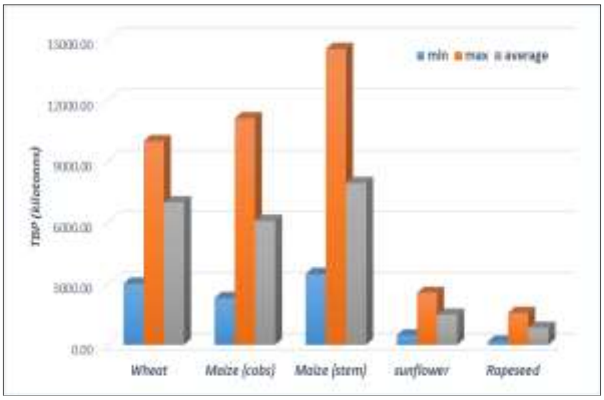

Fig. 4. Theoretical potential of biomass
Source: own calculations.

Regarding the agricultural residues resulting from the cultivation of sunflower and rapeseed, namely the stems left after the harvesting process to obtain the raw material (seeds, oils), their recovery could lead to an increase in biomass material.

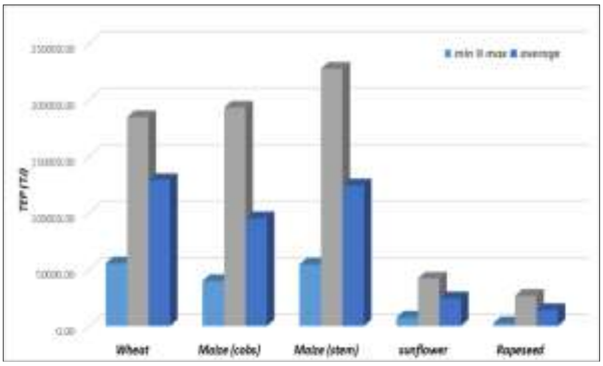

Fig. 5. Theoretical energy potential
Source: own calculations.

The average values of the theoretical potential of biomass resulting from the cultivation of sunflower and rapeseed were 1,479.50 kilotons and 831.01 kilotons, respectively, these being up to 4 times lower than the wheat and corn crop (these being the predominant crops in Romanian agriculture). Calculating the theoretical energy potential, it is observed that it is smaller compared to other crops, recording maximum values of 42,070.64 TJ and 26,753.99 TJ respectively.

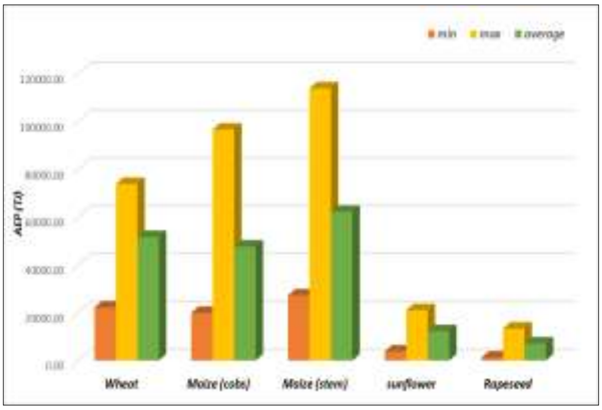

Figure 6. AEP (Available energy potential) TJ
Source: own calculations.

The available energy potential can represent the energy stock we can have following the recovery of agricultural waste. Analyzing the results obtained for the 4 crops, the highest value of the available energy potential is held by the residues resulting from the corn crop (strain), of 113,839.76 T. For the wheat and sunflower crop during the study period, an average available energy potential of 51,672.0 TJ and 12,242.83 TJ respectively.

CONCLUSIONS

Significant amounts of agricultural residues are available at EU level, which are estimated at an average annual value of 1,530 PJ, contributing to bioenergy production. The largest quantities of agricultural residues are available in Germany, Romania, France, Spain and Italy.

Romania has a very high biomass potential that can come from the agricultural and livestock sector.

The diversity of types of agricultural crops is quite large in Romania due to its climatic conditions and agricultural production. In addition to the geographical area in which the plants are grown, characteristics such as the value of crop yield and the method of harvesting may affect the amount of residues obtained from the crop. By capitalizing on agricultural residues, there is a high available energy potential, and the crops taken for analysis reveal this fact. The future recovery of agricultural waste through the use of conversion methods for the production of energy from biomass is an efficient method will have positive effects on the environment.

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