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# EVALUATION OF ROMANIA'S POTENTIAL FOR PRODUCING RENEWABLE ENERGY FROM AGRICULTURE AND FORESTRY

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**Abstract:** *Renewable energy production is an alternative to traditional energy resources that are being depleted, these new resources will gradually replace the exhausting energies by combining the three main features of the present century, so that sustainable development, energy security and environmental protection become defining elements in terms of renewable energy production.*

*The energy sector communicates and is closely linked to the economic sector, the defining resource with a major influence on the economy being oil, where its exhaustion and other natural energy resources would lead to economic and political instability, which is why it is necessary to highlight the possibility of substitution exhaustible resources through different sources of renewable energies: solar, wind, microhydro, geothermal and biomass.*

*In view of the above, we will highlight Romania's potential in the production of renewable energy from biomass, the materials provided by the agricultural sector and the forestry sector, but also the energy consumption in agriculture and forestry, as well as the type of biofuel used (liquid or solid), which draws a parallel between the two categories of biofuels obtained from the same resource.*

*We will also highlight Romania's position in the European Union in this field, highlighting the national and European objectives on this issue.*

**Key words:** *renewable energy, biomass, energy security*

**JEL classification:** *Q23, Q42*

## INTRODUCTION

Renewable energy from different sources comes as a response to all the world's problems with the depletion of natural resources. Over the last three decades, developed countries of the world are looking for solutions to this problem and admit that they face a major challenge that directly affects the lifestyle of man.

The increase in energy consumption has increased with the demographic increase of the population on the globe, which accelerates the pace of increase in the exploitation of natural resources.

The idea of renewable energy has been easily adopted and developed from year to year, so that major changes in the use of the amounts of energy from renewable sources can be observed. According to specialized sites, the amount of renewable energy produced in the European Union increased by 73.1% in 2015 as compared to 2005, representing an average increase of 5.6% per year and 184% over the year 1990 with an average annual growth rate of 4.3%. Total energy production from renewable sources was about 205 million tons of oil equivalent (TOE) in 2015 for the European Union accounting for 26.7% of the total primary energy used from all sources.

According to statistics, the most important source of renewable energy in the EU's 28 Member States is that of solid / liquid biofuels and waste from renewable sources, defined as "direct or indirect biofuels produced from biomass" where biomass represents : "the biodegradable fraction of agricultural and vegetable residues (forest and wood products), residues from related industrial sectors and energy crops", this source of renewable energy represented approximately 63,5% in 2015, of renewable energy production.

At national level, the amount of renewable energy from different sources has evolved, from 2005 to 2015 it increased by 32.5%, from 4,594 (TOE) to 6,090 (TOE), of which the largest source energy is supplied by biofuels and waste from renewable sources, representing 61.9%, followed by hydropower 26.5% being well above the European Union average of 16.5%, wind energy holds a national share of 8.8% in in terms of renewable energy, this is below the European Union average of

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11.1%, solar energy accounts for only 2.3% being below the EU average of 6.1% on the last place is geothermal energy with only 0.5% under U.E. of 3.2%.

There are significant differences from one country to another in terms of the supply of renewable energy from different sources, highlighting the country's natural and climatic conditions. For example, countries such as Cyprus and Malta receive renewable energy from solar energy, with this type of energy accounting for a majority share of 66.8% and 83.1% of the total renewable energy produced in the country. In other countries where the mountainous relief prevails (Sweden, Austria, Slovenia, etc.), renewable energy is largely obtained from hydropower, this type of energy represented more than one-third of the renewable energy production in Montenegro, Turkey, Macedonia, Serbia, Norway and Albania, where the share reached almost 90%. Where there are active volcanic processes, renewable energy production is most likely derived from geothermal sources, with the best example being Italy where 23.2% of energy production is obtained from this source. In terms of wind energy, Denmark (34.4%) and Ireland (57.6%) stand out.

Although each type of renewable energy meets certain environmental and climatic conditions, we can state that at European level, agriculture and forestry play an increasingly important role in the supply of organic matter (biomass) in the production of renewable energy, in the year 2015 the production of solid biofuels from agriculture and forestry was 91 million tons of oil equivalent, 5.9% more than the energy produced in 2010 and 4.8% more than in 2014.

According to the current European legislation on the use of energy from renewable sources, adopted by co-decision (Directive 2009/28 / EC, repealing Directives 2001/77 / EC CE and 2003/30 / EC) on 23 April 2009, set the following objectives:

By 2020, the European Union's energy consumption should come from 20% renewable energy sources and all Member States must ensure that by 2020, 10% of transport fuels come from renewable sources.

## **MATERIALS AND METHODS**

One of the methods used in the work is the quantitative and qualitative analysis of statistical data provided by various national, European, or world-wide specialized sites. Analysis of existing legislation on the use of renewable energy at both national and European level, highlighting the current political framework on this subject, in particular reports and regulations of the European Commission's Directorates-General for Renewable Energy, as well as analysis of existing documents Specialty literature.

I will also use the comparative analysis highlighting the main renewable energy producing countries from the two sectors, agriculture and forestry, compared to Romania.

## **RESULTS AND DISCUSSIONS**

Primary energy obtained from biomass and renewable waste in 2015 was 130 million toe in the 28 EU Member States (representing 63.4% of total renewable energy) as can be seen in Table 1, resulting from solid biofuels (Table 2) and liquid biofuels (Table 3) used in transport, agriculture / forestry and related services.

For the year 2015, the largest share of primary energy production from renewable sources in agriculture and forestry as biomass and renewable waste from the total European Union is held by Germany, according to Table 1, it can be seen that this country holds the highest share (20.15%), followed closely by France (10.7%) and Italy (8.25%).

Table no. 1  
Primary energy production from renewable sources in agriculture and forestry  
Biomass and renewable waste

*Thousands of tons of oil equivalent - TOE*

Country / year	2013	2014	2015
European Union (28 countries)	125776	125229	130201
Belgium	2369	2252	2163
Bulgaria	1187	1171	1247
Czech Republic	3651	3793	3863
Denmark	2016	1922	2222
Germany	<b>23860</b>	<b>25493</b>	<b>26229</b>
Estonia	1075	1132	1223
Ireland	303	338	333
Greece	1073	1098	1178
Spain	6761	7036	7009
France	14418	13263	13931
Croatia	1511	1432	1584
Italy	10640	9973	10740
Cyprus	18	20	19
Latvia	1876	2188	2158
Lithuania	1186	1261	1359
Luxembourg	73	93	85
Hungary	3110	2793	3034
Malta	2	3	3
Netherlands	3788	3917	3971
Austria	5302	5079	5401
Poland	7752	7169	7473
Portugal	3099	3136	3104
Romania	<b>3824</b>	<b>3772</b>	<b>3698</b>
Slovenia	652	563	620
Slovakia	987	1014	1203
Finland	8758	8869	8750
Sweden	10633	10245	10480
United Kingdom	5852	6205	7126

Table no. 2  
Solid biofuels (excluding coal) from biomass and renewable waste

*Thousands of tons of oil equivalent - TOE*

Country / year	2013	2014	2015
European Union (28 countries)	90347	87229	91443
Belgium	1389	1104	1171
Bulgaria	1122	1087	1160
Czech Republic	2769	2842	2954
Denmark	1426	1308	1590
Germany	<b>10902</b>	<b>11425</b>	<b>12062</b>
Estonia	1067	1122	1209
Ireland	183	210	202
Greece	847	869	952
Spain	5205	5161	5260
France	10360	9078	9661
Croatia	1465	1375	1532
Italy	7448	6539	7340
Cyprus	5	7	7
Latvia	1752	2046	2009
Lithuania	1041	1117	1205
Luxembourg	46	66	55
Hungary	2683	2363	2511
Malta	:	:	:
Netherlands	1202	1290	1364
Austria	4718	4227	4474
Poland	6837	6180	6268
Portugal	2662	2671	2603
Romania	<b>3657</b>	<b>3646</b>	<b>3621</b>
Slovenia	616	533	590
Slovakia	769	760	890
Finland	8082	8117	7901
Sweden	9211	8923	9129
United Kingdom	2884	3165	3824

Table no. 3  
Liquid biofuels obtained from biomass and renewable waste

*Thousands of tons of oil equivalent - TOE*

Country / year	2013	2014	2015
European Union (28 countries)	12743	13982	13661
Belgium	462	577	392
Bulgaria	47	68	60
Czech Republic	228	261	216
Denmark	20	19	13
Germany	3156	3597	3319
Estonia	:	:	:
Ireland	22	24	24
Greece	138	142	134
Spain	877	1318	1235
France	2419	2541	2519
Croatia	30	31	15
Italy	549	614	682
Cyprus	2	:	1
Latvia	60	67	61
Lithuania	118	112	114
Luxembourg	:	:	:
Hungary	305	306	377
Malta	1	1	1
Netherlands	1,482	1,520	1,440
Austria	231	381	445
Poland	700	745	936
Portugal	274	301	321
Romania	<b>147</b>	<b>106</b>	<b>167</b>
Slovenia	2	:	:
Slovakia	148	147	149
Finland	365	406	473
Sweden	457	311	276
United Kingdom	504	390	301

Source: Eurostat; June 2017; European Commission - DG Energy; Sankey diagram dataset - annual data

At the national level, out of the total of 238,397 thousand hectares, the sum of Romania's surface, 61,4% is represented by the agricultural area and 28,3% of the area covered by forests and other lands with forest vegetation, in 2015, about 3.7 million toe from biomass and renewable waste, in this context we can see that Romania held 2.8% of the total biomass and renewable waste obtained at European level, being on the 11th place, with the smallest amount of biomass and renewable waste being Malta with only 3000 tons of oil equivalent.

From biomass and renewable waste obtained from the forestry sector, mainly biofuels are obtained, which are defined according to national and international normative documents as the most easily obtained from biomass with vegetal source, from which can be obtained sawdust (briquettes), straw, etc. by transforming cellulosic waste, they can be used in thermal plants and thus can successfully replace coal which is considered a polluting fuel.

Biomass and renewable waste produced from the agricultural sector mainly produce liquid biofuels, characterized by biodiesel and bioethanol. Obtaining biodiesel is made from oilseeds and can replace all or part of the use of petrodiesel, it can also be mixed with diesel oil. The process of producing bioethanol is a little more complex, it can also be obtained from the agricultural sector in cereal plants, but also from the pulp sector, called second-generation bioethanol.

Thus, considering both table no. 2 and Table no. 3, we can see that from the same biomass and renewable waste source the different amounts of liquid and solid biofuels are obtained, out of a

total of 130 million toe obtained in 2015 at European level, 91 million toe biofuels solids, (2%) and 13 million tons of liquid biofuels (10%), the remaining 19.78% of biomass and renewable waste being lost to biofuel production. At national level of 3698 thousand biomass toe, are produced 3521 thousand toe of solid biofuels and 157 thousand toe of liquid biofuels.

In order to determine Romania's potential for biomass production, we divided the country into eight regions according to table no. 4, where the potential of biomass, regions and total is highlighted.

Table no. 4 Potential of areas in biomass production

No.	Areas	Forest biomass 1000 t/year TJ	Wood waste 1000 t/year TJ	Agricultural biomass 1000 t/year TJ
I	The Danube Delta	-	-	-
		-	-	-
II	Dobrogea	54	19	844
		451	269	13,422
III	Moldavia	166	58	2,332
		1,728	802	37,071
IV	Carpathian	1,873	583	1,101
		19,552	8,049	17,506
V	Plateau of Transylvania	835	252	815
		8,721	3,482	12,956
VI	Western Plain	347	116	1,557
		3,622	1,603	24,761
VII	Sub Carpathian	1,248	388	2,569
		13,034	5,366	40,849
VIII	Southern Plain	204	62	3,419
		2,133	861	54,370
Total		4,727	1,478	12,637
		49,241	20,432	200,935

Table no. 5 Biomass Energy Potential for 2030

Parameter	M.U	Technical	Economic
a) Plant biomass			
Thermal / electrical energy	TJ/year	471000	289500
	1000 toe/year	11249	6915
b) Biogas			
Thermal / electrical energy	TJ/year	24600	14800
	1000 toe/year	587	353
c) Urban waste			
Thermal / electrical energy	TJ/year	22800	13700
	1000 toe/year	544	327
Total	TJ/year	518400	318000
	1000 toe/year	12382	7595

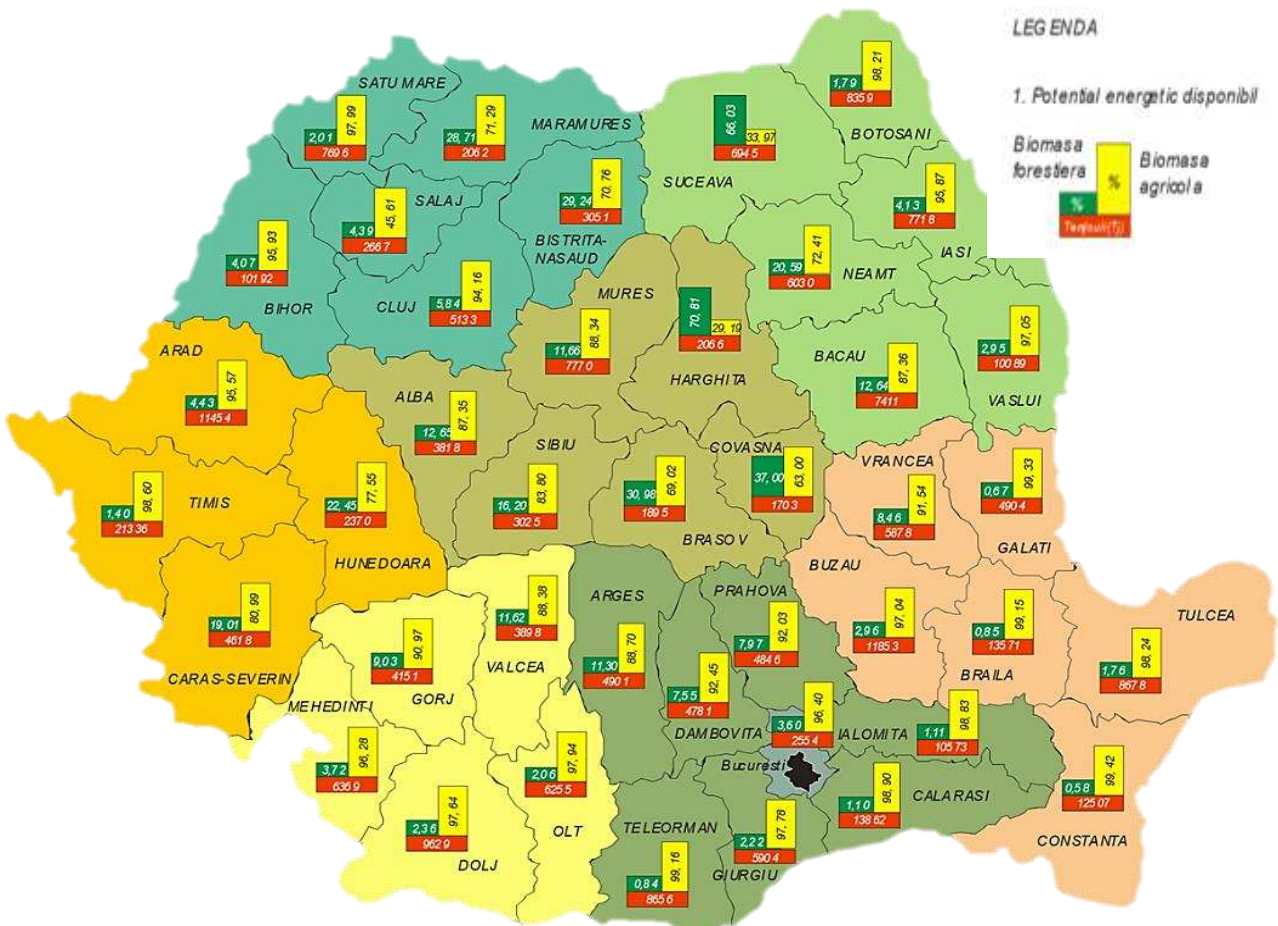
Source: INL ICEMENERG; Study on the assessment of the current energy potential of renewable energy sources in Romania (...), Identifying the best locations for developing investments in unconventional energy production (synthesis)

We find that the Sub-Carpathian region has the greatest potential in obtaining wood waste and forest biomass, with regard to the biomass obtained from agriculture, we can see that the South Plain Region is highlighted, recording the largest quantities. The total amount of biomass is of 18,842 thousand tons or 270,608 terajoule representing, by the conversion process, 6463 thousand tons of beer by 74% more than in 2015. Thus, by 2030, according to the National Institute of Research and Development for Energy (ICEMENERG Bucharest), the plant biomass obtained from the forestry and agricultural sector will produce a thermal / electric energy of 11249 thousand TOE/ year equivalent to 471000 terajoule /year.

Analyzing figure no. 1, where the geographical distribution of the vegetal biomass resources is presented, we can see that the richest counties of forest resources for the purpose of energy production are: Suceava (647 thousand cubic meters representing 66.03% of the total biomass resources obtained at county level), Harghita (206.5 thousand m<sup>3</sup> / 70.81%), Neamt (175 thousand m<sup>3</sup> / 20.59%) and Bacau (132 thousand m<sup>3</sup> / 12.64%). At the opposite pole with the poorest counties on this type of resource are the counties located in the south of the country: Constanta (10.4 thousand mc / 0.58%), Teleorman (10.4 thousand mc / 0.84%), Galați 10 thousand cubic meters / 0.67%) to mention is that in these counties the agricultural resource predominates.

The richest counties from the point of view of the agricultural resource used as biomass in energy production are Timis (1432 thousand tons / 98.6%), Călărăși (934 thousand tons / 98.9%) and Brăila (917 thousand tons, 99.15%). At the opposite pole with the poorest counties on this type of resource are the counties: Harghita (41 thousand tons) Covasna (73 thousand tons), Brașov (89 thousand tons) although at the county level the type of agricultural resource predominates, the obtained quantities are the smallest country-wide.

Figure no. 1 Romanian Energy Potential in Biomass Production



Source: INL ICEMENERG; Study on the assessment of the current energy potential of renewable energy sources in Romania (...), Identifying the best locations for developing investments in unconventional energy production (synthesis)

Biomass is a source of energy for Romania that can be successfully exploited, economically promising and with a very high potential especially due to the possibilities of use, resulting biofuels being used in agriculture and forestry, for the 2013-2015 timeframe about 52 thousand toe of solid biofuels and 4.5 thousand toe of liquid biofuels were used in these sectors. By drawing a parallel between the two types of biofuels (liquid / solid), we note that largely solid biofuels from the forest sector are used at national level.

Developing the use of biomass at national level has certain strengths but also weaknesses, so that through the following SWOT analysis we can identify these points as well as the opportunities and risks in this field.

STRONG POINTS	WEAK POINTS
<ul style="list-style-type: none"> <li>✓ Existence of large areas of unused agricultural land or degraded land for classical crops that can be used for the establishment of energy crops</li> <li>✓ Existence of large quantities of agricultural residues from classical cultures usable for energy production</li> <li>✓ Growing demand for thermal energy by reducing emissions related to energy deployment / use</li> <li>✓ Preoccupation of public authorities for the use of building heating solutions using renewable energy, especially biomass</li> <li>✓ Existence of certain associations of forest entrepreneurs</li> <li>✓ The emergence of clusters (Green Energy, ProWood, RegioFA, RenErg etc) that promote technological and innovative transfer in the field of renewable energy / biomass.</li> <li>✓ The current existence of Norwegian funds with application domains - RES use</li> <li>✓ The Structural Funds provide for all the funding areas provided as eligible actions to increase energy efficiency and renewable energy production.</li> <li>✓ Higher education institutions / research with research platforms dedicated to renewable energy eg: - Transilvania University of Brasov;</li> </ul>	<ul style="list-style-type: none"> <li>✗ Excessive use of wood waste for non-energy industrial applications;</li> <li>✗ Reduced woodland areas with sustainable management to provide an important amount of wood biomass;</li> <li>✗ The difficulty of organizing biomass feedstocks for medium / long term biomass for high power projects;</li> <li>✗ Reduced market for biomass products: briquettes, pellets - necessary for individual heating applications for dwellings;</li> <li>✗ Lack of an implemented system for the collection of agricultural waste for biomass.</li> <li>✗ Lack of studies - potential analysis of biomass by type at regional level</li> <li>✗ Hard access to high performance technologies (such as high efficiency cogeneration) for biomass use due to high prices</li> <li>✗ Insufficient funding for biomass use projects;</li> <li>✗ Lack of funding lines to support the establishment of energy crops;</li> <li>✗ Stop the "Green House" national programs devoted to the transition to heating systems using RES / biomass;</li> <li>✗ Lack of training and certification programs for installers of renewable energy systems;</li> <li>✗ Low level of staff training in town halls to identify and promote projects for the use of local biomass resources.</li> </ul>

OPPORTUNITIES	THREATS
<ul style="list-style-type: none"> <li>✓ The ever-increasing price especially for natural gas will lead the consumer towards the use of biomass</li> <li>✓ Establishment of energy crops on unused land, which can support this area</li> <li>✓ Possibility of occurring in the big cities of biomass thermal energy production systems that can be occupied by a neighborhood or block of buildings</li> <li>✓ The development of the economic environment will increase the demand for biomass necessary for industrial processes</li> <li>✓ Promotion of public-private partnerships for the implementation of pilot projects on the use of biomass</li> <li>✓ Developing technologies in the use of biomass</li> <li>✓ National support programs from European funds for the establishment of energy crops</li> <li>✓ Increasing the interest of local and foreign investors regarding a possible investment in the production and / or use of biomass-biofuels</li> <li>✓ The emergence of national programs dedicated to supporting the transition to individual or collective heating systems using biomass</li> </ul>	<ul style="list-style-type: none"> <li>✗ Increased use of wood waste for non-energy industrial applications;</li> <li>✗ Medium-term non-tariffing in Romania of the prices of electricity and natural gas at European levels will not allow the realization of investments in biomass projects;</li> <li>✗ Prevalence of export of raw or processed biomass on domestic use (eg export-oriented pellet market);</li> <li>✗ Further reducing the number of centralized heat distribution systems in cities;</li> <li>✗ The non-allocation by the central authorities of the necessary funding for programs to promote the use of biomass</li> <li>✗ Limiting access to state-of-the-art and state-of-the-art biomass technologies due to the high investment value;</li> <li>✗ Lack of a coherent policy and government strategies to promote the use of local resources for energy production.</li> </ul>

Source: Local Action Plan for Bioenergy / Biomass 2014-2020 - Central Region

With the issuance of European Directive 2009/28 / EC, Romania has set ambitious targets for renewable energy for 2020, and in order to achieve these targets, a number of strategic documents have been issued as follows:

- Romania's energy strategy for the period 2007-2020 - approved by GD no. 1069/2007, which has as a general objective the satisfaction of energy both presently and in the medium

and long term with the lowest price. The strategic objectives being given by energy security, sustainable development, environmental protection and competitiveness.

The energy strategy highlights the need for large-scale exploitation of biomass yields that cover about 50% of total energy sources at national level.

➤ Law 220/2008 on the Promotion of the Production of Renewable Energy

This law creates a legal framework for expanding the use of renewable energy sources by setting sustainability criteria for biofuels and bio liquids obtained from biomass, reducing environmental pollution by reducing emissions of greenhouse gases and greenhouse gases, stimulating sustainable local development and regional development and the creation of new jobs for the processes of capitalizing on renewable energy sources.

## CONCLUSIONS

Romania is able to develop production systems for all types of renewable energy, depending on the specificity of each geographical area in the country, but the greatest potential in the production of renewable energies is held by: biomass with 65%, wind energy 17%, energy solar 12%, 4% hydrothermal and 2% geothermal and 2% geothermal.

Biomass is the main fuel in the countryside, it has wide uses but it is mainly used in space and water heating, but this renewable energy source covers about 7% of the primary energy and reaches about 50% of Romania's renewable resources potential, this is an important solution for the production of thermal energy through cogeneration technologies, being also the most convenient solution from a financial point of view.

If all the estimated biomass quantity shown in Figure 1 could be used energetically, Romania could meet the Union 2020 target for renewable energy use.

The use of biomass at national level should be promoted and developed, especially in areas that have potential for this type of resource, national legislation on this area should be clearer and the Romanian state should support action on to the use of biomass both thermally and electrically.

This paper cannot explain enough the necessity of using renewable energies at national level, but it may increase your interest in this topic.

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