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ASSESSMENT OF BIOMASS ENERGY POTENTIAL IN KOSOVA

Final Report

Prishtina, November 2014

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CONTENT

LIST OF ABBREVIATIONS, SYMBOLS AND INDEX

Abbreviation

NFI	National Forest Inventory of Kosova
MNK	Mass unit of animals
CH4	Methane
Hu	Low Heat Value
AMMK	Environment Protection Agency of Kosova
DLG	Tree diameter on the chest level
RES	Renewable Energy Sources
NREAP	National Renewable Energy Action Plan
NFI-I	First National Forest Inventory in Kosova
NFI-II	Second National Forest Inventory in Kosova

1. EXECUTIVE SUMMARY

The structure of primary energy sources used for electricity production in Kosovo with the rate of 98% from fossil resources (coal) and only 2% from renewable sources (water) is very inadequate in the context of sustainable energy supply and context environmental implications associated with the production of electricity. Improving relations within the structure of primary energy sources will not only contribute to the stabilization of power supply but will be reflected positively in the process of fulfilling the country's obligations in relation to international institutions, primarily in relation to the requirements of the Energy Community. To address these issues the Government of the Republic of Kosovo is committed to taking the actions necessary for the production of a significant amount of electricity and thermal energy from various types of biomass. However, realization of such plans requires accurate estimates about the existing potential and undertaking special studies on technical and economic feasibility for building new power capacity based on biomass utilization. Therefore, as a first step in this direction, is contracted to draft the current study which aims to assess the potential in quantitative and qualitative terms for each of the types of biomass energy potential assessment of their cost of production evaluation forms various energy and assessing the likelihood of achieving its goals in relation to the biomass.

At the beginning of the current study it was done an analysis of the different ways of classifying biomass and it was decided that for the purposes of this study biomass will be classified by its origin. Such a classification, beside it enables more accurate assessment of the potential; it allows also the possibility of identifying the priorities and constraints for the use of such at potential.

Through the study it is made a detailed analysis of the potential of all types of biomass and for each of the types is analyzed and summarized results and presented at the end of the respective sections. It was found that in the case of biomass originating from forests, a considerable amount of biomass can be gained if it is executed annual allowable cut and if it is achieved sustainable management of existing forests for the purpose of taking cuttings (thinning) with the planned rate of cutting and with the purpose of collection of existing residues or generated residues from regular cuttings. In this way it is found that besides the potential for meeting the needs of current consumption conform 1,129,092 m^3 solid timber respectively 1,737,064 m^3 folded timber, there is possibility of using of additional wood biomass at the rate of 434.108 m^3 (solid).

Also for the biomass derived from agricultural crops it is found a considerable potential, despite having only about 30% of these crops usually is used as biomass for energy needs. Thus, within the study it was concluded that from the remains of cereals it can be produced 438.940 t/year of solid biomass, while from green plants and fodder it can be produced about 38,506,554 m^3/year of biogas.

Another type of analyzed biomass is livestock farming biomass. It was found that even after excluding the amount which is currently used for the needs of the fertilizer, the amount of remaining of fertilizer would be enough for generating 179,073,930 m^3/year of biogas.

Other types of analyzed biomass are biomass from orchards and vineyards, biomass from waste wood industry and sawmills and biomass from municipal waste (urban waste). In the relevant sections of the study is determined that from orchards and vineyards can be produced 17,356 t/year from pruning waste, from the timber industry and sawmills 40,367 m^3/year, while from urban waste it can be utilized around 264,309.08 t/year (as currently collected) respectively 606,000 t/year (if it is collected the entire generated amount).

A detailed analysis has been made about the amount of electricity and thermal energy produced in the co-generation plants using different types of biomass. Results are calculated by taking into account that the whole potential is used only for the production of electricity, or only for the production of thermal energy or for both, electricity and thermal energy.

One of the very important goals of the current study was the assessment of the cost of energy production from various types of biomass for purposes of comparison with the cost of producing energy from fossil sources. Although it is very difficult to be done such an analysis in generalized form, in this study are given orientation costs based on the cost of investment, operation and maintenance cost and cost of biomass. The results obtained show indicative values for typical technology of primary energy conversion of biomass into electricity, thermal energy or combined production (co-generation).

At the end of the study it has been made an analysis of the possibility of fulfillment of the set targets for energy production from biomass and it has determined that in case of utilizing the identified potential, even partially, the realization of such targets can be easily fulfilled.

2. INTRODUCTION

Like all other European countries, Kosovo is obliged to cover the portion of its demand for energy by using renewable energy sources. In this context, it is designed the National Renewable Energy Action Plan (NREAP 2011-2020), in which are set obligatory targets for the share of renewable energy at the level of 25 % in the total of consumed energy in 2020. However, Kosovo will aim a higher objective of 29.47% of gross energy final consumption until 2020 pursuant to the Administrative Instruction on Targets on Renewable Energy Sources. Appropriate planning of such targets requires sufficient and reliable data about the potential of using different forms of Renewable Energy Sources. In this context, it is also planned implementation of this Study which main goal is to identify the potential of all types of biomass in Kosovo, assessing the amount of electricity and thermal energy or co-generation of electricity and thermal energy, including an adequate economic analysis of existing utilization of biomass in Kosovo. The aimed final result of the study would be an evaluation of opportunities to fulfill the set targets regarding energy production from biomass, and delivering a document in connection with biomass energy potential in Kosovo.

2.1. GOAL OF THE STUDY

General goal of this study is to promote the use of biomass for energy production, and promotion of the use of Renewable Energy Sources. Preparation of an summarized study material with relevant data for the full potential of energy of all kinds of potential biomass utilization in Kosovo, so that they are usable for conducting further technical and economical studies, and for implementation of specific projects dealing with energy produced from biomass.

The main goal of the study is the evaluation of all forms of biomass that can be used for the purposes of producing electricity, thermal energy and co-generation. In this context it is intended definition of quantity and quality (calorific value) of biomass in order to prepare a relevant database with regard to its energy potential.

2.2. DISCUSSION, APPROACH AND TREATMENT OF THE PROBLEM

The importance of detailed treatment of biomass in the context of meeting the targets set about Renewable Energy Sources at the country level, in general, is discussed within the introductory section. On the other hand extended description of how this problem is addressed in the present study and the methodology used to extract, analyze and use relevant data is given at the beginning of the relevant chapters in the framework of which has become the treatment of types of certain biomass.

Depending on the adopted classification it is defined the methodology of evaluation of the energy potential of different types of biomass. The assessment methodology is based on the evaluation of existing studies, in analyzing the situation on the ground, official data and interviews with representatives of relevant institutions and companies that their activities are involved in biomass inventory situation or which have the potential for the production of biomass.

Before identifying the potential of biomass within this study, it was made classification of existing biomass in Kosovo, based on relevant international standards, literature, existing studies in Kosovo and field researches.

Based on this, biomass in Kosova could be classified as:

- Biomass from forestry
- Biomass from agriculture crops
- Biomass from orchard and vineyard
- Biomass from livestock farming
- Biomass from industrial timber residue
- Biomass from urban waste

3. BIOMASS FROM FORESTRY

There are several studies and official reports regarding the Kosova forests, their condition, management and economic utilization. Beside the large amount of data collected from these studies, they aren't adequately systemized and no consistency among data for the same issue. This is more related to the specific data for remaining after the wood cutting and natural dry of timber, rarefaction or pre-commercial cutting of timbers and low heat value of biomass timber. Having in regard the situation with these forest data, on this study are used only data from the official documents or reports and documents prepared from other companies for the need of Government institutions. More recent documents were primarily considered as source, and when there was missing of data, the studies, literature or other sources of data were used and identified as source in footnote.

Most of the necessary information regarding the forestry area, their condition, volume of timbers, growth, licensed cutting that secures sustainable development of forestry sector etc, can be found in the Report for National Forest Inventory (NFI) of Kosova prepared by Ministry of Agriculture, Forestry and Rural Development. First National Forest Inventory in Kosova (NFI-I) was prepared on 2002/2003[1] whereas second inventory (NFI-II) was prepared 10 years later, on 2013[2]. According to NFI-II, basic data for the forestry in Kosova didn't change much for 10 years period. Based on NFI-II, forest area is 481,000 ha, which is 44.7 % of total area of Kosova. From this area of forests, 38% are private property and 62% is public property. Another important data from the report NFI-II is quantity of timber with diameter on level of chest (dlg) ≥7cm, which is 40,509,000 m^3 respectively if we refer to the forest area average of timber volume is 84 m^3/ha. Type of trees and their share on the total volume of growing stock presented on Table 1.

[1] Tomter, Stein M. Inventory Document. FAO Kosovo Forest Inventory Project (OSRO/KOS/105/NOR), FAO/Norwegian Forestry Group, Pristina, December 2003

[2] Tomter, Stein M. et. al: Inventarizimi Nacional i Pyjeve të Kosovës 2012, Ministria e Bujqësisë, Pylltarisë dhe Zhvillimit Rural, Prishtinë, 2013

Table 1– Type of trees in forest of Kosova and their volume

Type of trees (in English)	Type of trees (in Latin)	Volume m³ according NFI-II
White oak	Quercus cerris	4,282,000
Sessile oak	Quercus petrea	3,669,000
Oak	Quercus sp	1,292,000
European Beech	Fagus sp	18,524,000
Other broadleaves	-	6,750,000
Silver fir	Abies Alba	1,573,000
Spruce	Picea abies	1,840,000
Pine	Pinus sp	2,502,000
Other conifer	-	77,000
Total		**40,509,000**

Determining parameter for calculation of allowed cutting of timber according to the sustainable development criteria is annual growth. According to NFI-II, annual growth of timbers with $d_{lg} \geq 7$cm is 1,556,000m^3. Long-term net maximal rate of allowed cutting for Kosova, based on the same document is 1,200,000m^3, but having considering of unavailable area (difficult terrain) and restrictions for cutting in national parks (cutting in the national parks is allowed only on selected area) this rate of cutting has to decrease. But in the document NFI-II it is not specified how much has to be the decrease of this rate, and this remains an open option. On the other document for NFI-I, the allowed level of cutting of timbers in the forests is given the figure 900,000m^3. For our study the allowed level of timber cutting is taken in consideration the value from the actual inventory of forests NFI-II, 1,200,000m^3. Having in consideration that 95% of actual consumption of wooden biomass is used as timber for fireplace at the household for heating purpose and only 5% is used as technical timber[3], therefore from total amount of allowed cutting, 1,140,000m^3 is used at households for purpose of heating while the 60,000m^3 remains to be used for purpose of wood industry. Therefore for purpose of energy needs is biomass volume 1,140,000m^3.

[3] L. Norden et. al.: Studimi i sektorit pyjore të Kosovës 2013, ORGUT Consulting AB, Sweden

Another source of biomass is from the residues from tree cutting and the dead standing trees (e.x from any tree disease). There are different data for the stock of biomass from tree residues. Based on the international literature[4], the remains from the tree cutting (branches and other tree parts) present around 21% of the gross mass of trees on the forests (the part of tree without stub and roots). The other part 75% present stub with peel that could be utilized for the need of wood industry or the firewood for household, and the remaining 4% of total mass of tree are the leaves. At this balance are not included stub and roots which from technical point of view, utilization could be used as biomass source with very high costs. Beside this, the utilization of stub and roots is not recommended because of ecology reasons[5]. On the other hand, the leaves usually are not considered as a useful source of biomass. This is not only because of their small share of the total exploitable biomass but also because of the large content of nutrients important for the sustainable development of forests and biodiversity conservation[6].

In regional studies about the potential of biomass from forests it is reported a similar share of residues from tree cutting on the total mass of cut trees, respectively between 15 up to 22%[7].

In order to evaluate the consistency of data for dead tree given in NFI-II report, in the present study it is made an assessment of residues starting from the annual cutting of forests in Kosovo reported. According to NFI-II this cut amounts to 1,600,000m^3 per year (about 33% higher to the allowed cutting). If it is considered that 21% of this amount remains at the forest area then it appears that the amount of waste in the forest every year is around 336,000m^3. Because of the difficult terrain the amount that can be used is only 80%, therefore it turns out that the annual potential of utilization of wood residues in forests is around 268,800m^3. This amount is quite close to the value of dead lying tree from the report NFI-II. But this represents the actual amount of residue, thus in the condition where cutting is happening over allowed quota of about 1,200,000 m^3.

Such a condition of forest cutting is not sustainable in the long term, therefore the potential of wood biomass from forest residues, for the purposes of the current study will be calculated based on the allowed rate of cutting. Thus, the annual wood residues that could be utilized are calculated to be in the amount 0.8 x 0.21 x 1,200,000 =201,600m^3.

[4] Richardson, J. et.al: Bioenergy from Sustainable Forestry, Kluwer Academic Publishers, New York, 2002

[5] Richardson, J. et.al: Bioenergy from Sustainable Forestry, Kluwer Academic Publishers, New York, 2002

[6] European Environment Agency: Environmentally compatible bio-energy potential from European forests, Copenhagen, 2007

[777] A. Vasiljevic: Potentials for forest woody biomass production in Serbia, Thermal Science Journal, Beograd, 2014

On the other side, the dead standing trees reported in NFI-II in quantities of 556,000m^3 can be calculated as the potential of wood biomass. But, for the planning of new energy potentials, it is reasonable to consider that such potential can't be used immediately, but within a (10) year period which corresponds to the period between forest cleaning and pre-commercial forest cutting. Therefore, for the purposes of this study, potential of annual dead standing trees is considered to be 55,600m^3.

Another source of wood biomass from forests represent trees obtained through cleaning (release) is pre-commercial cutting which is expected to be taken in periods of (10) years in order to create conditions for normal development of forests. Pre-commercial cutting is usually recommended for forests younger than (20) years. The forest area younger than (20) years in Kosovo reported in PCI-II is 144.400 ha, but in the same document it is emphasized that the forest area which needs a kind of forestry (cutting care) is 119,400ha. The amount of wood biomass that can be gained from such a process depends on many factors such as the condition of the forest, the type of trees, their annual growth etc. In official documents are not provided such data, but the study of the World Bank-PROFOR[8] program is that the average volume that can be obtained from pre-commercial cutting is 14m^3/ha. Therefore, the total volume that can be obtained from pre-commercial cutting is 119,000 x 14 = 1,666,000m^3. Assuming that such a cut through a good management will be implemented gradually within a period of (10) years, it results that every year in Kosovo could be gained 166,000m^3 of wood biomass from pre-commercial cutting.

The total annual amount of biomass wood that can be gained through appropriate management of forests in Kosovo is presented in Table 2.

Table 2 – Biomass potential from forests

Type of biomass from forests	Quantity (m^3/year)
Biomass available by allowed cutting	1,140,000
Lying timber residues	201,600
Dead trees standing	55,600
Pre-commercial cutting	166,000
Total	**1,563,200**

[8] Hajredini, E. Kampen, P.: Analiza mbi prodhimin aktual dhe potencialin e biomasës drusore, CNPV, WB-PROFOR, Prishtinë, 2013

Regarding the potential presented in Table 2 it must be noted that, based on official reports for the period 2010-2011[9] the consumption of biomass from forests in the form of fire wood is 1,737,064m^3 folded timber or 1,129,092m^3 solid timber (about solid timber see explanations in section 3.1). Consequently, the net potential for utilization of wood biomass for construction of new power capacity is 434,108m^3.

3.1. FORESTRY BIOMASS ENERGY POTENTIAL IN KOSOVA

The key indicator in relation to the energy potential of a certain type of fuel is their low heat value. This is a parameter that indicates the amount of energy or heat that can be released as a result of the combustion of specific fuel. Heat of combustion (calorific value) of fuels can be expressed through high heat value and low heat value of combustion. For the purpose of assessing the energy potential of various materials usually it is used low heat value of combustion Hu (kJ/kg)[10]. Heat of combustion of wood depends on the type of wood but mostly from moisture content in wood. The moisture content of fresh wood (newly cut) varies between (50-60)%, while by standing in open space with good ventilation by air, the moisture content can be reduced significantly. As much as the wood is dried, respectively as small is the content of moisture in the wood, the greater will be the heat that can be released during its combustion. Despite the fairly frequent cases of burning of trees relatively fresh, relevant studies have shown that about 50% of customers supplied with firewood 2-6 months before the heating season[11], therefore this time can be regarded as having been the time of their natural drying. On the other hand, during natural drying of wood in a period of about 3-8 months his relative humidity level drops to 30%[12]. Consequently, given that 95% of the volume of timber cut in Kosovo is used as firewood, it can be considered that representative moisture for calculating combustion heat of woods in order to evaluate the consumed energy from households is 30%. However, in the case of planning the construction of large power plants ex. district heating plants or plants for co-generation, fuel must be adequately prepared before is injected in the combustion process. Therefore, to assess the energy potential within the current study will be considered that the moisture content of wood biomass is 20%. Based on Annex I, density of wood with a moisture content of 20% is 714 kg/m^3 and low heat value of combustion is 14,026kJ/kg.

[9] ECn: Biomas Consumption Survey for Energy Purposes in the Energy Community, UNMIK National Report, 2009/2010 & 2010/2011

[10] N. Sahiti, M. Pireci, B. Veselaj: Doracaku për burimet e ripërtëritshme të energjisë, UNDP, Prishtinë, 2013

[11] Opalic, T., Safar, L.: Study on firewood and other wood biomass use by population-Household Survey, Regea&CNPV, WB-PROFOR, Prishtinë, 2013

[12] LfU: Holzhackschnitzel-Heizanlagen, Karlsruhe, 2001

Another issue that was taken into consideration in determining the low heat value of combustion is the type of forest trees Kosovo. Based on the structure of the standing volume of trees presented in PCI-II, is calculated weighted average of the low heat value of combustion of wood in Kosovo. Low heat value of combustion calculated in this way for trees with moisture of 30% is 11,967 kJ/kg (see Annex I). Since the amount of trees in the respective studies presented in m^3, is also necessary that the heat of combustion is expressed in this unit. For this reason it is first necessary to know the density of trees at appropriate moisture. The density of trees depends on the type of wood and mostly from the moisture content of wood. Therefore, similar as in the case of the combustion heat, for the purposes of this study, the density is determined based on the structure of the standing trees. In this way, the relative moisture of 30% it is calculated that the average value weighted of density of the trees in Kosovo is 798 kg/m^3.

However, during the conversion of combustion heat into unit volume, it has to be taken into account that the PCI-II and forestry statistics generally refers that the m^3 is the mass of pure wood (solid) while in the market quantity of wood is evaluated in m^3 folded spatial trees. The conversion factor from solid m^3 in space m^3 depends on the size, form and method of folding the trees. For the purpose of the current study is considered to $1m^3$ folded trees (m^3 spatial) $=0.65m^3$ of wood mass (solid)[13].

3.2. ASSESSMENT OF QUANTITY OF ENERGY THAT WOULD BE PRODUCED FROM BIOMASS FROM FORESTRY

3.2.1. ELECTRICITY

There are various facilities for the production of electricity using forest biomass energy as the primary energy, but the most prevalent form of the plant is equipped with boiler with furnace and combustion moveable grate and steam turbine which works on the principle of condensation. Similarly as in the case of the use of coal for electricity production, the amount of electricity that can be produced by the burning of forest biomass depends on the efficiency of the whole plant and the quality of the fuel. On the other hand the efficiency depends on the quality of the development process of combustion and a range of other factors such as optimal dimensioning of equipment, selection of modern technology and installation of a modern control and regulating system of process. In professional studies it is evaluated that efficiency of the plant for production of electricity from biomass and biogas ranges between 30

[13] L. Norden et. al.: Studimi i sektorit pyjore të Kosovës 2013, ORGUT Consulting AB, Sweden

and 40%[14]. For the purpose of the present report, the value of the efficiency of these plants will be considered to be 35%.

The quality of the fuel as another important parameter with influence on the amount of produced energy depends primarily from content of moisture of biomass of wood but also by its size and shape. Since in this case it is about facilities with large capacity of power and based on the explanations given in the previous section it can be considered that low heat value of combustion of forest biomass to be 14,026 kJ/kg.

The electricity that can be produced through the burning of wood biomass can be determined by the following expression:

$$E_{el} = m_{ld} \cdot H_u \cdot \eta \qquad (1)$$

Were:

E_{el} (kWh) - electrical energy,

m_f (kg) - mass (quantity) of fuel,

Hu (kJ/kg) - low heat value,

η (-) - efficiency of the power plant

The quantity of fuel in kg can be measured based on the available volume and density of wood biomass, and then doing an adequate transformation of units, from the expression (1), it can be determent that the amount of electricity that can be produced from biomass wood is E_{el} = 423,002,249 kWh/year = 36.38 ktoe/year.

3.2.2. THERMAL ENERGY

Available forest biomass can be used in any plant for district heating in order to gain thermal energy to meet the needs of heating for several buildings along or of any particular settlement. Similarly as in the case of plants, even in the case of plants for district heating amount of produced thermal energy depends on the efficiency of the plant and the quality of the fuel. Plant efficiency depends primarily by the efficiency of the boiler used for burning of biomass, and on the other hand this depends on the form of combustion process but also by other factors. For the purpose of the current study it will be considered that efficiency of district heating plant is equal to 85 %[15]. Having in regard that the values for Hu and m_{ld} are the same as in section 2.2, from

[14] EURELECTRIC&VGB: Efficiency in Electricity Generation, July 2003
15 FNR: Leitfaden Feste Biobrennstoffe, 2014

equation (1) it can be found the amount of thermal energy that can be produced from wood biomass E_{th}=1,027,291,176 kWh/year = 88.35 ktoe/year.

3.2.3. ENERGY FROM CO-GENERATION

Co-generation or otherwise known as co-generation means technological process in which from the same source of energy it can be produced both electricity and thermal energy. Depending on the type of biomass, co-generation technologies vary from case to case, but in the case of wood biomass, so far in practice have been proven power plants combined with the steam turbine. In the context of such power plants, in the boiler is made the burning of wood biomass and energy released from the combustion process is used to evaporate the water. Then steam is used for rotation of turbine blades-rotor which is coupled with the rotor of generator of electrical energy. After steam expansion in the turbine, the steam enters to the condenser where remaining heat is transmitted to the working fluid which is needed for heating needs of any settlement or needs of any industrial process.

Co-generation power plants are characterized by high energy efficiency compared with total efficiency of separate production of electricity or thermal energy. Although in these systems the efficiency of electricity generation is around 20% and the efficiency of thermal energy is about 60%, the total co-generated energy efficiency is 80%.

Based on equation (1), it appears that the total generated energy by co-generation is E_{co} = 966,862,282 kWh=83.15ktoe. On the other hand, the amount of electricity that can be produced from cogeneration is $E_{el,co}$=241,715,571kWh = 20.79ktoe, and the amount of thermal energy is $E_{th,co}$ = 725,146,712kWh = 62.36ktoe.

3.3. SUMMARY OF PRODUCED ENERGY FROM FORESTRY BIOMASS

A summary of the quantities of electricity, thermal energy and produced energy by cogeneration by using forest biomass as the primary energy source is presented in the Table 3.

Table 3– The annual amount of electricity, thermal and co-produced energy from forestry biomass

Quantity of biomass from forestry (m^3)	Amount of electrical energy (ktoe/year)	Amount of thermal energy (ktoe/year)	Amount of energy from co-generation (ktoe/year)	
			Electrical	Thermal
434,108	36.38	88.35	20.79	62.36
1,563,200*	131	318.13	74.85	224.56

* The amount of energy that could be produced if it's taken into consideration the total biomass which includes also the consumption of trees for firing.

4. BIOMASS FROM AGRICULTURE CROPS

In principle there are two possibilities of using agricultural crops for biomass production:

- Production of biomass from agricultural residues (straw, corn stalk etc.)
- Production of biomass from fruit crops (wheat, barley, corn, etc.)

Having in regard the country's potential to meet the needs for food manufacturing and beverage and current technological development, biomass production from fruit crops is not currently realistic option for Kosovo. Therefore in relation to agricultural crops as potential source for biomass production remains just use of their waste-residues.

Crops that are commonly cultivated in Kosovo that could have potential for producing biomass plants consist of group cereal plants (wheat, rye, barley, oats and corn) and the group of plants and crops harvested fodder in the green condition (green wheat, green rye, hay, grass, etc.). Assessing the amount of waste that can be obtained by cereal plants usually is done based on the ratio between the amounts of fruits and measures the respective plant. Based on such report in the relevant studies reported in the region[16] and production reported in 2013[17], the data were extracted for total production of biomass from waste of cereal plant in Kosovo, Table 4.

Table 4 – Cereal plants, wheat production and biomass from their waste in 2012

Type of cereals	Area (ha)	Wheat production (t/year)	Mass of fruits/ Mass of plant	Mass of waste from cereals (t/year)
Wheat	102,918	345,027	1:1	345,027
Rye	253	740	1:1.2	888
Barley	568	1,808	1:1	1,808
Oat	2,294	4,913	1:1	4,913
Corn	22,758	60,353	1:1	60,353
Corn (mixed)	8,423	25,951	1:1	25,951
Total	**137,214**			**438,940**

[16] J. Petrovic: Uspostavljenje Berze Biomase u AP Vojvodini, Fakultet Technickih Nauka, Novi Sad, 2012
[17] ASK: Anketa e Ekonomive Shtëpiake Bujqësore 2012, Prishtinë, 2013

Although total biomass that can be obtained from the waste of cereal plants is 438,940 t/year, it can't be utilized completely for energy production. This is because some part of it is used for livestock feed, another part of it is used for litter as bedding for animals (which later can be sued as soil for fertilization) and another part of it is used for industrial needs. In the general case, the percentage of waste from cereal plants that can be used for energy needs ranges between 10-40 %[18]. Having in regard insufficient industrial development, in Kosovo it can't currently expect any widespread use of such residues for industrial needs; therefore it can be considered that about 30% of waste from cereal plants could be used for energy needs. Such an amount is consistent with data reported in the regional resource[19,20]. Consequently, Kosovo annual potential production of biomass originating from residues of cereal plants that currently could be used for energy production is **131,682 t/year**.

As for the other agriculture crops such as fodder and green cereal, those are currently used mainly for animal feeding. But technically there is a possibility for such plants to be used for biogas production, therefore, by assuming that at a future in Kosovo could create organizational and legal opportunities for the development of such systems, it is reasonable to assess the current study to be given basic data about this group of crops that could be used for initial planning of their possible energy potential. Along other values in the Table 5 are presented wasteland area of land which in the case of cultivation could also provide a certain amount of biomass potential. The values presented in the table are taken from the source[21,22].

[18] M. Kaltschmitt et. al: Energie aus Biomasse, Springer, 2009
[19] J. Petrovic: Uspostavljenje Berze Biomase u AP Vojvodini, Fakultet Technickih Nauka, Novi Sad, 2012
[20] B. Labudovic: Obnovljivi izvori energije, EM, Zagreb, 2002
[21] ASK: Anketa e Ekonomive Shtëpiake Bujqësore 2012, Prishtinë, 2013
[22] FNR: Biogas Basisdaten Deutschland, 2008

Table 5– Green cereal, fodder plants and the wasteland

Types of green cereal, fodder plants and wasteland	Area (ha)	Production (t/year)	Specific production of biogas (m^3/t)	Biogas production (m^3/year)*
Green wheat	141	456	172	69,020
Green Oat	860	2,904	172	439,549
Green Corn	2,511	28,006	202	4,978,347
Hay (meadow)	72,048	166,519	172	25,204,316
Grass	3,677	8,980	172	135,921
Lucerne	13,330	46,828	172	7,087,886
Clover	1,328	3,908	172	591,515
Wasteland	17,865	-	-	-
Total	**111,760**	**257,601**		**38,506,554**

* It has been taken into consideration the loses of biomass on the silo (silage) on the amount of 12%

Similarly as in the case of cereal plants, taking into consideration that even in the case of green cereals and fodder crops, about 30% of them could be used for energy production of biogas production, resulting that biomass quantity that will actually be can be used for energy production from this type of crop is **77,280t/year**, respectively quantity of produced biogas would be **11,551,966m^3/year**

But, if the whole amount of biomass produced by the agriculture crops would be designated for the production of various forms of energy, then the total biomass of all crops presented in Table 4 and 5 that could be used for this purpose is **696,541t/year**.

4.1. ENERGY POTENTIAL OF BIOMASS FROM AGRICULTURE

Wastes from agricultural crops or cereal plants adequately preserved can be used for meeting energy needs. Besides the quantity, the energy potential also depends on their heat of combustion which in turn depends on the moisture content. The waste of cereals (straw) which is good preserved is characterized with the moisture content around 15% in the equilibrium condition[23]. Low heat value of such waste of cereals is presented on the Table 6.

Table 6 – Low heat value of waste from agriculture cereals[24]

Type of cereal plant	Low heat value Hu (kJ/kg)
Wheat	14,000
Rye	14,000
Barley	14,200
Oat	14,500
Corn	13,500

The use of fodder and green cereals for energy production can be done by setting the substrate of such plants in the respective bioreactor with purpose of fermentation and to produce biogas which is then used as fuel in power plants for production of different forms of energy. Low heat value of combustion for biogas produced in this way has the value of (Hu = 21,600 kJ/m^3=6 kWh/m^3)[25].

4.2. ASSESSMENT OF AMOUNT OF ENERGY THAT COULD BE PRODUCED FROM AGRICULTURE BIOMASS

Energy from biomass originated from agricultural crops can be obtained in two forms:

1. Through the burning of solid biomass (straw and mocking) that remains after the collection of cereal
2. Through the burning of biogas produced from green cereals

4.3. ENERGY THAT COULD BE GAINED FROM BURNING OF AGRICULTURE BIOMASS

In order to reduce the costs for transport and storage as well as for the purpose of efficient combustion, it is recommended biomass that originate from agricultural crops in the form of compressed pellets of cylindrical or prismatic shape with different dimensions, depending on the used technology for compressing. For example, in the case of cylindrical shape of compression, dimensions could be: the

[23] M. Martinov et.al: Program za ocenu ekonomskih pokazitelja za energetsku primenu biomase, Fakultet Technickih Nauka, Novi Sad, 2011
[24] D. Gvozdenac: Razvoj trzista biomase u Vojvodini, Fakultet Technickih Nauka, Novi Sad, 2010
[25] FNR: Biogas Basisdaten Deutschland, 2008

diameter = 60cm, length = 120cm, whereas in the case of prismatic shape compression, the dimensions could be: the width = 120cm, the length = 200cm and the height = 85cm.

The process of burning biomass derived from agricultural crops is characterized by significantly higher emission of harmful particles and ash compared to the amount of these substances that can be emitted respectively generated during combustion of forest biomass. A result of this is that the combustion technology biomass differs between each other but not that much in terms of their efficiency[26]. Therefore it can be considered that the efficiency of the equipment for the production of electricity, heating and cogeneration from biomass originating from agricultural crops is the same as the efficiency of these devices in case of forest biomass.

4.3.1. ELECTRICITY

The amount of electricity that can be produced through the burning of biomass derived from agricultural crops can be calculated according to equation (1). Based on the identified potential for production of 131,682 t/year, considering that the lower heat value of biomass from crops is 14,000 kJ/kg and the efficiency of power plant for producing electricity is 35%, than it can be found that during the year it can be produced 179,377,220 kWh = 15,43 ktoe.

4.3.2. THERMAL ENERGY

Similarly, as the biomass from forest, the biomass from agricultural crops can be used in any plant for district heating in order to gain thermal energy to fulfill the needs for heating of some blocks of buildings together or any particular settlement. Work efficiency of these plants is about 85%, while other necessary variables for calculation of produced thermal energy are identical with the ones of the previous paragraph. Therefore, it can be concluded that thermal energy which can be produced within the year has the value of 435,630,392 kWh = 37.46 ktoe.

4.3.3. ENERGY FROM CO-GENERATION

Combined production of energy or as it's known co-generation in principle is developed similar as in the case of burning wood biomass, therefore also in this case it can be considered that the total efficiency of the cogeneration energy is 80% while the efficiency of electricity production is 20% respectively thermal energy is 60%.

[26] Th. Launhardt: Umweltrelevante Einflüsse bei der thermischen Nutzung fester Biomasse in Kleinanlagen, Dissertation, Universität München, 2002

Consequently, it can be calculated that the total energy generated by co-generation is E_{co} = 410,005,075 kWh = 35.26ktoe, were the amount of electricity is $E_{el,\ co}$ = 102,501,269 kWh = 88.15ktoe, while the amount of thermal energy is $E_{th,co}$ = 307,503,806 kWh = 26.44ktoe

4.4. SUMMARY OF ENERGY PRODUCED FROM COMBUSTION OF BIOMASS ORIGINATED FROM AGRICULTURE CROPS

A summary of the quantities of electricity and thermal energy produced by co-generation through biomass burning originated from agricultural crops is presented in the Table 7.

Table 7 – Annual amount of electricity, thermal energy and co-generation produced from combustion of biomass originating from agriculture crops

Quantity of biomass from agriculture crops (ton)	Amount of electricity (ktoe/year)	Amount of thermal energy (ktoe/year)	Amount of co-generation energy (ktoe/year)	
			Electricity	Thermal energy
131,682	15.43	37.46	8.815	26.445

4.5. ENERGY THAT COULD BE GAINED FROM COMBUSTION OF BIOGAS PRODUCED FROM GREEN CEREAL

Biogas produced through the fermentation process of green cereal it is a fuel which in principle can be used to produce electricity, heat and fuel for driving the vehicle. However, the most common form of the use of biogas in Europe is its use as an energy source for the combined production of electricity and thermal energy. The use of biogas for co-generation of energy presents the most economical form of use of this fuel. The rate of use of modern generators for co-generation of energy is up to 90%, where the efficiency of electricity generation is around 40%, whereas the thermal efficiency is about 50%[27,28].

Utilization of thermal energy produced in the generator of co-generation represents an important element for the economic performance of these equipments. One part of the thermal energy, about 1/3 can be used for heating the substrate in fermentor (bioreactor) and the reservoir for mixing. The remaining 2/3 of produced thermal

[27] T. Al Seadi et. Al: Bioplin prirucnik, 2008

[28] J. Messner: Wärmenutzung in landwirtschaftlichen Biogassanlagen, LVVG Aulendorf

energy, in principle, can be used to heat complex of buildings or certain settlements. However, considering that biogas production plants typically are built in locations away from the settlements, the use of thermal energy for heating needs is usually not profitable due to the high cost of infrastructure for district heating. Therefore, thermal energy usually it's used for space heating of farms or management facilities when they are near the plant for biogas production.

The amount of electricity and thermal energy produced from co-generation by combustion of biogas originating from green cereals is presented in the Table 8.

Table 8 – Annual amount of electricity and thermal energy from co-generation from biogas originating from green cereals

Biomass (ton/year)	Biogas (m^3/year)	Co-generated energy (ktoe/year)	
		Electricity	Thermal energy*
77,280	11,551,966	2.39	1.83

*The amount of thermal energy that remains after 1/3 of generated energy is used for self consumption of bioreactor.

5. BIOMASS FROM ORCHARDS AND VINEYARDS

Details about the types of fruit trees and grape and planted area with these cultures is provided by the Statistical Office of Kosova[29] , while the value of specific residues as a result of pruning trees and vineyards are provided by the relevant literature[30]. Summary results for the planted areas with trees and grape and annual pruning residues are presented in Table 9.

Table 9– Type of fruit trees and grape 2012

Type of fruit trees/grape	Area (ha)	Production (t/year)	Reside form the pollard (t/ha)	Residues from annual pollard (t/year)
Apple	1,725	8,120	3.399	5,863
Pear	326	1,562	3.399	1,108
Quince	52	506	3.399	177
Medlar	16	66	3.399	54
Plum	1,404	17,514	3.399	4,772
Apricot	22	83	3.399	75
Peach	39	173	3.399	133
Cherry –sweet	50	167	3.399	170
Cherry – sour	107	1,175	3.399	364
Walnut	57	234	3.399	194
Hazelnut	2	2	3.399	7
Grape for vine	510	7,182	3.020	1,540
Grape for table	960	8,689	3.020	2,899
Total	**5,270**	**45,473**		**17,356**

5.1. ENERGY POTENTIAL FROM ORCHARD AND VINEYARD BIOMASS

Branches that can be gained from the process of paring trees and vineyards may represent a valuable energy potential if collected and stored in a convenient location. Naturally, for this type of biomass, its energy value depends on the moisture content. Remains from paring of orchards and vineyards well preserved

[29] ASK: Anketa e Ekonomive Shtëpiake Bujqësore 2012, Prishtinë, 2013
[30] D. Gvozdenac: Razvoj trzista biomase u Vojvodini, Fakultet Technickih Nauka, Novi Sad, 2010

are characterized with moisture of about 14% in equilibrium[31]. Low heat value of combustion of such remains is given in the Table 10.

Table 10 – Low heat value from biomass from orchards and vineyard

Origin of biomass	Area (ha)	Yearly debris from pollard (t/year)	Low heat value Hu (kJ/kg)
Orchards	3,800	12,917	14,150
Vineyards	1,470	4,439	14,000
Total	5,270	17,356	14,075*

*Average value

5.2. ASSESSMENT OF AMOUNT OF ENERGY THAT COULD BE PRODUCED FROM BIOMASS ORIGINATED FROM ORCHARDS AND VINEYARDS

The chemical composition of biomass originating from orchards and vineyards is similar to wood biomass, therefore in principle it can be used the same technology to produce electricity, thermal energy or for the combined production of energy. Similar chemical composition influences the heat of combustion to be approximately the same for both types of biomass in question. Therefore, by using the same procedures and by acquiring the low heat value 14,075 kJ/kg, are calculated quantities of the respective energies that can be gained by utilizing the combustion of biomass from orchards and vineyards. Results are presented in the Table 11.

Table 11 – Annual amount of electricity, thermal energy and co-generation energy from biomass form orchards and vineyards

Biomass from orchards and vineyards (ton/year)	Electricity (ktoe/year)	Thermal energy (ktoe/year)	Co-generation (ktoe/year)	
			Electricity	Thermal energy
17,356	2.05	4.97	1.17	3.51

[31] D. Gvozdenac: Razvoj trzista biomase u Vojvodini, Fakultet Technickih Nauka, Novi Sad, 2010

6. BIOMASS FROM LIVESTOCK FARMING

One of the possible sources of biomass for energy production is also the waste of various animals in livestock farms. By applying the appropriate technology, from such waste it can be produced biogas which afterwards can be used as fuel to produce electricity or thermal energy. The quantity and quality of biogas produced depends on the type of animal and the amount of waste. The necessary information about the type of animal and the number of farms in Kosovo was provided by the Statistical Office of Kosova[32] (Table 12). However, to calculate the potential for the production of biogas, besides the type and number of animals it is required to know the other parameters such as the amount of waste for each animal daily, the reference values of the amount of biogas that can be produced per unit of waste from animals etc. In the absence of such data in local documents, values are extracted from the literature. One of the basic parameters for the extraction of the necessary data is conversion factors of weight of animals to weight unit of animal (MNK). MNK serves as the comparison factor between live animals of various sizes and corresponds to the weight of 500kg. Live weight for the majority of animals was taken from the literature[33], while for a smaller portion of animals the live weight is taken from the source [34] which represents the average weight of the respective animals (measure which takes into account the number and different age of specific type of animal). In the Table 12 are presented different kinds of animals and the number of MNK to the types of animal.

[32] ASK: Anketa e Ekonomive Shtëpiake Bujqësore 2012, Prishtinë, 2013

[33] Detaillierter GV-Schlüssel des Sächsischen Landesamtes für Umwelt, Landwirtschaft und Geologie - Teil Rinder, 2014 (http://www.landwirtschaft.sachsen.de/landwirtschaft/2217.htm)

[34] Brkic, M., Janjic, T: Nova procena vrsta i količina biomasa vojvodine za proizvodnju energjie, Savremena Poljoprivredna Technika, Vol. 36, No. 2, 178-188, 2010

Table 12 – Calculated number MNK for different kinds of animals

	Number	Live weight of animals	Total o live weight	Number of MNK	Number MNK for different kinds of animals
Cattle	313,843				
Calves younger than 6 months	57,966	110*	6,376,260	12,7	277,277,519
Calves between 6 months up to 1 year	43,926	225*	9,883,350	19,7	
Calves between 1 year up to 2 years	21,722	400*	8,688,800	17,3	
Calves older than 2 years	5,439	500*	2,719,500	5,43	
Milky cow	183,340	600	110,004,000	220	
Bulls	1,450	750	1,087,500	2,1	
Pigs	55,775	60	3,346,500	6,6	6,693
Sheep and goats	122,872				11,746
Lambs	14,510	34**	493,340	987	
Sheep for reproduction	93,851	50	4,692,550	9,38	
Ram for reproduction	2,393	110	263,230	526	
Goat	12,118	35	424,130	848	
Horses	2,139	400	855,600	171	1,711
Poultry (hen and other poultry)	2,318,037	1.5	3,477056	695	6,594

*Average value between weight of calves of dairy cow and calves of meet cow

**Average value of weight of lambs for different age

In relation to the amount of manure that can be produced by animals, data from the literature show a large discrepancy of the values as well as the type of fertilizer that refer (solid, liquid, organic mass of fertilizer etc.). The figures presented in Table 13 refer to the solid manure with a participation of dry mass produced fertilizer by about 25%.

Table 13 – Production of manure from animals[35,36]

Kind of animals	Number MNK per kinds of animals	Daily manure production per MNK (kg/MNK)	Annual manure production for kinds of animals (t/year)
Cattle	277,519	40	4,051,777
Pigs	6,693	25	61,074
Sheep and goat	11,746	35	150,055
Horses	1,711	23	14,364
Poultry	6,594	44	105,900
Total manure production			**4,383,170**

From the data presented in Table 13, results that total potential for manure production from cattle in Kosovo is 4,383,170t/year. However, based on official statistics[37], for the needs of fertilizing the agricultural land it is consumed 568,017t/year of organic manure. That means for energy needs it can be utilized only 87% of total organic manure produced or about 3,813,358t/year.

6.1. ENERGY POTENTIAL OF BIOMASS FROM LIVESTOCK FARMING

The potential of biomass production from livestock depends on the number of animals and their species, and the energy potential of a given quantity of biomass by livestock depends on the amount of biogas produced and its quality, respectively from the content of methane (CH4) in produced biogas. For the purpose of calculating of the total amount of biogas that can be produced in Kosovo, it is considered that from each type of organic manure, for biogas production can be used only 87% of the total produced quantity. The calculated values based on the reference values obtained from the relevant literature[38,39,40] are presented in Table 14.

[35] Rühlmann, O:. Wirtschaftsdünger, effektiv und umweltschonend lagern und einsetzen, LUFA Sachen-Anhalt, 2000
[36] Jäkel, K., Mau, S.: Biogaserzeugung und –verwertung, Sächsische Landesamt für Umwelt,2003
[37] ASK: Anketa e Ekonomive Shtëpiake Bujqësore 2012, Prishtinë, 2013
[38] Umweltbundesamt GmbH: VERGÄRUNG VONWIRTSCHAFTSDÜNGERN IN BIOGASANLAGEN, Wien, 2012
[39] FNR: Biogas Basisdaten Deutschland, 2008
[40] D. Deublein, A. Steinhauser: Biogas from Waste and Renewable Resources, Wiley-VCH, Weinheim, 2011

Table 14 – Annual amount of produced biogas and its energy potential

Kind of animal	Utilized quantity of manure (t/year)	Biogas production per ton of fresh fertilizer (m^3/t)	Biogas production per animal (m^3/year)	Average low heat value Hu (kJ/m^3) [29]
Cattle	3,525,046	45	158,627,070	**21,600**
Pigs	53,134	60	3,188,040	
Sheep and goat	130,548	70	9,138,360	
Horses	12,497	60	749,820	
Poultry	92,133	80	7,370,640	
Total	**3,813,358**		**179,073,930**	

6.2. ASSESSMENT OF AMOUNT OF ENERGY THAT COULD BE PRODUCED FROM BIOMASS ORIGINATED FROM LIVESTOCK FARMING

The chemical composition of biogas produced from livestock farming is approximately the same as the biogas produced from green cereals. Therefore, in principle, forms of energy generation – electricity, thermal energy or co-generation used from the biogas utilization from green cereals could be applied also for the biogas produced from livestock farming. Therefore, by using the same procedures are calculated amounts of respective energy that could be gained by combustion of biogas from livestock farming. Results are presented in the Table 15.

Table 15– Annual amount of electricity, thermal energy and co-generation from the biomass originated from livestock farming

Biomass (ton/year)	Biogas (m^3/year)	Co-generation (ktoe/year)	
		Electricity	Thermal energy*
3,813,358	179,073,930	36.99	28.36

*Amount of thermal energy that remain after using 1/3 of energy for self-consumption of bioreactor.

7. BIOMASS FROM WASTE OF INDUSTRIAL TIMBER

Although only 5% of the total quantity of timber from the forests of Kosovo is used for the production of industrial timber[41], in Kosovo there are a significant number of wood processing enterprises. From different activities of such enterprises, respectively in various stages of wood processing, are formed unusable residues (waste – shavings or chaff). Such waste, depending on the amount, may represent a significant source of energy production. On the other hand the amount of wood waste from industrial enterprises depends on the structure of such enterprises and the ways of managing them. While before the war woodworking sector dominated by a few large companies with public ownership, today in this sector operates over 1,400 enterprises of which 120 are medium or large. The main activity of such enterprises is the use of wood for the manufacture of doors, windows, furniture etc. There is also a very limited number of sawmills enterprises with a saw capacity of up to 100,000 m^3 of timber, which is considered below international standards. Therefore currently more than half of the saw timber in Kosovo is imported from neighboring countries.

In the absence of data on the amount of waste that may occur in wood processing enterprises, for the purpose of the current study was conducted a survey of a selected number of such enterprises. The key questions for which is requested a response through a survey, was the quantity of big scrap form wood waste, the quantity of tiny waste, quantity of waste used by the enterprises itself and the forms of utilizing them.

A total of 50 companies were surveyed of which 20 belong to the category of medium or large sized enterprises and 30 belong to category of small enterprises. The survey showed that small enterprises do not have the potential for producing wood waste that can be used for energy needs, since the quantity produced is small and it's for self-consumption. While the amount of waste from medium and large wood processing enterprises partly it is used for their own needs to produce briquette, pellet or as firewood while another part waste is offered for sale therefore it can be considered as potential for energy production. The amount of waste from medium and large enterprises that can be used for energy production is presented in Table 16.

[41] L. Norden et. al.: Studimi i sektorit pyjore të Kosovës 2013, ORGUT Consulting AB, Sweden

Table 16 –Annual waste from timber processing industry

Large and medium enterprises for timber processing					
Numbe	Residues in unit for enterprises		Annual residues by type		Residues (m^3/year)
	Large scrap (m^3/year/enter)	Small scrap (m^3/year/ enter)	Large scrap (m^3/year)	Small scrap (m^3/year)	
120	13.30	166.84	1,596	20,021	**21,617**
Sawmill Industry					
Average amount of processed timber (m^3/year)		Residues in percentage (%)		Residues (m^3/year)	
75,000		25		**18,750**	
Total residues				**40,367**	

Conversion of amount of residues from m^3 into tons can be calculated by multiply amount in m^3 with the average density of residues 375kg/m^3, taken from literature[42].

7.1. ENERGY POTENTIAL OF BIOMASS FROM WASTE OF INDUSTRIAL TIMBER

Energy potential of biomass from industrial timber residues, aside from the quantity also depends on its heat of combustion. On the other hand the heat of combustion for any kind of wood mainly depends on its moisture content. Based on data from the literature[43], the moisture of waste (shavings) from wood processing enterprises for the production of furniture ranges between 10 and 22% humidity and waste resulting from the sawmills industry (chaff) ranges between 45 and 60%.

High moisture of waste from sawmills industry refers to the situation of these residues immediately after processing trees and eventually should be used as a reference parameter when planning their use to a limited extent for example

[42] M. Brkic et. al: Raspolozivost i troskovi biomase za potrebe sistema daljinskog grejanja na podrucju opstine Vrbas i Kule, CeSID, Novi Sad, 2012

[43] Risovic, S., Domac, J.: Stanje koristenja i energetski potencijal biomase iz drvno-preradivacke industrije u Zagrebackoj Zupaniji, Sumarski list br. 9, pp. 453-459, Zagreb, 1999

household. In that case it should be calculated the low heat value of combustion of 11,700kJ/kg. However, when it is planned to build large power plants for example district heating utilities or power plants for co-generation, fuel must be adequately prepared before it is injected/inserted in the combustion process. Therefore, for assessment of the energy potential within the current study it will be considered that the moisture content of biomass from sawmills industry is 20%.

Low heat value of industrial wood waste is given in the Table 17.

Table 17– Annual residues from timber processing industry. Low heat value of biomass from industrial timber residues

Origin of timber waste	Relative moisture (%)	Low heat value Hu (kJ/kg)
Waste from timber processing industry	10-22	14,600
Waste from sawmill industry	20	14,600

7.2. ASSESSMENT OF AMOUNT OF ENERGY THAT COULD BE PRODUCED FROM WASTE OF INDUSTRIAL TIMBER

The chemical composition of biogas produced from waste (residues) of industrial timber is approximately the same as the biogas produced from forestry. Therefore, in principle, it could be used the same technology for production of electricity, thermal energy or co-generation energy. Similar chemical composition influences that heat of combustion to be approximately the same for both types of biomass in question. If it is considered that the waste from wood processing industry and sawmills industry, before injected in the combustion process are prepared in advance, then the calculation of the quantities of energy that can be produced from these types of waste can be done using the values of the heat of combustion in Table 18. The results are presented in the following Table 18.

Table 18– Annual amount of electricity, thermal energy and co-generation energy from biomass originated from residues of industrial timber

Type of residues	Biomass (m^3/year)	Electricity (ktoe/year)	Thermal energy (ktoe/year)	Co-generation energy (ktoe/year)	
				Electricity	Thermal
Processing industry of timber and sawmills	40,367	1.85	4.49	1.06	3.17

8. BIOMASS FROM URBAN WASTE

In order to reduce environmental problems and sustainable development support most of the countries in world implement waste management based on strategies developed for this purpose. The focus of such strategies, in addition to measures to reduce waste generation in their initial phase of generation, there are also measures to address them in order to reuse them for different products. In this context especially municipal (urban) waste can represent a significant potential raw material for the production of energy. Based on the Law on Waste[44] urban waste is generated from household waste, and waste from other activities which because of their nature or composition it is considered similar to those of the household. In the current study is considered that, within the amounts reported for municipal waste also includes commercial waste (waste from recreational facilities and services) which is similar to municipal waste in nature and their collection system.

Based on official reports, Kosovo annually generates a significant amount of urban waste. The amount of waste collected in Kosovo's regional landfills for 2012 reported by the Environmental Protection Agency of Kosovo[45] is presented in Table 19.

Table 19– Annual amount of waste collection on the regional dumps of Kosova

Location of waste dumps	Amount of waste (t/year)
Prishtinë	78,393.54
Gjilan	31,753.58
Prizren	61,749.16
Podujevë	7,528.09
Pejë	32,623.00
Sharr	4,530.00
Mitrovicë	33,458.20
Ferizaj	14,273.51
Total	**264,309.08**

[44] Ligji Nr. 04/L-060 për Mbeturina, 2012
[45] AMMK: Raport për Mbeturinat dhe Kemikatet, Prishtinë, 2014

On the other side the reported quantity[46] of waste generated on Kosova level for the year 2012 is **606,000 ton** of urban waste which is average of 0.9 kg/person/day.

8.1. ENERGY POTENTIAL OF BIOMASS FROM URBAN WASTE

The potential of urban waste to energy production primarily depends on their composition. Based on the analysis of the participation of various waste from Municipality Pristina, Prizren, Viti and Hanin e Elezit[47], taking into account the number of people reported in official statistics[48], it is found that the average composition of urban waste in Kosovo is as follows:

Table 20 – Participation of various urban waste in Municipalities of Kosova

Type of waste on urban waste	Participation (%)
Biodegradable	41.8
Wood	3.16
Paper / Cardboard	11.79
Plastics	12.36
Glass	5.13
Textile	3.35
Metal	2.24
Household Hazardous waste	0.22
Inert	8.40
Other	11.55

Based on this participation of urban waste and on the reported participation from AMMK in 2008[49] and low heat value of relevant components[50] it is calculated average low heat value from urban waste in Kosova to be Hu= 7500 kJ/kg.

8.2. ASSESSMENT OF AMOUNT OF ENERGY THAT COULD BE PRODUCED FROM URBAN WASTE

The chemical composition of biomass from municipal waste varies significantly from common types of biomass. This makes even that low heat value of combustion of municipal waste to be significantly smaller than low heat value of other forms of

[46] AMMK: Raport për Mbeturinat dhe Kemikatet, Prishtinë, 2014
[47] Planet për menaxhimin e mbeturinave të komunave: Prizren, Viti, Hani i Elezit
[48] ASK: Vlerësim Popullsia e Kosovës 2012, Prishtinë, 2013
[49] AMMK: Raport për gjendjen e mbeturinave në Kosovë, Prishtinë, 2008
[50] EC: Waste Management Options and Climate Change, 2001

biomass. In addition, municipal waste incineration is characterized by much higher emissions of environmentally harmful particles therefore; it requires additional protective measures in relation to the environment. In relation to power generation, municipal waste can be used to produce electricity, thermal energy but also for combined energy production.

There are different technologies for combustion of urban waste, but in terms of efficiency of transformation of chemical energy of urban waste to electrical energy, thermal energy or a combined energy, they do not differ much from burning of other forms of solid biomass. Studies show that with this form of biomass, energy efficiency of production of electricity is approximately 30%, for thermal energy 85% and for combined production of energy 80% (20% for electricity and 60% for thermal energy). By using the same methodology as in previous cases are calculated the quantities of production of relevant energies and the results are given in the Table 21.

Table 21 – Annual amount of electricity, thermal energy and co-generation energy produced from urban waste

Quantity of urban waste (ton)	Electricity (ktoe/year)	Thermal energy (ktoe/year)	Co-generation energy (ktoe/year)	
			Electricity	Thermal
264,309.08	14.22	40.28	9.48	28.44
606,000.00*	32.60	92.36	21.73	65.20

* If it’s collected the entire amount of generated waste

9. TOTAL POTENTIAL BIOMASS OF KOSOVA

Total potential of biomass of all types that could be produced in Kosova is presented in the Table 22.

Table 22 – Total production potential of biomass in Kosova

Type of biomass	Total quantity produced (t/year)	Quantity that actually can be utilized for energy needs (t/year)	Exploitable potential for energy needs*** (t/year)
Biomass from forests*	1,247,434	346,418	1,247,434
Biomass from agriculture	696,541	208,962	208,962
Biomass from orchards and vineyards	17,356	17,356	17,356
Biomass from farming	4,383,170	3,813,358	3,813,358
Biomass from industrial timber waste**	15,138	15,138	15,138
Biomass from urban waste	606,000	264,309	606,000
Total	**6,965,639**	**4,665,541**	**5,908,248**

*The total amount in tone/year is obtained by multiplying the total volume of 1,563,200m^3 (table 2) or net volume of 434,108m^3 of trees with average tree density 798 kg/m^3

**The total amount tone/year is obtained by multiplying the total volume of 40,367m^3 (table 16) with the average tree density of 375 kg/m^3

*** The amount of biomass presented in this column represents the total potential biomass taking into account the current consumption of firewood and considering that with a better management could be collected whole amount of generated urban waste.

10. SUMMARY OF PRODUCED ENERGY FROM ALL TYPES OF BIOMASS

Aggregated results of the quantities of energy that could be produced from existing potential of all types of biomass in power plants for individual production of electricity, thermal energy or combined production of energy are presented in the Table 23.

Table 23 – Annual amount of electricity, thermal energy and co-generation for all types of biomass*

	Electricity		Thermal energy		Co-generated energy			
					Electricity		Thermal	
	GWh/year	ktoe/year	GWh/year	ktoe/year	GWh/year	ktoe/year	GWh/year	ktoe/year
Forestry Biomass	423	36.38	1,027	88.35	242	20.79	725	62.36
	1,523	131	3,699	318.13	870	74.85	2,611	224.56
Biomass from cereal	179	15.43	436	37.46	103	8.815	308	26.445
Biomass from fodder	-	-	-	-	28	2.39	21	1.83
Biomass from orchard and vineyards	24	2.05	56	4.97	14	1.17	41	3.51
Biomass from livestock farming	-	-	-	-	430	36.99	330	28.36
Biomass from timber industry and sawmills	22	1.85	52	4.49	12	1.06	37	3.17
Biomass from urban waste	165	14.22	468	40.28	110	9.48	331	28.44
	379	32.60	1,074	92.36	239	21.73	758	65.20
TOTAL	**813.02**	**62.92**	**2,041**	**175.56**	**938**	**80.68**	**1,792**	**154.11**
	2,126.95	**182.92**	**5,318.89**	**457.42**	**1,709.37**	**147.01**	**4,105.54**	**353.08**

*Presented amount in the highlighted rows is the amount of energy that could be produced taking into account actual consumption of firewood and if it is considered that all amount of urban waste generated could be collected and utilized for energy production.

11. EVALUATION OF FINANCIAL COSTS OF PRODUCED ENERGY FROM BIOMASS

The potential of a certain country for building of additional power capacity, based on different sources of biomass, could not be more relevant if the cost of its use is unsustainable. Therefore, in parallel with determining of potential, its crucial for decisions making on building new power capacities, is the assessment of feasibility of the cost for exploitation. Of course before any large-scale investment, like investments for identified potential of biomass, it is required a detailed assessment of the economical and technical feasibility for the use of any of the identified potential of biomass. However, in the context of the current study it will be assessed the costs that can be expected to produce electricity, thermal energy and energy from co-generation plants, relying on relevant studies from other countries and taking into account local specificities, especially in relation to the cost of biomass.

Numerous types of biomass as a raw material for energy production and diversified technological systems, makes the evaluation of the cost for energy production from biomass quite complicated.

Cost of energy production from biomass can be divided into:

1. The investment costs,
2. Operation and maintenance costs, and
3. The costs of biomass

Investment costs comprise all costs necessary for the construction of a plant ready to start operation, including marginal costs such as costs for drafting plans for permission etc. These costs can be divided into equipment cost and marginal cost.

Equipment costs are:

- Cost for mechanical installations,
- Cost for electrical and instrumentation and control installations,
- Cost of construction (buildings, access to roads, etc.)
- Access to infrastructure services (electrical network, water supply, sewerage etc.).

In marginal costs are:

- Relevant studies (feasibility, environmental impact assessment, etc.)
- Obtaining approval for construction of the plant,

- Supervision, construction and commissioning,
- Capital funds for financing and return of interest

The costs of operation and maintenance costs are costs that have to be an inevitable part of calculating the price of energy production regardless of the biomass. In this group of costs are:

- The cost of fuel needed for continuous operation of utility for pwer production from biomass
- Cost for maintenance and repairs
- Cost of personnel
- The cost of insurance or eventual rent
- Other variable costs (water, electricity, waste, cleaning tools, etc.)

The costs of biomass are specific costs for each country or location where is planned construction of utility for the production of energy from biomass. To have a reliable supply of energy from power plants based on biomass, the biomass supply must be continuous and reliable. The more accurate determination of the costs of biomass is particularly important because often such costs can be decisive for the final assessment about the economic viability of using certain biomass. Therefore, during its definition it should be considered all factors. In the context of such factors are the cost of transport, storage, and preparation of biomass for use. The level of such costs depends on the type of selected biomass, the available space, the distance of the place of use to the supplying place, etc. Some of the costs can be estimated relatively easily whereas others have to assume.

Having in regard the specific technology for certain type of biomass utilization and specific cost of certain biomass, in the following sections are calculated energy production costs in particular for each of the types of biomass analyzed.

11.1. PRODUCTION COSTS OF ENERGY FROM FORESTRY BIOMASS

Forest biomass can be used to produce electricity, thermal energy or for combined production of electricity and thermal energy. Cost of the respective power plants depends on their size respectively from electrical or thermal power of the plant. The total power that can be installed to use the potential of a certain type of biomass can be calculated by acquiring the number of expected operating hours during the year of a utility. It is considered that power plants for electricity production operates 6,000 h/year, while power plants that are used for heating and co-generation operates about 3,500 h/year except for co-generation plants that use biogas as fuel which are considered to operate about 6,800 h/year[51]. Thus, based on the quantities of energy that can be produced it can be found total electrical power for example, the electrical power of utility that might be installed for electricity production is 423,000MWh/6,000h = 71MW. Specific investment cost is estimated to be 2,250Euro/kW and operation and maintenance costs can be about 2% of the total investment cost per year. The annual cost of the investment is determined by multiplying the total investment value of the annuity factor. Annuity factor is the factor that takes into account the annual depreciation of capital invested and durability of respective power plants. For the purpose of this study it is considered that an rate of capital depreciation is 7%, while the durability of plants 15 years[52]. On the other hand, considering that the cost of selling wholesale wood biomass is about 25 € for spatial m^3 of firewood, it is resulting the price of wood biomass to be 39.5 €/MWh of electricity produced. Therefore, the orientation cost of produced electricity from forest biomass is calculated as follows:

Table 24 – Costs of electrical energy from forestry biomass

Type of costs	Value (€/MWh)
Investment costs	41.2
Operation and maintenance costs	7.5
Costs for biomass from forestry	39.5
Total	**88.1**

Here should be added that the calculated price from 88.1 (€/MWh) is the oriented price only for electricity production, thus excluding the level of profit which the relevant companies will enhance in this price.

Similarly it can be found cost of production of thermal energy. Results are summarized as follows:

Table 25 – Costs of thermal energy from forestry biomass

Type of costs	Value (€/MWh)
Investment costs	19.8
Operation and maintenance costs	3.6
Costs for biomass from forestry	16
Total	**39.6**

[51] Ministry of Economy (Republic of Slovenia): Methodology for determining reference costs of electricity generated from renewable energy sources, 2009

[52] D. Loncar et. al: PODRŠKA DEVELOPERIMA - PRIMJERI NAJBOLJE PRAKSE ZA KOGENERACIJU NA DRVNU BIOMASU, CTT, Zagreb, 2009

To calculate the cost of electricity produced in cogeneration plants, it is preceded similar to the above described cases, but this time it is taken into account the fact that a large part of the profit, companies can generate from the sale of produced thermal energy. The sales price of thermal energy is calculated based on the cost of biomass per unit, which wooden biomass is 14 €/MWh. Profit from the sale of thermal energy per unit of electricity is calculated by dividing the value of 14€/MWh with efficiency of thermal energy production, then by multiplying the obtained value with total of thermal energy produced in the co-generation plant and by dividing the product with the amount of electricity produced in co-generation plant. Corresponding results are presented in the Table 26.

Table 26 – Costs of electrical energy form co-generation form forestry biomass

Type of costs	Value (€/MWh)
Investment costs	78.4
Operation and maintenance costs	14.3
Costs for biomass from forestry	69
Profit from sales of thermal energy	49.4
Total	**112**

As can be seen, the cost of producing electricity in co-generation plant is higher than cost of electricity produced in the plant for sole electricity production. This is because of shorter period of operation of the co-generation plant (3500 h/year) compared with the time of operation of the power plant for separate production of electricity (6000 h/year). Consequently, as longer is the period of operation in co-generation plant that more is effectiveness of their operation. The best case is the use of these plants for the production of electricity and thermal energy (for example for the need of any process technology) during the whole year.

Note: Having into the regard the same chemical composition of biomass from orchards and vineyards with the forest biomass also the technical solutions of systems for energy production and parameters for construction and operation are the same. The same applies to the biomass from wood industry and sawmills. This indicates that electricity costs, thermal energy and combined energy production from forest biomass, orchards and vineyards and wood industry/sawmills are the same.

11.2. COSTS OF PRODUCTION OF ENERGY FROM CEREAL BIOMASS

In principle, also the cereal biomass could be used for the production of electricity, thermal energy or for combined production of electricity and thermal energy. Since in this case it comes to solid biomass, determination of cost of production of the respective energies can be made by using parameters similar to those used in the case of such calculations of forest biomass, but this time by calculating the price of biomass by 50 Euro/tone. Results are given in the Table 27.

Table 27 – Costs of electrical energy from cereal biomass

Type of costs	Value (€/MWh)
Investment costs	41.2
Operation and maintenance costs	7.5
Costs of cereal biomass	29.4
Total	**78**

Table 28 – Cost of thermal energy from cereal biomass

Type of costs	Value (€/MWh)
Investment costs	19.8
Operation and maintenance costs	3.6
Costs of cereal biomass	12
Total	**35.5**

Table 29 – Cost of electrical energy in co-generation from cereal biomass

Type of costs	Value (€/MWh)
Investment costs	78.4
Operation and maintenance costs	14.3
Costs of cereal biomass	51
Profit from sales of thermal energy	35
Total	**109**

11.3. COSTS OF ENERGY PRODUCTION FROM GREEN CEREAL

As it was pointed out in Section 3.4, biogas produced from green cereal can be used for energy production in power plants for co-generation. The usefulness of such power plants is that 1/3 of produced thermal energy can be used for the self consumption of bioreactor, while the rest of 2/3 of energy can be sold. This makes the cost of electricity production to be attractive to potential investors. The cost of electricity produced by equipment for co-generation of biogas, can be calculated in a similar method as in the previous cases. Investment cost of such plants is about 3,300 €/MWh, while biomass costs are about 30 €/ton. Results are presented in Table 30.

Table 30 – Costs of electrical energy co-generated from green cereals

Type of costs	Value (€/MWh)
Investment costs	53.3
Operation and maintenance costs	9.7
Costs of cereal biomass	84
Profit from sales of thermal energy*	15
Total	**131**

*Low value of profit from sale of energy is due to the fact that only 2/3 of energy produced can be sold while 1/3 of energy I for self-consumption of equipments of bioreactor

11.4. COSTS OF PRODUCTION OF ENERGY FROM LIVESTOCK FARMING

The technology for utilization of biogas from livestock farming is the same with technology for utilization of biogas from green cereals. However, due to differences in the amount of produced biogas and the cost of biomass, the cost of producing energy will change from this type of biomass. In the case when utilities for production and utilization of biogas are used locally by farmers, the cost of biomass can be considered zero. But, in the case of building larger plants it is preferable of establishing a symbolic price for the cost of biomass from livestock farming, for example to cover the cost of transport. In this study it is considered that 1 ton of biomass from livestock costs 5 Euro. The results about the cost of electricity produced from biogas originating from livestock are presented in Table 31.

Table 31 – Costs of electrical energy co-generated from biogas originated from livestock farming

Type of costs	Value (€/MWh)
Investment costs	53.3
Operation and maintenance costs	12.1
Costs of biomass from farming	44
Profit from sales of thermal energy*	15
Total	**94**

*Low value of profit from sale of energy is due to the fact that only 2/3 of energy produced can be sold while 1/3 of energy is for self-consumption of equipments of bioreactor.

11.5. COSTS OF ENERGY PRODUCTION FROM URBAN WASTE

Municipal waste (urban waste) can be considered as the solid biomass hence this type of biomass in principle can be used for production of electricity, thermal energy and also for combined production of energy. Although this type of biomass can be provided free of charge, the cost of energy production is significant, due to higher costs of operation and maintenance compared to other types of biomass. For needs of the current study, the investment cost for electricity production are considered to be 2,200 Euro/kWh and the cost for operation and maintenance are considered to be about 3.5% of the total investment cost. The summary results regarding the costs of electricity, thermal energy and combined production of energy are presented in the following tables.

Table 32 – Costs of electrical energy from urban waste

Type of costs	Value (€/MWh)
Investment costs	40.3
Operation and maintenance costs	12.8
Costs for urban waste	0
Total	**53.1**

Table 33 – Costs of thermal energy from urban waste

Type of costs	Value (€/MWh)
Investment costs	19.8
Operation and maintenance costs	6.3
Costs for urban waste	0
Total	**26.1**

Table 34 – Costs of electrical energy co-generated from urban waste

Type of costs	Value (€/MWh)
Investment costs	75.3
Operation and maintenance costs	24
Costs for urban waste	0
Profit from sales of thermal energy	0
Total	**99**

11.6. SUMMARY OF COSTS FOR PRODUCTION OF ENERGY FROM DIFFERENT TYPES OF BIOMASS

Depending on the type of used biomass, costs for electricity production ranges between 53.1-88.1 Euro/MWh, the costs for production of thermal energy between ranges between 26.1-39.6 Euro/MWh while the cost for co-generation for electricity production are between 94-131 Euro/MWh. Review of the relevant costs for each type of biomass and energy form are presented in the following table.

Whereas the current cost of electricity production from Kosovo A and B are 27 Euro/MWh and the cost of production of thermal energy from TERMOKOS are about 60 Euro/MWh, it can be concluded that the cost of electricity production from biomass is usually higher than in the case of its production from coal, but the opposite is true for the cost of production of thermal energy.

Table 35 – The costs of production for different types of energy depending from the type of biomass.

Type of biomass	Production costs (Euro/MWh)		
	Electrical energy	Thermal energy	Electrical energy from co-generation
Biomass from forestry, orchards/vineyards and from industrial timber/sawmills	88.1	39.6	112
Biomass from cereals	78	35.5	109
Biomass from green cereals	-	-	131
Biomass from livestock farming	-	-	94
Biomass from urban waste	53.1	26.1	99

12. ASSESSMENT OF POSSIBILITIES FOR FULFILLMENT OF TARGETS FOR RES FROM BIOMASS ENERGY

Targets production of electricity and thermal energy from biomass are defined in PKVBRE (National Plan of Action for Renewable Energy Sources)[53]. Targets of energy production from RES in this plan are set taking into account the actual consumption of firewood. According to this plan, it is estimated that Kosovo in 2020 can produce 105GWh of electricity from solid biomass. Regarding the estimated potential to produce thermal energy (heating/cooling), in NREAP it is not foreseen any substantial increase of the potential of biomass compared to the potential which in this document is currently estimated to exist. Thus, by 2020 in NREAP it is foreseen that Kosovo would have the potential to produce thermal energy by 284.05ktoe.

On the other hand, in the present study it was concluded that in total (including the current consumption of firewood and the total amount of waste generated) Kosovo can produce about 457.42 ktoe/year (see Table 23). This means that even after fulfilling the demand for thermal energy, it will remain available for use 173.37 ktoe, respectively 2,015.98 GWh of thermal energy. This figure is equivalent to 830 GWh of electrical energy which corresponds to approximately the value of the electricity of 813.02 GWh, which can be produced by the sole existing potential (Table 23), thus excluding the current consumption of firewood and taking account only the amount of collected urban waste (about 44% of the amount of generated). Therefore, taking into account that stated target in NREAP for electricity production is 105 GWh, it can be concluded that in the case of exploitation of the potential of biomass, identified within this study, Kosovo can reach easily this targets for production of electricity and thermal energy from biomass.

[53] MZHE: Plani Kombëtar i veprimit për Burime të Ripërtëritshme të Energjisë (PKVBRE) 2011-2020, Kosovë, 2013

13. CONCLUSION

The current study provides comprehensive data about existing potential of all types of biomass that are present in Kosovo. In order to provide more accurate data, first it was made a detailed breakdown of biomass according to its origin, although some types of biomass are similar in their nature. Thus, for example, wood biomass is classified to biomass originated from forestry, biomass originating from orchards and vineyards and biomass originated from wood industry and sawmills. Such classification has made possible a more detailed treatment of these forms of biomass in terms of their size, potential condition at the time of collection but also their caloric value. Furthermore, adequate systematization of various forms of biomass, beside of much more accurate assessment of their potential it makes possible of draw appropriate conclusions about the difficulties of providing relevant biomass, possible risks related to building new power capacities but also opportunities for expansion of these capacities.

In relation to forest biomass it can be concluded that based on the annual allowable cut and the current state of forest, Kosovo has a good potential of this type of biomass. One such potential could eventually be extended, if appropriate measures are taken by the institutions in order to reduce current high consumption of forest biomass for heating purposes.

Besides the potential of wood biomass, an important potential identified in the sector of agricultural crops and livestock farming from which, with proper organization it could be produced a considerable amount of solid biomass or biogas.

As a special type of biomass, in this study is considered the municipal waste with the aim of identifying their potential for energy production and in this form to contribute in the collection and their best handling. Data obtained from the relevant reports have shown that less than half of the reported collected waste are managed to be dumped in the appropriate landfill. Based on the current study it can be concluded that if it's used only collected amount of municipal waste may greatly contribute for increasing of power capacities.

An important part of the report, represents the evaluation of the cost of each type of biomass for which it is concluded that there is potential for exploitation. The estimation is based on data and experiences of other countries regarding investment costs, operating and maintenance costs and based on the estimated costs of various types of biomass in Kosovo.

At the end of the study is also done an analysis of the possibility of completing the official targets on the amount of energy produced from biomass. Analysis has shown that these targets can be achieved without difficulty, if its utilized identified potential in this study.

14. ANEX-I

Density and low heat value of trees depending from moisture

Moisture (%)	Density(kg/m³)	On mass init	On volume unit			
			Solid tree		Wood pile	
		Hu(kJ/kg)	Hu(MJ/m³)	Hu(kWh/m³)	Hu(MJ/m³)	Hu(kWh/m³)
0	646	18144	11721	3256	7619	2116
10	678	16085	10913	3031	7093	1970
15	696	15055	10478	2910	6810	1892
20	714	14026	10019	2783	6513	1809
30	798	11967	9549	2653	6207	1724
40	931	9908	9224	2562	5996	1665
50	1117	7849	8768	2436	5699	1583
60	1396	5789	8085	2246	5255	1460