Forest Biomass Characteristics in Kosovo

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Forest Biomass Characteristics in Kosovo: *Current paper provides an overview of the forest based biomass potential of Kosovo, major tree species and their share in the total forest volume. Current work focuses on description of procedures for estimation of energetic value of wood biomass and provides results in different units and for different wood moistures common in practice. Weighted average heating values for wood in Kosovo are presented and recommended to be used in future by institutions.*

Key words: *Tree species, Wood biomass, Production potential, Heating value, Humidity*

INTRODUCTION

There exist several studies and official reports related to Kosovo forests, their condition, managing and economic benefits from them. The data which can be obtained from such documents are quite a lot, but inadequate systematization and in particular inconsistency of the data regarding the same issue represents a big problem. Data related to forest area, their condition, standing volume, growing stock and annual allowable cut are available in the National Forest Inventory [1,2]. Based on these references, the forestry area comprises 481,000 ha and represents ca. 45 % of entire area of the territory of Kosovo. Among tree species dominates broadleaved within which Fagus species contributes with 46% and Quercus species with 23% whereas conifer species contributes only with 15 % to the total volume of growing stock. Mean growing stock in Kosovo is 84 m^3/ha.

BIOMAS PRODUCTION POTENTIAL

Different approaches might be followed to estimate the total production potential for the forestry biomass [3]. The differences are essentially driven due to final goals of corresponding studies namely depending whether the goal is estimation of the total harvesting potential regardless the current use or only the part of biomass which can be additionally harvested. Current study provides the entire potential for forest biomass production.

Basic parameter which should be considered in order to estimate the biomass production potential is the allowable annual harvesting level or allowable annual felling rate which does not exceed the growing potential of the forest. According to [1] this volume is 900,000 m^3 whereas [2] estimated a maximum long-term harvesting level of 1.2 million m^3. By considering that 95 % of wood volume consumed in Kosovo is used for heating purposes and only 5 % for industrial needs, it may be concluded that allowable wood volume to be used as fuel wood amounts 1,140,000 m^3.

Other forest biomass resources are forest residues produced during forest cut and residues generated by dead wood. Based on international literature [4] residues left after tree cut (branches including bark) represent 21 % of the total tree mass over the ground. Foliage which represents ca. 4 % of the total tree mass over the ground and stump-root system usually are not considered because of many factors (contents in nutrients, ecological reasons, technical reasons etc.). A similar proportion, namely between 15 and 22% of forest residues left after tree cut is reported also in regional studies [5]. Current biomass volume from forest residues is estimated based on maximal allowable felling rate. By considering that due to terrain difficulties only 80 % of forest residues can be harvested one can expect the volume of forest residue to be in order of 0.8 x 0.21 x 1,200,000 =201,600 m^3.

The reported salvageable standing volume of dead wood at the level of 556,000 m^3 [2] represents a biomass potential which cannot be harvested within a short period of time. By taking a harvesting period of 10 years which corresponds to the recommended period between forest pre-commercial thinning actions, one can add to the volume of forest residues the volume of 55,600 m^3 in an annual basis.

Finally, another forest biomass resource represents wood volume which can be generated by pre-commercial thinning of forests recommended for standing volumes younger than 20 years. A forest area of 119,400 ha is recommended to be treated from the view point of some kind of forest silviculture or harvesting operation [2]. Wood volume which can be harvested by pre-commercial thinning is estimated at 14 m^3/ha [6]. Assuming a 10 years period for accomplishing of pre-commercial thinning process, one can estimate a wood volume at the level of 166,000 m^3 to be annually generated by forest pre-commercial thinning.

Taking into consideration that currently 95 % of the total harvested wood is used for heating purposes and assuming same trend also in future, one can conclude that Kosovo biomass production potential is equal to: 1,140,000+201,600+55,600+166,000= 1,563,200 m^3/a. On the other hand, official reports [7] show that actual fuel wood consumption is 1,737,064 m^3 (stacked) respectively 1,129,093 m^3 (solid). Thus, based on current production potential and current level of firewood consumption, Kosovo has a potential of 434,108 m^3 for additional biomass based energy production.

METODS FOR ASSESSING OF ENERGY POTENTIAL

Thermal energy content of a fuel, in general, depends on chemical composition and amount of energy stored in organic molecules. In case of wood, the amount of energy release by combustion depends also on storage conditions, pre combustion preparation and combustion technique. Heating value is the parameter which describes the amount of energy released by the fuel during the combustion. Depending on whether the energy for vaporization of water present in the wood is utilized or lost with combustion gasses heating value might be given as high (gross) heating value HHV or as low (net) heating value LHV. HHV is usually laboratory determinated whereas the LHV is calculated from HHV due to subtraction of energy required for evaporation of water vapor during combustion process. A part of water vapor is generated by combustion of hydrogen (h) present in the wood and the other part originates from the moisture content of the wood (w). From stoichiometric equation for hydrogen combustion one can find that for h kg of hydrogen the amount of 8.937 h kg H_2O is created. Therefore the estimation of LHV of wet wood from HHV is calculated by following equation:

$$LHV = HHV - \frac{8.937 \cdot h}{100} \cdot r - \frac{w}{100} \cdot r \qquad (1)$$

Where HHV (kJ/kg)- high heating value of wood, h (%)- hydrogen content of the wood, w (%)- moisture content of the wood and r=2447 (kJ/kg)- latent heat of water vapor (referent state of water: 1 bar and 25 °C).

For practical reasons many relevant sources provides the data for high heating value and hydrogen content of different wood species in a dry mass basis as HHV_d and h_d. These data can be used to derive low heating value of wood for different moisture percentages. In that case values of HHV_d and h_d should be converted in a wet mass basis by multiplication with the factor $\left(1 - w/100\right)$ and thus eq. (1) takes following form:

$$LHV = HHV_d \cdot \left(1 - \frac{w}{100}\right) - \frac{8.937 \cdot h_d \cdot \left(1 - \frac{w}{100}\right)}{100} \cdot r - \frac{w}{100} \cdot r \qquad (2)$$

In most of technical studies (in present work also), LHV is used to describes energetic potential of a fuel. Heating value of different wood types depends on their elemental composition. On the other hand the elemental composition of wood including different tree parts (roots, stump and branches) is widely independent from wood type [8]. Therefore heating values expressed in kJ/kg are also quite similar for different wood types. In general, conifer species are characterized by ca. 2 % higher heating values in kJ/kg compared to broadleaved species [9].

Expression of heating value in mass units is not very practical in firewood market due to difficulties to measure or asses a certain wood amount in mass units. Key market actors expresses wood in volume units e.g. in m^3. In order to convert a certain would amount from mass to volume units one needs to know wood density which on the other hand depends on water content and wood type. One can find in the literature densities of various wood types in absolutely dried condition (ρ_0) and then calculate corresponding densities for different wood moisture content w (%). During the variation of wood moisture within the hygroscopic field (w<23 %) a volume shrinkage and swelling is registered and this phenomena should be taken in account by shrinkage factor β which is specific for each wood type.

For calculation of wood density based on corresponding density in dried condition ρ_0, moisture content w and shrinkage factor β following formulas applies [9]:

$$\rho = \rho_0 \cdot \left(1 + \frac{w}{100 - w}\right) \Big/ \left(1 + \frac{\beta}{100 - w} \cdot \frac{w}{30}\right) \qquad \text{for } w<23\ \% \qquad (3)$$

$$\rho = \rho_0 \cdot \left(1 + \frac{w}{100 - w}\right) \Big/ \left(1 + \frac{\beta}{100}\right) \qquad \text{for } w>=23\ \% \qquad (4)$$

Another factor influencing wood density is the volume to which it refers which might be solid volume, stacked volume or balk volume. The conversion factors from one volume to other differ slightly depending on the reference, however usually following conversion factors applies:

$$1m^3\ solid \approx 1.54\, m^3\ stacked \approx 2\, m^3\ bulk \qquad (5)$$

RESULTS

Major forest species encountered in Kosovo within broadleaved are beech (*fagus*), oak (*quercus*), turkey oak (*quercus cerris*), birch (*betula* sp.) and hornbeam (*carpinus betulus*) whereas among conifer species these are pine (*pinus*), spruce (*picea*) and silver fir (*abies alba*).

Densities of wood species, calculated based on eq. (3) and (4) and referent values for ρ_0 and β taken from reference [10] are presented in Fig. 1. Corresponding results for LHV calculated based on eq. (2), reference values for HHV_d and h_d taken from [11], and by using of previously calculated densities, are presented in Fig. 2.

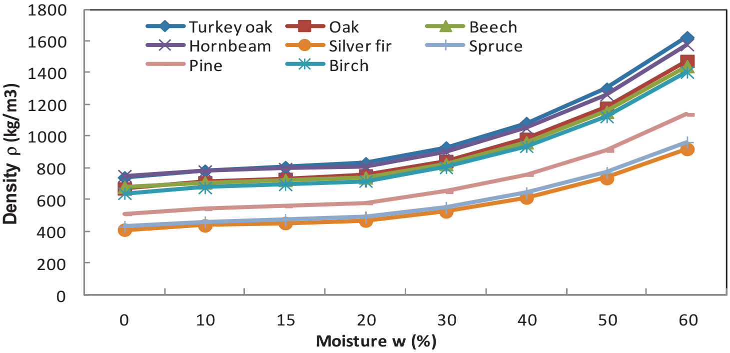

Fig.1. Density of major broadleaved and conifer species in Kosovo

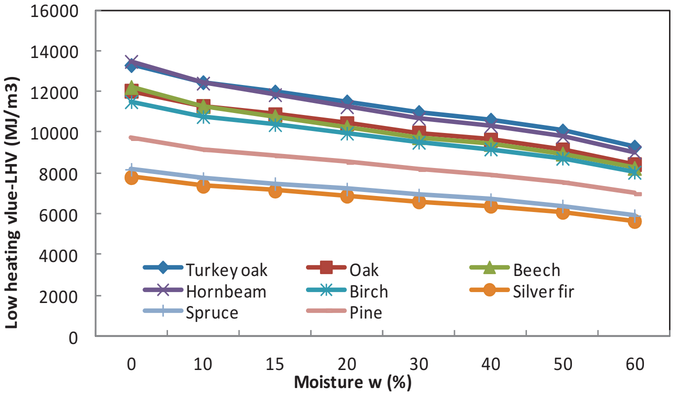

Fig.2. Low heating value of major broadleaved and conifer species in Kosovo

As it can be noted from presented diagrams, wood moisture influences significantly heating value of wood. The question here is which moisture applies for different storage practices. According to [12] one can calculate with wood moistures presented in Tab. 1, depending on storage period applied.

In order to provide to engineers and technicians reference heating values of common wood types in market in different units and for different storage period, corresponding values are presented in Tab. 2. In the same table are given weighted average heating values of wood calculated by taking in consideration share of tree species in Kosovo forests [2] which are recommended for institutional use.

Table 1. Wood storage period and corresponding humidity

Description	Storage period	Moisture content
Fresh wood, moist	0	60 %
Fresh wood, green	0-4 weeks	50 %
Moist wood	1-4 months	40 %
Semi dried	3-8 months	30 %
Dried	2 years	15 %
Absolutely dried	Not possible	0

Table 2. Low heating values of common woods in different units

Description	Humidity (%)	Low heating value-LHV kJ/kg	MJ/m^3 solid	MJ/m^3 stacked	kWh/m^3 stacked
Beech	30	11857	9770	6350	2714
	40	9814	9434	6132	2620
	50	7770	8963	5826	2490
Oak	30	11857	9991	6494	1804
	40	9814	9647	6270	1742
	50	7770	9166	5958	1655
Turkey oak	30	11857	11005	7153	1987
	40	9814	10627	6907	1919
	50	7770	10097	6563	1823
Hornbeam	30	11857	10694	6951	2971
	40	9814	10326	6712	2868
	50	7770	9811	6377	2725

Wood (in general)	30	11967	9549	6207	1724
	40	9908	9224	5996	1665
	50	7849	8768	5699	1583

CONCLUSIONS

Current work provides basic parameters of Kosovo forests, major species and annual biomass production potential from allowable felling rate, forest residues, deed wood and pre-commercial thinning. It describes also procedures for estimation of wood energy potential and corresponding influencing factors. Furthermore recommended values to be used from engineers are provided. Major conclusion is that due to very high rate of wood usage for heating purposes, Kosovo has no potential for new energy capacities based on wood biomass. Another conclusion is that heating value of wood may vary significantly based on storage time and reference volume used to express it.

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