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HARVESTING AND PROCESSING OF FOREST WOOD BIOMASS FOR ENERGY PURPOSES IN BULGARIA

Lyubcho Trichkov[1*] and Dinko Dinev[2]

[1]Executive Forest Agency, 55 Hristo Botev blvd., 1040 Sofia, Bulgaria.
[*]E-mail: lptrichkov@iag.bg
[2]Southest State Enterprise, Sliven. Address for correspondence:
Izgrev Complex, bl. 36, 8008 Burgas, Bulgaria. E-mail: dinevds@gmail.com

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Abstract

Having in mind the assortment and age structure, the tree composition and other specific peculiarities of Bulgarian forests, as well as the national timber market, about 70 % of the harvested timber is used for technological purposes, e.g. for production of particle boards, cellulose and for energy purposes, like firewood for residential heating. Along with the harvested logs (saw logs, pulpwood and firewood), Bulgaria has also considerable recovery of other biomass. In 2014, the share of the categories 'woods' and 'brushwood' is about 50 % of the total timber harvested volume in Bulgaria. Practically, in our country the wood waste from felling together with the brushwood is about 1.4 Mio (m^3/y) of solid waste. That wood waste presents a significant energy potential but the degree of its quantitative concentration is low and often this resource is at big distances from the settlements. The most important advantages and benefits of the utilization of solid wood biofuels in the form of pellets, briquettes, charcoal and chips for energy purposes are: ecological – decrease of the carbon emissions and air pollution and economic (social in this account) – decrease of the costs of energy resources, which ensures both economic and social effect of the use of biofuels produced from wood biomass. In Bulgaria, the volume of wood energy products in 2014 is: 52,550 t pellets, 6,800 t briquettes, 11,550 t charcoal and 9,400 t wood chips, respectively. About 60 % of the number of pellet producing companies has a share of 15–20 % in the total pellet production. Such small-size firms use small-size pressing machines. The general analysis related to the sale of wood pellet and briquette shows that about 2/3 are realized for export based on preliminary signed contracts and the introduction of quality requirements. Most often the export is for Greece, Turkey and Italy. According to our assessments, the best conditions for development exist for briquettes production and wood chips designed to home market, of pellets designed to international one and of charcoal for both.

Key words: biofuels, briquettes, charcoal, chips, wood biomass, wood pellets.

Introduction

The wood biofuels market is scarce in Bulgaria as no conditions have been created therein for a complex use of the forest wood biomass and for subsidies of heating systems which are relatively expensive. And besides, there is also a rather poorly developed distribution. Market conditions have to be created there for a supply of home produced biofuels. As a whole, the waste biomass potential is estimated to amount to 91.5 PJ/year. Including the forest potential is equal to 19 %, approxi-

mately and it is expected to go on rising, The technical potential of the forest biomass for energetic utilization is equal to 44.4 PJ/year, approximately (Dinev and Trichkov 2010, Trichkov and Dinev 2013).

Many studies prognosticate a significant increase in the use of woody biomass for energy in the forthcoming years (Ferranti 2014, European Commission 2014, Sikkema et al. 2011) and the forest industry is already exploring this new growing market. There is no doubt: the biomass harvesting contributes to the complexity of forestry and similarly offers a significant opportunity of increasing efficiency, raising the value recovery and reducing the logging and management costs (Pelkonen et al. 2014).

A strong connection exists between the energy sector and the forestry and forest products industry, because the direct harvest of fuel wood and other forest fuels implied a certain amount of wood residues generated at different stages in the production chain for different wood products (Thiffault et al. 2015, Sikkema et al. 2014).

According to Korpunen et al. (2011), the increasing use of forest raw materials for energy production gives a rise to a necessity of an effective system of planning for management and planning of supply chain. Such system includes decisions on how, when and where wood and its waste could be processed and how, when and where it could be stored and transported to the consumers.

As the forest wood biomass is generally spread within a large geographic region, the supply chain simulation requires true and correct information on the biomass location and accessibility (Cozzi et al. 2013, Goltsev 2014, Alam et al. 2012). The quality management of forest biomass is relevant to the functioning of the entire supply chain and economy (Hillebrand and Raitila 2013). The conformity of business processes to the supply chain demonstrates that their number varies significantly, depending upon different operational environments (Windisch et al. 2011).

It has been established by Baker et al. (2010) that the integration of small-sized chippers systems (< 300 kW) could be successful within a restricted range of logging conditions, depending upon the volume of the produced biomass, compared to the volume of the round wood.

The basic objective of this study is to expand the range of previous ones related to the potential of forest wood biomass and its utilization for biofuels production in Bulgaria (Dinev and Trichkov 2010, Trichkov and Dinev 2013).

According to Sabeva et al. (2012), the standard components of biomass in Bulgaria do not exceed the maximum admissible values implemented by EU into production, wood chips, briquettes and pellets included.

Material and Methods

It is pointed out, in the analytical part of the National strategic documents related to Forestry sector, the National Strategy for Development of Forestry Sector in Bulgaria, 2013–2020 (National … 2013), as well as in the Strategic Plan for Development of Forestry Sector, 2014–2023 (Strategic… 2014), that a perpetual increase in the volume of wood obtained from the forests in Bulgaria, has been reported, as following: within the period 2005–2010, the annual average harvesting has arrived at 6,450,000 m^3 of standing timber, subsequently, during the period from 2012 up to 2014, comprised, it has raised by 1.3 Mio m^3 and reached the average amount of 7,758,000 m^3.

According to its predictions for the maximum sustainable use, logging should reach 8,587,000 m^3 towards 2015 and 8,825,000 m^3 towards 2020 (Kostov and Rafailova 2009). Taking into consideration other analyses, if the elaboration of such forestry plans starts, which ones aim at the utilization of about 75 %, at least, of the total annual growth, and the adoption of a number of measures for that, the annual use in all the forest territories could reach an amount of nearly 10.8 Mio m^3 of standing timber; obviously, in case, a right policy is led by our State and State Forestry enterprises towards the private entrepreneurs in the field of wood harvesting in the forests, tending to provide and stimulate investments into the infrastructure, new machinery and equipment (Marinova and Trichkov 2014). If the above indicated prognostic values are leading, they would contribute to keeping the actual state and even to increasing the amounts of firewood and forest wood biomass waste.

According to the National Strategy for Development of Forest Sector in Bulgaria, 2013–2020 (National... 2013) a change should be made in the existing models of utilization of forest resources promoting measures for stimulation and modernization of logging machinery, applying updated technologies to the logging and the development of our home market for wood, as well as tending to stabilize the demand and to adapt it to the market economy of the trade policy.

Taking into consideration the assortment and age structure, the tree species and other specific characteristics of Bulgarian forests, nationwide, there are 70 %, approximately, of the harvested wood which is used for technological and energetic purposes, i.e. for plates, cellulose and firewood production. In the recent years, the share of the wood belonging to category 'wood' and 'brushwood' is about 50 % of the entire amount of wood harvested in Bulgaria. The wood biomass, firewood, wood waste and their derivates included have a high energetic potential but a low degree of quantitative concentration; and, moreover, that kind of resource is often distant from settlements.

Energetic chips are usually sold by ton; their value depends, to the highest extent, on humidity. It is much easier to provide for a control of the volume in supply as it is used to be done in firewood supply. The tree species is of a great importance for the energetic chips and so important is the fraction size. The most serious problem in chips production, considered by the firms dealing with wood chips harvesting in our country, is the value of chips transportation. The wood chips are too voluminous, of a low specific weight, and all that results unprofitable on road transportation, at a distance of more than 1500 km. That is why for local utilization, i.e. for short-distance transport, it is appropriate to use wood chips for burning. The future trend will be the wood chips incineration. The chips market in our country is still underdeveloped, compared to the one in other states, even though certain good practices already exist, in the recent years. Such kind of heating is applicable mostly to houses where people still use to store firewood. To date, the population in Bulgaria has predominantly used firewood for heating; and it is really a pity that wood is burnt in incineration facilities which energetic efficiency is low (efficiency up to 50–60 %). If such incineration facilities are replaced by high energy efficient ones, the quantity of used combustibles, i.e. wood, can be increased about twice. The highest potential is that one in the public sector premises: schools, hospitals, kindergartens comprised. Besides, there are 5 thermal

power stations in our country where wood chips of moisture content up to 45 % are utilized. There is also logistics which plays a very important part, taking into account the way of performing such operations as packing, loading and unloading which raise the fuel cost.

For the time being, the most economic kinds of fuels produced from forest wood biomass are briquettes and wood, but some defects can also be found out therein, as following: a need of a larger areas or rooms for storage; wood chopping and subsequent piling; a larger quantity of ash released in burning; a longer and harder operations related to the boiler; there is also a lower efficiency of the boiler for firewood or briquettes, compared to the one for pellets: such fact shall not be neglected.

As regard to charcoal, it is the restrictive legal frame in Bulgaria, which shall be placed at the very first place as a hindrance because it puts under a ban the open-ended method for its production. There are also the economic aspects of production, where the retort method is used. The modern bio-refinery makes the wood consumption for of 1 ton charcoal production decrease from 30 to 50 %. Such process under oversight permits performance of a strict control on quality, a choice of the charring level, even a creation of different classes of products: from low to top quality ones, and the relative different prices.

The crisis in economy has also reflected on the producers themselves, as the greatest part of them use as a raw material technological waste generated from wood processing enterprises. And with the reduction of the material requisitions delivered to the above mentioned factories, the waste products, used as a raw material for production of pellets, have decreased, as well.

For keeping the biomass on as a competitive energy source, it is very important to provide for the optimization of the chain from the source to the end consumer. This study identifies the trends of utilization of the main wood biomass kinds in Bulgaria, regarding their quantity and spread, demonstrating how the forestry waste utilization can be optimized.

Results and Discussion

The modern trends to implementation of wasteless technologies and to economically efficient use of raw materials impose the all-round and full value utilization, even of the limited biomass resources. In logging conducted in the cutting areas or stacks, there are branches of different size, known under the common denomination of brushwood or slash, which are not used: they get burnt or are left in the cutting areas, instead, and then decay. Part of them with diameter greater than 3 cm can be used as firewood, while boughs of a diameter less than 3 cm are left unused in them. Taking into consideration the mountain scenery of our forest massifs, and not only it, along with what above mentioned, it has to be added that there are also some quantities of usable wood waste mainly consisting of branches and thin-size stems left in the cutting areas after cutting, and it is due to the fact that the transportation leads to decrease machinery productivity, hence, to a worsening of the economic indices. For that reason, there is a trend to increase such dropping material.

In that relation, there is a need of optimization consisting of a preliminary preparation by collecting of waste piles, chipping and transportation of chips to the end consumer: i.e. to the factory for pellets or

briquettes production. When the logging technology is not followed, it reflects on the biomass utilization chain and leads to a pile processing of less quantities of wood waste; hence, the device (machine) shall be continuously moved from one point to another, during the operation, which causes significant increase of the operating costs.

In the recent years, the cutting area residues utilization has been starting in our country, and it is a very important step to the assimilation of that biomass which consists of about 1.1 Mio m^3. Technologies are adopted, being already in the process of exploitation, for the post cutting assimilation of branches chipped by movable chippers in the cutting area. The loading of the chips is directly performed on trailers or trucks adapted for that purpose. The yield is of 10–18 solid m^3/day. Further on, that same technology is applied to work in stationary conditions; and the chips, obtained in the forest and subsequently processed, are used for production of briquettes made from forest waste. For example, when such technology is applied, 1 ton of briquettes can be obtained from an average quantity of 5 m^3 waste wood, using 3 presses. Annually, only in the summer, 350–400 t or about 1200 solid cubic meters of forest waste branches are processed. A positive trend is also the use of unutilized – even considered unnecessary – undergrowth: South European flowering ash (*Fraxinus ornus* L.), European hornbeam (*Carpinus orientalis* L.) and others, in parallel to the forest waste removal from the cutting areas.

Easier solutions could be found out regarding poplar and acacia cultures where whole trees are harvested and hauled. Usually, before chipping, huge piles are prepared which volume is of 150 t. 'JENZ HEM 581' or 'Doppstadt DH 608' chippers are used which productivity is of 70 t daily. The problem is that the working capacity of these machines cannot be sufficiently exploited. The chips obtained from the above mentioned cultures are designed to be burnt, for example, in thermal-electric power stations and others.

Along with the fast rising firewood and charcoal consumption, such a trend is also noted in pellets and briquettes instead of firewood consumption. There are reasons to suggest that the same trend would also be kept in the future, taking into account the high potential of wood-based biofuels, compared to all the renewable energy sources.

A table and a map have been elaborated, containing the main companies-producers, their location and the volume of production: pellets, briquettes and charcoal, respectively (Fig. 1 and Table 1). The surveys are related to 2014 and the expectations for 2015, on the basis of the data provided by Bulgarian National Statistical Institute and by a WS survey, after site visits to the firms-producers. The reasons for which we have had recourse to different sources are some doubts about incomplete information given to us by the firms.

The average annual production volume of the companies varies from 250–5000 t of pellets, 300–1000 t of briquettes and 100–4600 t of charcoal, respectively. The low volumes produced by small-scale firms while the high ones by large-scale producers: i.e. factories. The factories have put in their business plans production which is about twice higher than its volume indicated in documents. There are 60 %, approximately, of the pellet producers (where the pellet share amounts to 15–20 % of the total production) who use small-size presses.

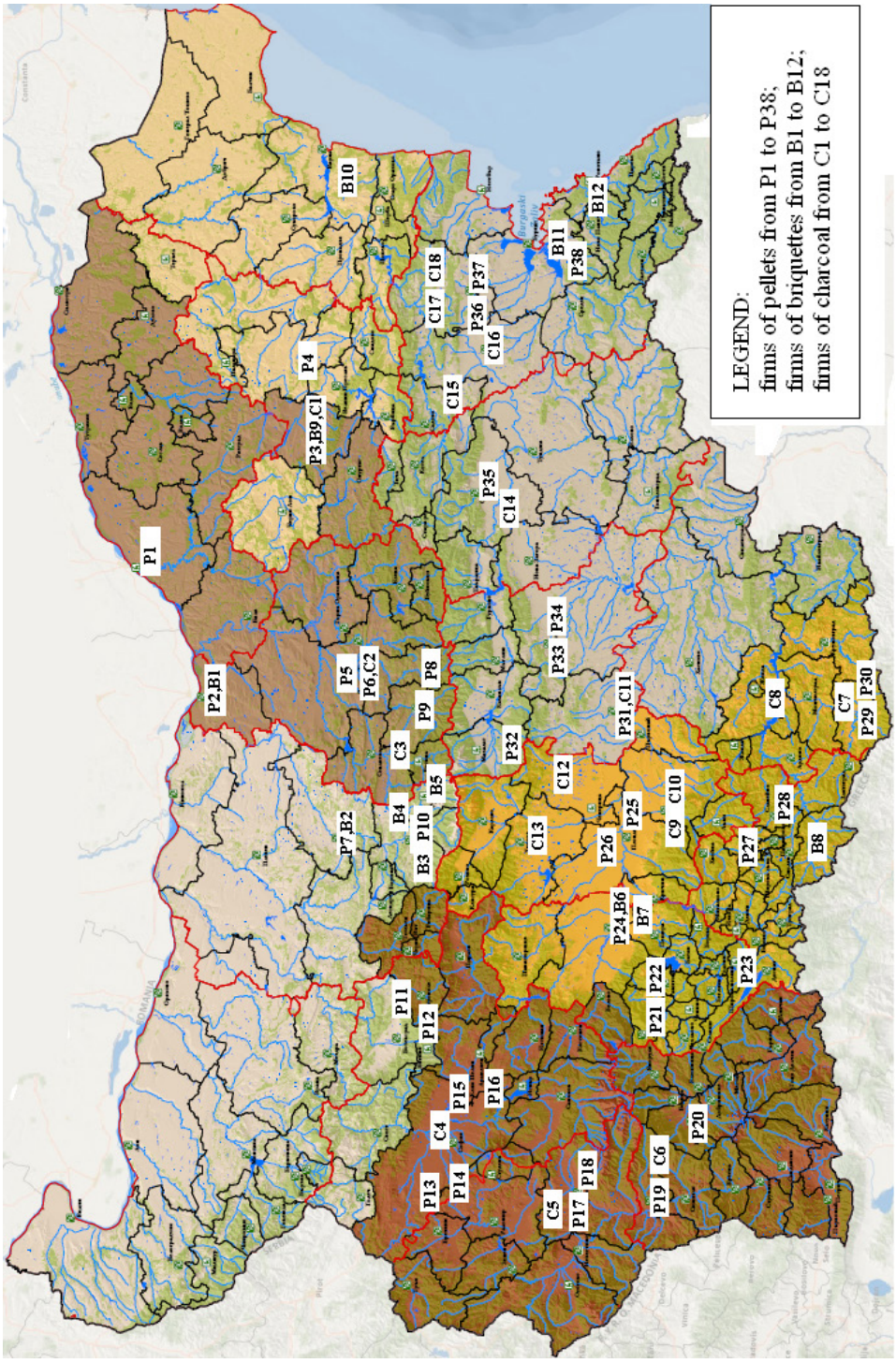

Fig. 1. Map illustrating the location of manufacturers producing pellets, briquettes and charcoal from the forest wood biomass in Bulgaria (in 2014).

Table 1. Real production from forest wood biomass in Bulgaria (2014).

No	Producer	Volume, t/year	No	Producer	Volume, t/year	No	Producer	Volume, t/year
				Pellets				
P1	Dentem	500	P14	Peleti Energy	2000	P27	Yola	500
P2	Ecoteknika	800	P15	Krearo	1000	P28	Vizor	5000
P3	Forinvest	2500	P16	Eco Aktiv	1000	P29	Bori	300
P4	Leskomers	500	P17	Eco Bio Fuel	500	P30	Daris	300
P5	DVT	1500	P18	Rosen Ganchev	500	P31	Carboni	1200
P6	Milev	250	P19	Supereco	300	P32	Tron	15,000*
P7	MM Grun	500	P20	Tehnowood	1000	P33	Sredna gor	500
P8	DIM Invest	500	P21	Toria-08	1500	P34	Eco Power	1000
P9	Ekoflame	300	P22	Tehnobio	1000	P35	BB Pelet	5000
P10	Bioenergy	300	P23	Inter Machinex	1200	P36	Ais Les	2000
P11	Eco Plam Produkt	500	P24	Primatex	1500	P37	Arex	1500
P12	National 7	1000	P25	Ahira	10,000	P38	Trakia Les	2000 10,000*
P13	Eco Flama	2000	P26	Bio heat	600			
				Briquettes				
B1	Екoteknika	500	B5	Ekoflame	1000	B9	Ecokomers	300
B2	Eco plam	500	B6	Primateks	700	B10	Rudi-An	1000
B3	Eko brik	300	B7	Bulpol	500	B11	Emko-G	600
B4	Elma 13	500	B8	Ekoterm	500	B12	Hodja Yurt	400
				Charcoal				
C1	Ecokomers	300	C7	Daris	300	C13	Carbol	1000
C2	Milev	200	C8	Gorsi	300	C14	Apolon	300
C3	Carbo Plus	100	C9	Nikimol	300	C15	Bulcarbon	200
C4	Arkan	500	C10	Okai	1000	C16	Ivmobil	500
C5	Balkanika	600	C11	Carboni	300	C17	Gorprom Invest	4600
C6	Rosima Charcoal	600	C12	Vibien	600	C18	Ruen Les	250

Note: * – data for 2015 (prognosis).

Such presses are of the so-called 'homemade machines' (constructed from different parts and accessories, here and there gathered) where saw-dust waste

from own production is used as a raw material; it is considered a mainspring for the rise of unfair competition because of undeclared production of pellets and their lower purchase prices. Other reasons are related to the existence of unregulated and vague market, disloyal firms and companies dealing with pellet production; scarce business opportunities in the country, on the one side, a low control not only on production but also on purchase, on the other, and the small targets set in front of the firms.

The distribution of biofuels produced in Bulgaria in 2014 and the prognosis for 2015 are indicated in Figure 2.

It is obvious that the prospective for biofuels production from wood is good, especially for pellets. At the end of 2014, a new factory for pellets in the environs of Burgas started working with a production volume amounting to 10,000 t per year, and in the beginning of 2015 another plant like the former one will start in the environs of the town of Kazanlak, with a prognosticated production volume over 15,000 t per year.

Production of pellets in Bulgaria in 2013, 2014 and a prognosis for it in 2015, according to the type of wood used for, is illustrated in Figure 3.

What makes an impression is that the production volume of pellets from coniferous wood has been growing on and it should be noted, significantly, according to the expectations for 2015 while a slight change only has been found out if other type of wood is used for.

The most frequent is the use of Bulgarian and Chinese machines (a small-size pressing machine and a small-size dryer) with some modifications (improvements) introduced by producers. Usually, such firms find niches at home market for placement of their production.

There is an enormous difference between the operating conditions in large-scale and small-scale firms. For example, in contemporaneous plants the process of production is dustless and completely automated while the operations in small workshops (most of which are no else but reconstructed ex-agricultural premises) are sordid and suffocating. As about the operational control, it is provided for the large-scale enterprises, but it is highly undervalued for the small-scale ones.

The total analysis of wood pellets and briquettes sales shows that about 2/3 of sales have been – and are being – real-

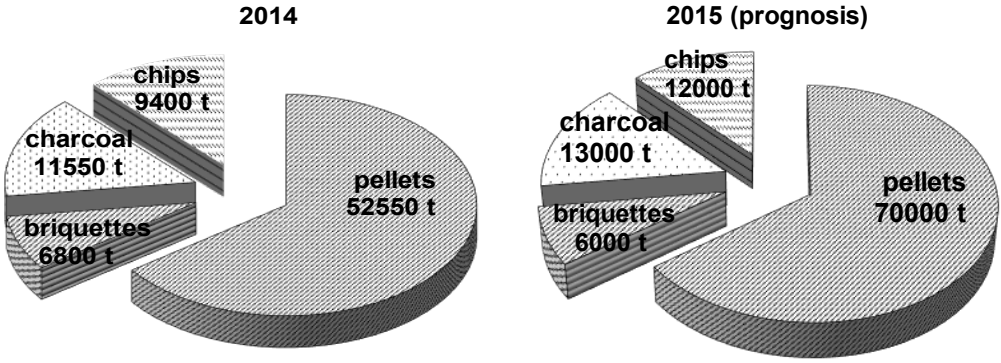

Fig. 2. Distribution of biofuels in our country in 2014 and 2015 (prognosis).

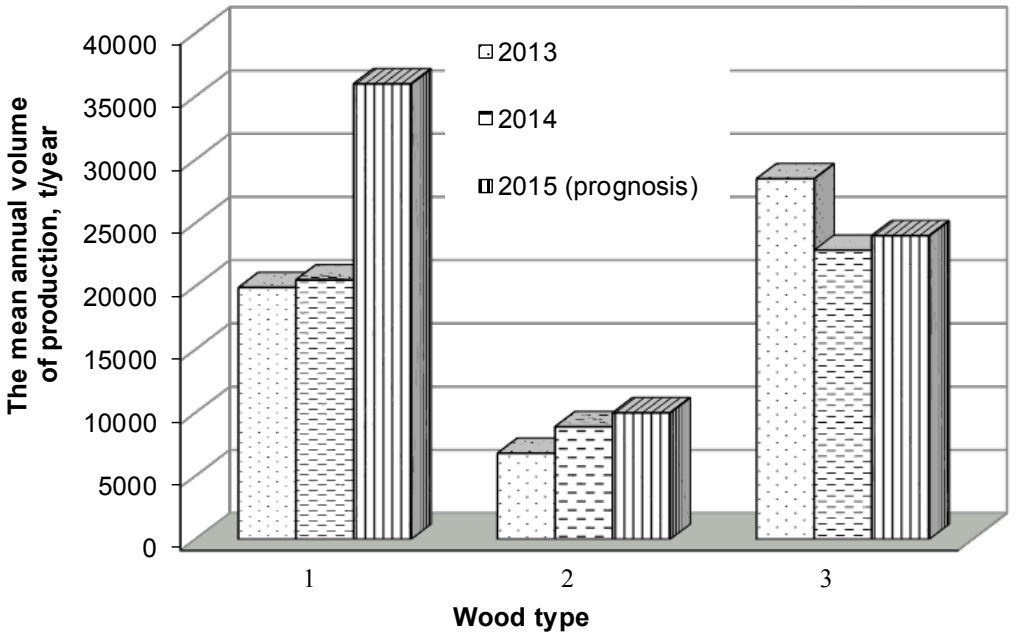

Fig. 3. Production of pellets.

Note about wood type: 1 – Coniferous (Black pine, Scots pine, Norway spruce, etc.); 2 – Deciduous (Oaks, Common beech and Black locust, Poplars, Limes, Common hornbeam, etc.); 3 – Mixture of deciduous and coniferous.

ized at home market, under previously concluded contracts, especially after quality requirements adoption. The most frequent exports are for Greece, Turkey and Italy.

Observations have been conducted where the costs for raw materials are considered to take the main part in the prime cost of production of pellets production. Other basic components of the costs and expenses are payroll and manufacturing costs where costs for drying are included: of 25 % and 20 %, respectively. In general, two workers only are necessary for the whole process of production.

Pellets of the best quality are produced from deciduous wood: from logs and not from wood waste. Higher is the content of bark in wood, worse is its quantity, i.e. the best pellets are produced by logs while the worst ones – from cuttings, shavings, branches etc.

According to our assessments, the most favourable production climate for development of briquettes, pellets and charcoal production is created when briquettes are produced for the home market, pellets for the foreign one and charcoal – for both of the markets.

On the grounds of the studies, conducted up to now, it has been stated that there are serious problems, in our country, regard to the construction of the plants and the production of biofuels from wood biomass (Table 2).

This study has examined mainly the aspects relative to production and some economic ones regarding indentifying the trends in the use of basic wood types in Bulgaria, in quantitative aspect, and their spread.

Table 2. Problems regarding the construction of plants and biofuel production.

Main problems	Explanation
Incorrect suppliers	Incorrect suppliers of machines and equipment.
Incomplete knowledge	When plants are tested, either suppliers or buyers are often not too familiar with the process; hence, such an incomplete knowledge leads to a delay in the credit allotment and repayment; subsequently, the amounts of the interests rise creating pecuniary embarrassments for both of the parties.
Maintenance services	Missing services for maintenance.
Provision of raw material	The large-scale companies are provided of raw material while the small-scale firms often miss it.
VAT registration	The small-scale firms have no VAT registration; that is why their purchase prices are lower.
Workers	It is very hard to find quality workers. Preliminary training should be provided but it is not regulated.
Purchase of standing timber	When raw material is purchased, especially if it is a purchase of standing timber, wood is not separated raw material designed for pellets, briquettes and charcoal but it is mixed with technological wood used for plates and cellulose production.
Unfair competition	There is also unfair competition in the field of charcoal production and sale both at home and international markets, especially, by states which are not EU members, and more concretely, in some neighbour countries bordering Bulgaria, as charcoal is produced therein using the open-ended method.
Funds	To start building a plant, one shall also rely on one` s own funds. One cannot rely on 100 % crediting by banks.

Further studies shall be performed on ecological and social consequences resulting from forest wood biomass use. Regardless the fact that the quality of the materials is an important parameter of the precarious forest wood biomass supply chain, reflecting on the quantity and the price of produced biofuels, we intend to make it the object of our next study.

Conclusions

In our country the production volume of energy products from wood in 2014 is, as following: 52,550 t of pellets, 6,800 t of briquettes, 11,550 t of charcoal and 9,400 t wood chips, respectively. The prospective for biofuel production from wood is good, especially if related to pellets where, according to the expectations for 2015, the production volume should amount, at least, to 18,000 t, mainly from coniferous wood, while if other type of wood is used for, a slight change only could be expected.

The average annual production volume of the companies varies from 250–5000 t of pellets, 300–1000 t of briquettes and 100–4600 t of charcoal, respectively. The low volumes produced by small-scale firms while the high ones by large-scale producers: i.e. factories. The factories have put in their business plans production which is about twice higher than its volume indicated in documents. There are 60 %, approximately, of pellet producers (where the pellet share amounts to

15–20 % of the total production) who use small-size presses.

It is necessary to apply simpler and clearer administrative procedures to investments into the production of fuels from biomass, technologies and means for their utilization. Corporate taxes and corporate tax fees shall be reduced for companies producing fuels from wood biomass and firms producing ecological and efficient appliances for wood-based biofuels.

Biological and ecological studies should be performed in the cutting areas, especially in those ones where a higher intensity of cutting is made, to determine the long-term consequences from wood waste removal and collection, after logging, aiming at waste utilization for energetic purposes.

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