POTENTIALS FOR FOREST WOODY BIOMASS PRODUCTION IN SERBIA

by

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The paper presents the analysis of possible potentials for the production of forest biomass in Serbia taking into consideration the condition of forests, present organizational and technical capacities as well as the needs and situation on the firewood market. Starting point for the estimation of production potentials for forest biomass is the condition of forests which is analyzed based on the available planning documents on all levels. Potentials for biomass production and use refer to initial periods in the production and use of forest biomass in Serbia.

Key words: *biomass, forest biomass, woody biomass, logging residue, forest use, devastated forests, plantations*

Introduction

Wood as the oldest form of energy, which has been in use for thousands of years, is regaining deserved attention nowadays. High prices of fossil fuels and political decisions in the direction of increasing energy security and mitigation of climate changes have provided a strong stimulus for the development of renewable energy sources in general, especially of energy obtained from wood. In activities directed towards the increase of energy production from renewable sources, the energy sector makes intensive connections with the sector of forestry and wood industry, thus stimulating competition and demand for wood. Consequently, energetics and wood industry have started competing over woody biomass and engaged and traded amounts are rapidly increasing.

By definition woody biomass is the accumulated mass, above and below ground, of the wood, bark, and leaves of living and dead woody shrubs and trees. In practice, forest woody biomass mostly includes wood of lower quality the use of which is not suitable for other purposes (primarily technical). If firewood as standard forest assortment is disregarded, wood which occurs as wood residue in logging and production process and which in traditional use remains in the forest is used for energy purposes. Another way for providing woody biomass is dedicated production in plantations of fast-growing species. It is not a rare case that forest biomass is also produced in the process of the reclamation of neglected agricultural areas covered with forest vegetation or in the process of devastated forests reconstruction.

The potential of the utilization of forests and forest biomass are limited by production capacity of forests and any exceedance of the planned yield volume usually leads to degradation

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of forests and their biodiversity with consequences which cannot be predictive. Another limitation is usually related to the cost of collection, transportation, and biomass processing.

Scope of work and objective

The main objective is to estimate real potentials for the production of forest woody biomass in Serbia. This paper has a particular objective attempting to give contribution in such a way that by using relevant methods and data from the National Forest Inventory (NFI) and from the practice of forest management, it is to give a realistic picture of forest woody biomass potentials in Serbia, thus dilemmas and polemics that exist among professional public and other stakeholders can be eliminated.

In planning of yield and wood production, it must always be borne in mind, that the forests are a conditionally renewable natural resource that must be managed in accordance with the principles of sustainable management. Biomass utilization in the amount which is envisaged in this paper requires the application of modern professional and technical achievements in the management and utilization of forests, which will provide the best fulfillment of economic, environmental, and social goals.

Method of work

Planning documents, forest management plans for state forests as well as database on the condition of these forests were used for estimating production potentials of forest biomass and forest condition. Data for private forests as well as for the estimation of barren woodland were obtained from the Serbian NFI, which, pursuant to the used methodology, provided data of sufficient accuracy for higher spatial levels (county, Republic). The NFI was conducted in Serbia in the period 2006-2008 and currently it is the most reliable source of data.

Estimation of wood residue after fellings was done based on the database from the record of executed works for the needs of the Public Enterprise (PE) "Srbijašume" for the period 2000-2009 where gross and net harvested wood volume for each individual stand were recorded. In order to additionally confirm the percentage of wood residue after harvests, assortment tables for main wood species used in Serbia, Bosnia and Herzegovina, and Montenegro were also used.

The paper also gives the estimation of potential production of forest biomass from devastated forests and coppices, which in the process of melioration (removal of parent stand and artificial forestation) will be transformed into high silvicultural form. For this estimation, data from spatial plans of Serbia were used, both from the valid [1] and the previous [2] spatial plan of Serbia, forest management plans and certain previous pieces of research. Other circumstances were also taken into consideration in the estimation, such as technical capacities and present scope of planting works realization, situation in nursery production as well as financial opportunities.

Research results and discussion

Overview of the research conducted to date

The first serious research in the area of observing potentials and opportunities for biomass use in Serbia was initiated in 1986 by the Vinča Institute for Nuclear Sciences – Laboratory for Thermal Engineering and Energy. Researchers from the Faculties of Agriculture, Forestry and Mechanical Engineering took part in the research as well. The first systematized results of this multi-annual research were presented in the monograph “Biomass for Energy Pur-

poses" from 1992 [3]. One of the papers from the stated monograph [4] gives the conclusion that woody biomass from forests, compared to other renewable resources, has significant advantages reflecting in available amounts, efficiency of sun energy use (photosynthesis), possibilities of storing for longer periods, renewability and sustainability of this resource. The same paper points for the first time at the fact that woody biomass treatment in Serbian energy balances is inappropriate, *i. e*. due to inappropriate statistical data there are no sufficiently accurate data on private forests and also the statistics does not include wood consumption for energy in rural households.

As a result of further research two monographs were published by the Yugoslav Association of Thermal Engineers. Volume one [3] gives detailed presentation of the structure of wood production and wood residues from forestry and wood processing were balanced and their availability was estimated. In volume two [5], a paper [6] directed attention to wood residues from wood processing. Available amounts of wood residues, their structure and characteristics as well as their spatial distribution were determined.

During the 1990s', the popularity of wood fuels use was reestablished, primarily of wood briquettes in Serbia [7]. On this topic, two projects were released which covered the issue of biomass. The results of the first project were presented in the monograph issued by the Faculty of Forestry in 1995 [8].

Researchers from the Faculty of Forestry took part in the production of two studies where energy potential and characteristics of biomass residue and technology for its preparation and use for energy in Serbia were treated [9], as well as technical potentials and economic justification of the use of biomass energy potential in the selected municipalities in Serbia [10].

It was common for the complete abovementioned research that it was based on insufficient knowledge of woody biomass resources available in Serbia which could be used for the production of wood biofuels. Therefore, the presented data varied a lot depending on the source (tab. 1).

Table 1. Potentials for woody biomass production in Serbia resulting from various pieces of research conducted in the period 1986-2009

Sources	Potentials for woody biomass production in Serbia (10^6 m^3 per year)						
	State forests	Private forests	Orchards & vineyards	Values out of statistics data	Wood processing	Wood waste	Total
[4]	2.03	1.19	0.50	2.80	–	–	6.52
[11]	0.68	2.69	0.50	3.50	1.12	–	7.29
[5]	1.23		–	–	0.99	–	–
[8]	0.69	1.19	–	–	0.94	–	–
[9]	1.1		–	–	0.24	–	–
[12]							12.0

Source: Authors named in column sources

The main reason for such a large discrepancy of final data regarding woody biomass potentials lies in the fact that the only stand forest inventories were conducted by 2008 and obtained information on the forest fund were directly used for making long-term and general plans for the management of private and state forests, macro-economic planning, correspondence

with the international community and other purposes [11]. The second reason is the fact that the system for recording increment, annual allowable cut and forest use, mostly relies on data from public enterprises and national parks. Data from private forests, orchards, public areas in populated places and village crofts were recorded only partially and thus they were insufficiently precise for realistic estimations of wood production and consumption in Serbia, especially for woody biomass used for heating.

There was a large shift in this area in the period 2006-2008 when according to the international methodology the first national inventory of Serbian forests was conducted [12]. In that way, a reliable database on forests in Serbia was established and certain assumptions were done, as among others, the ones for comprehensive and detailed analyses in the field of woody biomass supply and demand.

None of the abovementioned studies, projects or papers contained significant research regarding actual consumption of wood fuels in Serbia, especially in the segment of households which represent the field in which wood fuels are most consumed. This statement was one of the reasons for undertaking research as part of the project titled "Wood Based Energy for Sustainable Rural Development in Serbia", supported by the FAO organization. The most significant results of this project are presented in the paper [13].

In 2009 and 2010, two studies were also done for FAO needs, which included macro and micro economic effects and significance of the system of wood based energy in Serbia [14, 15]. At the moment, there are two ongoing projects at the Faculty of Forestry dealing with woody biomass. The first one is in the phase of final report submitting [16]. The main result of the project (in the area of biofuels) is the analysis of potentials for using woody biomass for co-generation of heat and electricity [17, 18] as well as [19]. The second project is at its beginning [20] and should answer to what extent the use of woody biomass in Serbia could contribute to the reduction of CO_2 emission.

Condition of forests in Serbia and production potentials

Forest area in Serbia was significantly reduced at the beginning of the 19th century, giving space to agricultural land. However, today, at the beginning of the 21st century, changes have the opposite direction. Agricultural land in mountainous and hilly areas is abandoned to a high extent and the changes indicate that forest again takes over the areas that used to belong to it. Data from the National Forest Inventory [12] confirm this trend. Comparing the condition determined in 2008 with the condition from 1979, the difference in areas is positive and amounts to 270,000 ha, namely forest area is enlarged by 9,000 ha per year. The enlargement of the area covered with forests results partly from the conducted afforestations and largely from natural overgrowing of agricultural land in hilly and mountainous areas, which is abandoned now. The Inventory also registered 174,800 ha (or 7.8% of total forest land) artificially established forests, which resulted from the afforestation works from the beginning of the second half of 20th century.

The condition of forests in Serbia can be characterized as unsatisfactory, however, with positive trends. According to the data from the NFI, forests in Serbia (without Kosovo) cover the area of 2,252,400 ha or 29.1% of the total area of the Republic. Other woodland as well as infertile lands cover 474,400 ha (6.1%), meaning that about 35% of the area of the Republic of Serbia has specifically a purpose connected with forest and forestry.

The other data on the condition of forests in Serbia are not encouraging. They point at a high degree of forests of coppice origin (1.45 million ha or 64.7%). These forests have low average volume (124.4 m^3/ha) and increment (3.1 m^3/ha) so that their production, environmental,

aesthetic and other potentials are significantly reduced. There are about 27% of insufficiently stocked stands, while entirely devastated forests participate with 2.5% in total area [12].

Next indicators of the condition of forests in Serbia are the standing volume which is 362.5 m^3 or 160.9 m^3/ha and annual increment of 9.08 m^3 or 4.0 m^3/ha, both below optimal values.

Ownership structure of forests is somewhat more favourable and benefits the state forests (1.19:1.06 million ha). The condition of private forests is far more unfavourable and they are mostly dedicated to the production of firewood, for the needs of forest owners and in smaller degree for the market. This is an unfavourable fact; in particular that private forests are characterized by extremely low average area of lots amounting only to 0.3 ha, as well as that the total number of private owners is more then 0.5 million. Figure 1 shows the current situation regarding the presence of state and private forests.

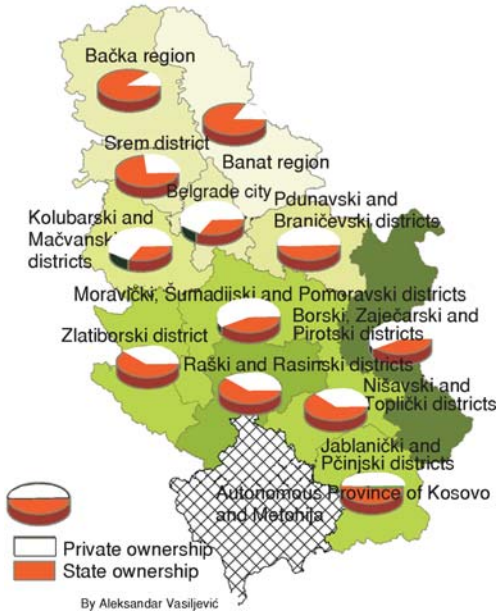

Figure 1. State of forest in Serbia by ownership [12]

Annual allowable cut that can be realized is limited by natural conditions on one hand, and legislation on the other. Exceeding of planned allowable cuts most frequently leads to the devastation of forests, so strict control is needed as well as the observance of plans. Annual allowable cut is determined based on forest inventory and for Serbia it can be estimated to about 5.7 million m^3 on annual level (tab. 2). Here, potential annual allowable cut in state forests is 2.38 million m^3 per year and in private forests it is 3.32 million m^3. Potential annual allowable cut for private forests is estimated based on the NFI data because stand inventory is not done for this forest ownership category and there are no detailed plans of cuts. According to [21], the potential yield of our forests is estimated at 6.34 million m^3 per year, if adequate monitoring and silviculture works were provided (in the broadest sense).

Annual cut realized in Serbia differs from potentials. The reason for this lies in the inaccessibility of forests and insufficient openness to forest roads. In 2010, gross amount of 1.99 m^3 of wood was cut in state forests in Serbia. Firewood and pulpwood participated with 54% in this amount [22].

Regarding private forests, there are no exact data on annual production volume of wood assortments because the owners use most of the produced amounts for their own purposes. Authorized offices record annual allowable cut of about 1.0 million m^3. However, numerous estimations indicate that the total production in private forests is several times higher than the registered amount. Upper limit of allowable cut in private forests definitely must not approach the amount of 3.7 million m^3 of gross wood volume, which is the annual increment of these forests.

In the sense of forest biomass use for energy purposes, it most frequently includes wood left over after cuts, thin trees, wood damaged by fire or other cause, dedicated produced wood in short-rotation plantations, *etc*. Practically, forest woody biomass means wood and wood assortments which are not rational to be used for other technical purposes. In present practice, it is possible to identify several potentially significant resources which can contribute to the increase of forest woody biomass production.

Logging residue (Wood residue after felling)

Present practice of forest use is such that out of the overall tree biomass, the part of stem above ground and branches up to 7cm thick are most frequently used. All other biomass (root, thin branches, leaves), including rotten, damaged and unusable parts because of other reasons, remains in the forest as logging residue. From the environmental aspect of forest management, this residue is not harmful because in the decomposition process it transforms into useful substances. However, observed from the economic aspect, it can represent reduction of income from forest use.

The amount of wood that remains in the forest after cuts depends primarily on tree species, forest age and quality, regeneration type and organization of operations regarding forest utilization, *etc*. Technology of cuts and extraction of wood assortments may have an impact on increase of wood utilization and its application depends on investments in modern equipment, stand condition and forest management pattern, accessibility of terrain and many other factors. As a rule, clear cuts as well as high intensity cuts enable higher utilization degree of forest woody biomass, however, they are frequently less desirable from the aspect of forest management. Compared to the present situation regarding biomass use in Serbia, it is indisputable that certain amounts of wood which could be used for energy purposes remain in forests after cuts.

Based on the records of the executed works regarding forest use at the PE "Srbijašume", which implies the recording of gross and net logged wood, for the period from 2000 to 2009*, it was found that average forest residue ranged from 15.2% to 22.4% of gross wood volume. This percentage includes tree parts above ground which cannot be processed into standard forest assortments.

Another source of data on wood residue amounts after cuts can be found in assortment tables which are used for qualitative estimation of wood assortment production. Assortment tables for the territory of Serbia are made for beech high and coppice forests [23]. Average value of wood residue after cuts is 14.15% for high forests and 15.48% for coppices, according to these tables.

Logging residue amounts obtained in the analysis of performed cuts and amounts from volume tables sufficiently overlap in order to be accepted for further estimations. If minimal value of wood residue from the records of performed cuts of 15.2% is taken as an initial value, which is approximate to the value of assortment tables for beech, and compared to the total annual allowable cut in state forests (the amount of 2.38 milion m^3 of wood), data is reached that 0.36 milion m^3 of forest residue for woody biomass can be expected on annual level.

However, due to numerous limitations, it is impossible to fully use this amount of wood residue, not even under ideal circumstances. Utilization degree of forest residue depends on many factors. Development of forest roads network, skidding distance, biomass quality, technical equipment of producer, collection costs, prices on the market are only a few of the factors which impact its utilization. Regarding biomass collection, it is of great importance to be cost effective and in compliance with the requirements of the market, which is basically the main driver of these activities.

Estimation of actually possible degree of biomass utilization after cuts can also be obtained by comparing the experience of other companies in the neighboring countries, which started these activities much earlier. Thus, for example, the Slovak company for forest manage-

* Observed for 34,500 stands where harvesting occurred in the period 2000-2009

ment ("Lesy SR")*, after years of experience in forest woody biomass production, produced 159,690 tons of woodchips in 2010, which is about 4% of total harvested wood volume [24]. The other company, Austrian Federal Forests ("OBF")* produced 91,000 m^3 of forest woody biomass for energy purposes in the same year, which is about 5.3% of total harvested wood.

Practice of forest biomass use in Serbia is not developed yet, consequently there is no experience based on which degree of possible utilization could be determined. Taking into consideration the experience from other countries as well as the existing limitations present in Serbia referring to the lack of modern technology, insufficient openness of forests, undeveloped market of forest woody biomass and other weaknesses, the estimation is that in first phases about 40% of available amounts of wood residue can be used. With such increase of wood residue utilization degree in the initial period, participation of biomass in total harvested gross wood volume in state forests would be 7%. For the territory of P. E. "Vojvodinašume", this percentage would be slightly higher (10%) due to more favourable terrain configuration and higher intensity of cuts per surface unit.

Based on the given estimation in state forests, annual production of woody biomass is possible on the level of 0,17 mil.m^3, which is expected to be cost-effective.

Extent and effects of private forests use in Serbia are not known to the level as for state forests. Therefore, estimation of potentials for forest woody biomass production cannot be done pursuant to the same methodology. According to assortment tables, average percentage of forest waste is 11.7% for oak and 15.5% for beech coppice, which is about 0.45 milion m^3 annually.

However, owners of private forests largely use all available wood, including the wood with quality below official standards, so that these data on forest residue should be taken as orientational potential. On the other hand, cuts in private forests should be mostly thinning and sanitation cuts characterized by the cut of trees with smaller percentage of waste. Many other problems that exist in the private forestry sector point at the assumption that degree of the increase of cut wood utilization in private forests cannot be entirely identified with state forests, however residue utilization could be expected in the amount of 8% of gross wood volume. Compared with total possible allowable cut in private forests, estimation of annual amounts of 0.27 milion m^3 of wood is reached.

Finally, observing total possible allowable cut in state and private forests in Serbia, with actual possible increase of logging residue utilization degree after cuts, biomass production in the amount of 0.43 milion m^3 annually can be realized (tab. 2). The most important driver for achieving this level is the market of woody biomass, its price and required amount.

With the realization of amounts given in tab. 2, utilization degree of cut wood will be significantly increased but a part of production potentials will still remain unused. For further increase of utilization degree of forest woody biomass, it is necessary to entirely use allowed annual allowable cut of forests. Also, the increase of use of logging residue requires the implementation of measures to advance technology and organization of forest utilization, improve the quality and network of forest roads, investments in modern equipment for harvesting and transport of biomass and other measures.

Under present conditions, significant increases of utilization volume cannot be observed as realistic.

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* Lesy Slovenskej republiky, š. p., Banska Bystrica, Slovakia
** Osterreichische Bundesforste A. G. (OBF), Austria, which had total wood production of 1.7 milion m^3 in 2010

Table 2. Estimation of potential use of logging residues after cuts in forests in Serbia

Statistical territorial unit NSTJ-3	Total annual yield			Logging residue		
	State	Private	Total	State	Private	Total
	[10^3 m^3 per year]					
Belgrade city	97	87	184	6	7	13
Kolubara and Mačva districts	109	394	503	7	32	39
Podunavlje and Braničevo districts	173	219	391	11	18	29
Zlatibor district	191	421	612	12	34	46
Morava, Šumadija, and Pomoravlje districts	256	501	757	16	40	56
Bor, Zaječar, and Pirot districts	314	639	952	19	51	70
Raška and Rasina districts	311	414	724	19	33	52
Niš and Toplica districts	170	174	344	10	14	24
Jablanica and Pčinj districts	176	360	536	11	29	40
Srem districts	240	72	312	24	6	30
Bačka region	98	19	116	10	1	11
Banat region	251	15	266	25	1	26
Total	2385	3316	5701	170	265	435

Souce: Calculation based on possible yield and increasing of utilization level

Melioration of devastated forests

The condition of forests in Serbia is not satisfactory because about 30% of the territory is covered with insufficiently stocked and devastated forests. Reasons for the devastation of these forests are numerous, however, the strongest cause is unplanned use and deforestation long ago. Volume and increment of these forests according to their scope and quality are below expected values. According to [25], on a large area forests need to be "restored" for the purpose of preventing and mitigating all unfavorable consequences and increase of production and other expected functions of forests .

In order to achieve the most important objective of forest management and forest development strategy [26], referring to the necessity to improve the condition of forests, one of the measures for a part of stands could be total reconstruction. In this measure, the entire stand is removed in clear cut and afterwards adequate species are introduced, most often pioneer species, depending on habitat conditions [27]. Such a strict measure with the application of appropriate silvicultural measures can contribute to the improvement of economic, environmental, social and other functions of forests.

Works on the melioration of devastated forests were planned to a significant extent in the previous period. Thus, the Spatial Plan from 1996 [2] anticipated the melioration and reconstruction of devastated forests on the area of 106,000 ha by 2010, or about 7,000 ha annually. At the PE "Srbijašume", based on the long-term plans, stands where reconstruction should be undertaken cover the area of about 16,000 ha.

According to [28], in devastated forms of coppice forests it is necessary to perform clear cuts without the substitution of species on 63,000 ha and clear cuts with the substitution of

species on 47,000 ha, which makes the total of 110,000 ha. This area, as in the case of the Spatial Plan of Serbia from 1996, represents a long-term objective.

Implementation of these plans was almost symbolic in the previous period. Reasons why are primarily of financial nature. Namely, by using these forests, assortments of very poor quality are obtained, frequently below minimum set in standards, and with no market for them. On the other hand, costs of field preparation, planting and tending far exceed the incomes which could be realized from wood. Subsidies from the budget of Serbia for these works were also not sufficient stimulus for users of state forests, while these subsidies were not available to private owners.

The problem of the placement of poor quality wood obtained in devastated forests can be expected to be overcome with the development of woody biomass market, including wood chips. This solves one of the problems for the intensification of activities to improve forest condition through reconstruction

Based on the data from the NFI, Serbia has 55,000 ha of devastated forests, 33,600 of which are state owned. If these data are compared with reconstruction plans for devastated forests pursuant to long-term plans for the PE "Srbijašume", it can be observed that there is a significant compatibility and that long-term plans for the reconstruction of devastated forests on the area of 16,000 ha are realistic.

By analogy of the data from the NFI and forest management plans, it can be estimated that reconstructions can be implemented in at least 50% of devastated forests, which gives the total area of 27,600 ha for a 10-year period. It can enable production of 220,000 m^3 of forest woody biomass annually. This amount implies total wood mass which can be on average obtained annually in melioration procedure. However, it should be taken into consideration that other wood assortments will also be obtained in the production process, primarily firewood, which will reduce the total amount of available woody biomass.

Annual scope of 2,760 ha can be achieved only with investments in strengthening capacities for the production of planting material, development of technology for forest utilization, terrain preparation, planting and tending of new stands. Under present conditions, there are no sufficient amounts of available planting material of adequate quality as well as other required capacities for the purpose of melioration of devastated forests, planned afforestation and growing of dedicated plantations. Besides, due to increasingly expressed climate changes and longer periods of drought, planting pattern and seedling types need to be significantly changed in the direction towards the use of containerized seedlings which are adapted to longer periods of drought. Otherwise, a significant success of planting could not be expected, which would lead to negative consequences and compromise of the concept.

If satisfactory environmental and economic effects are achieved in initial phases, activities could be spread to rest of coppice and insufficiently stocked stands whose reconstruction could significantly increase the production potentials in future.

Restoration of forests after fire

Permanent damage inflicted on forests due to natural disaster where the condition of a stand is infringed to such extent that its removal and replanting is required mostly occurs in Serbia as a consequence of forest fires. Depending on fire type and intensity, wood obtained after cuts is often quite damaged and usable only as firewood or biomass. Also, fires most frequently occur in coniferous stands which have not achieved their technical maturity, thus the percentage of technical wood is minimal. Restoration of burnt area most often is not cost-effective due to the damage of trees and low value of assortments. As for many reasons, these stands need to be

recovered in as short time as possible, by removing burnt trees, field preparation and planting, they represent a potential resource for biomass production.

According to [29], 16 357 ha was burnt in forest fires (853) in the period 1999-2008. Average burnt area per forest fire was 19.18 ha. For the purpose of burnt area restoration by means of artificial recovery, 8,355 ha were recovered by planting, 2,491ha were recovered by seeding.

Beside the efforts made on the prevention of forest fires, taking into consideration increasingly expressed negative effects of climate changes, registered trends regarding the increase of the number of forest fires not only in Serbia but globally, it is necessary to have in mind and make long-term plans for burnt area reclamation with full application of measures which will provide preservation of forest ecosystems. Even with the optimistic forecast that scope of fires and amount of trees that needs to be cut will be reduced owing to the undertaken measures for fire prevention in the following period, cuts of certain amounts of trees will still need to be planned, which will be required before reforestation for the purpose of the reclamation of burnt areas. With highly cautious forecast, the amount of about 40,000 m^3 of biomass on annual level can be estimated as the result of the reclamation of existing burnt areas which have not been reclaimed so far, as well as of the ones expected in the following years.

Planting of plantations for forest woody biomass production

One of the objectives of the Forestry Development Strategy for the Republic of Serbia, which originates from insufficient percentage of forest cover in Serbia, implies the necessity to prevent the decrease of areas covered by forests and taking measures for their enlargement.

The Spatial Plan of Serbia from 1996 [2] defined that present percentage of forest cover should be increased to 41.4%, which was then determined to be the optimal level of forest cover. This percentage of forest cover also remained in the Spatial Plan of the Republic of Serbia (2010-2014-2021). Implementation of this objective implies the enlargement of areas covered with forests via afforestation and forest growing on abandoned agricultural, devastated and treeless land, namely on land where it is economically and environmentally justified to grow forests. Practically, for achieving the stated objective it is necessary to grow about a million ha of new forests in long term.

By applying different methodology and approach from the one applied in the Spatial Plan of the Republic of Serbia from 1996, the NFI also estimated with quite high reliability that there were 474,400 ha (6.1%) of the so called other wooded and barren land in Serbia. The forest inventory did not cover agricultural and marginal agricultural land, so that plans about potential million ha of new forests are not unfounded. In the Spatial Plan from 1996, total agricultural land was planned to be reduced by about 34,200 to the benefit of other purposes, including forests. The valid Spatial Plan of the Republic of Serbia anticipates that 26,900 ha should be afforested in the period 2010-2014, or 5380 ha per year.

Having in mind these plans referring to the enlargement of areas covered with forests and the needs of society for a significant amount of biomass, it is necessary that part of new forests are earmarked for biomass production. Due to the significance of woody biomass, the percentage of dedicated plantations for its production should not be less than 10% of total afforested areas. If objectives from the Spatial Plan of the Republic of Serbia are accepted where annual afforestation level of about 5,000 ha, data is obtained that in the next 10 years it is necessary to grow new 5,000 ha of forests for this purpose. If identical area of agricultural land is dedicated for the same purpose, annual level of planting of 10,000 ha of short-rotation dedicated plantations for woody biomass production could be reached. Having in mind that this is planting

of fast-growing tree species, total average annual production of these stands should not be less than 100,000 m^3 of forest woody biomass. Further increase of the area under forest plantations is certainly possible and can significantly affect the increase in biomass production.

Firewood

Firewood is often categorized as biomass since it is primarily intended for the production of thermal energy. However, traditional manner of firewood use is contrary to the objectives of modern biomass use and it should be observed separately.

Throughout history, Serbia has leaned on forests and wood has been an important and always present energy-generating product for centuries. Tradition has remained that forests in private ownership are mostly used for heating and food preparation. This form of energy is still the most acceptable for the population from the economic aspect. Wood is mostly used from own forests, owners perform cuts, production and transport of wood on their own so that their costs are minimal.

Today in Serbia, firewood has a very developed market and consumers spend practically all produced amounts. The use of firewood has a highly expressed social component because it is the only available energy-generating product for a large part of the population. Redirection of firewood market from present consumers to another consumption type (district heating systems, pellets, wood panels, *etc*.) could lead either to social problems (because of the reduction of firewood supply for population) or to increased scope of forest use (over the allowed limits), namely social and economic component of forest management would be significantly jeopardized. These are the reasons why firewood in the present consumption manner cannot contribute to the provision of additional amounts of biomass in Serbia.

The exact scope of cuts in private forests is unknown. With full control and recording by companies operating in private forests, about 1 milion m^3 of wood is cut annually, out of which more than 80% is firewood. Additional one milion m^3 of firewood is produced in state forests, which is the total of almost two milion m^3 of officially registered firewood annually.

However, many studies on firewood consumption point at the fact that actual firewood consumption is much higher than the officially registered. According to the study on evaluation and financing of forests in Serbia, consumption of firewood from forests was determined to be 8.72 milion m^3 [30]. Another study, also on firewood consumption in Serbia [31], came to the conclusion that "'Firewood is still the most widespread energy resource for households. A survey conducted among households shows that about 11-12 milion m^3 of wood is used for heating during winter time in Serbia".

According to [13], based on the results of the TCP/FAO Project "Wood-based energy for sustainable rural development in Serbia", total firewood consumption for household heating purposes was 6.36 milion m^3 in 2010 . Research in this project represents comprehensive research regarding wood fuel consumption, which implies the conclusion that the obtained results have a high reliability.

Without analyzing actual consumption of firewood in Serbia, it can be concluded that it is much higher than the officially registered value and that it represents a significant energy resource. Also, use of wood as energy resource in households is extremely irrational due to the use of outdated and inadequate stoves. This leads to an obvious conclusion that with the increase of efficiency degree of firewood use significant amounts could be "released" which would contribute to the increase of modern biomass production. Practically, transfer from traditional to modern way of biomass use can create space for the substitution of other energy-generating products without increasing cuts.

Total potentials for biomass production

Based on the given analyses, it can be concluded that total estimated potentials for forest woody biomass production can reach the amount of 0.795 milion m^3 on an annual level (tab. 3). An amount of 0.5 milion m^3 could be reached in initial years of use and does not require significant investments. An amount of 0.795 milion m^3 of woody biomass annually is estimated for the following period of use and it requires investments, technical preparations, subsidy measures and other preconditions. If production is realized in this amount, and that previously necessary requirements have not been met or consumption of fuel wood not reduced, with certainty it can be estimated that sustainability of forest yield is to be compromised.

Table 3. Potential annual production of forest woody biomass (without firewood) in Serbia

Resource	Biomass [10^3 m^3 per year]	Tonnes of dry wood [10^3 t per year]	[kWh]	[toe]
Logging residues	435	300	1,005,285	86,439
Reconstruction of devastated forests	220	152	508,420	43,716
Restoration of burnt forests	40	23	92,440	7,948
Short-rotation plantations	100	50	231,100	19,871
Total	795	525	1,837,245	157,975

Source: original (author's calculations)

After the first years of forest woody biomass use, further increase of use is possible and will depend on achieved development objectives in the previous period. This primarily depends on the results achieved in the reconstruction of devastated forests, growing of dedicated plantations, extent of forest roads construction, technical equipment and other factors.

Amounts of forest woody biomass given in tab. 3 are estimated only for forests and woodland. Abandoned agricultural and other land, which in natural succession is overgrown with bushes and forest trees, represents potentially significant resource of forest biomass and it should be analyzed from the aspect of agricultural areas preservation. If agrarian policy defines the need to preserve these areas for agricultural purposes and if subsidy measures are used to stimulate activities for the removal of bush and tree vegetation, additional amounts of biomass could be produced. On the other hand, by changing the purpose of these areas in the direction of biomass production also opens new perspectives in long term.

Comparing the obtained results with the results of previous research shown in tab. 1, significant discrepancies are noticeable. These discrepancies result from different approach to the analysis of potentials for biomass production. Research in this paper had the aim to point at production potentials which are not operational now and which can be activated with the change in approach to forest use and technology improvement. Earlier analyses included also the existing firewood production as a potential for biomass production, which is not the situation in this analysis. It surely is biomass, however not in the present constellation due to the reasons given in the previous chapter. Additionally, analysis included potentials of forests and woodland only, unlike previous studies which also included non-forest areas.

It should be mentioned that the realization of the stated plans requires unambiguous and clear support of authorized institutions and subsidies from the budget of Serbia. Realization also requires establishment of control and supervision system in the chain of forest woody bio-

mass use, as well as the adaptation of planning and forest management systems. It must not be allowed for uncontrolled market development and increase of woody biomass demand to lead to intensified pressure on forests and exceeding the allowed cuts. In that case, positive effects of biomass use on one side could lead to the degradation of forests on the other.

Conclusions

In forest biomass production in Serbia there are unused potentials. However, Serbia has not great reserves in forest biomass, but there is a potential for its future production. Total estimated potentials for forest woody biomass production, without firewood, in the first phase of its utilization is around 0.766 milion m^3 on annual level. Scope of using these amounts is directly connected with investments. Further increase of the scope of use is possible and will depend on achieved development objectives in the previous period, achieved results regarding the reconstruction of devastated forests and size of established forest plantations as well as other conditions already stated

In present conditions, firewood represents a significant energy potential which is not used in an appropriate manner. Today, firewood in Serbia has a very well developed market and consumers who practically consume all produced amounts. Firewood use has a highly expressed social component and it needs to be available to the population. Increase of efficiency degree of firewood use can "release" significant amounts which would contribute to the increase of biomass production in its contemporary form and way of use. Moving from traditional to modern manner of biomass use can create free space for the substitution of other energy-generating products without increasing the volume of cuts.

Intensive use of forest biomass requires the establishment of system measures for control and supervision in the chain of use as well as the adaptation of the planning and forest management pattern. It must not be allowed for the increase of woody biomass demand to lead to the increased pressure on forests and exceeding of allowed cuts. In that case, positive effects of biomass use on one side could lead to the degradation of forests on the other.

Abandoned agricultural and other land, which in natural succession is overgrown with bushes and forest trees, was not the subject of this analysis, however it represents a potentially significant source of biomass and their potentials should be analyzed from the aspect of agrarian policy and preservation of agricultural areas. Also, wood residue from primary and final processing, recycled wood and other potential biomass sources can have a significant contribution to the increase of total available amounts.

References

[1] ***, Spatial Plan of the Republic of Serbia, Serbian Parliament, Belgrade, 2010
[2] ***, Spatial Plan of the Republic of Serbia, Serbian Parliament, Belgrade, 1996
[3] Ninić, N., Oka, S., Biomass Combustion for Energy Purposes, *Proceedings*, Round table "The Use of Biomass Combustion", Yugoslav Society of Thermal Engineers & Naučna Knjiga, Belgrade, 1992, p.104
[4] Nikolić, S., Forest Biomass as a Significant Component in Solving the Global Energy Crisis, *Proceedings*, Round table "The use of Biomass Combustion", Yugoslav Society of Thermal Engineers & Naučna Knjiga, Belgrade, 1992, pp. 45-60
[5] Oka, S., Jovanović, Lj., *Biomass – Renewable Energy Source* (in Serbian), Yugoslav Society of Thermal Engineers & Naučna knjiga, Belgrade, 1997, p. 117
[6] Danon, G., *et.al*., *Forest Biomass as a Significant Source of Energy* (in Serbian), Yugoslav Society of Thermal Engineers & Naučna knjiga, Belgrade, 1997, pp. 29-51
[7] Zubac, M., Domestic Equipment and Briquetting Technology, *Proceedings*, Conference The Importance and Perspectives of Biomass Briquetting, Vrnjačka Banja, Serbia, 1996, pp. 25-34

[8] Janežić, T., *et al*., Bark Utilization for Energy Purposes, *Proceedings*, 8th European Conference on Biomass for Energy, Environment, Agriculture and Industry, Wien & London, 1994-1995
[9] Ilić, M., *et al*., The Energy Potential of Biomass Residue and Technologies for Its Preparation and Use of Energy in Serbia, NP EE611-113A, Ministry of Science and Technological Development, Belgrade, 2003
[10] Grubor, B., *et al*., The Technical Possibilities and Economic Feasibility of Biomass Energy Potential in selected Municipalities in Serbia, NP EE271048, Ministry of Science and Technological Development, Belgrade, 2005
[11] Banković, S., *et al*., National Forest Inventory of the Republic of Serbia (in Serbian), *Šumarstvo, 3* (2008), July-Sept., pp. 1-16
[12] ***, National Forest Inventory of the Republic of Serbia, Ministry of Agriculture, Forestry and Water Management, Belgrade, 2008
[13] Glavonjić, B., Consumption of Wood Fuels in Households in Serbia Present State and Possible Contribution to the Climate Change Mitigation, *Thermal Science, 15* (2011), 3, pp. 571-585
[14] Glavonjić, B,. The Economic (Macro-Level) Aspects of Wood Energy Systems in Serbia, FAO, Rome, 2009
[15] Glavonjić, B., The Economic (Micro-Level) Aspects of Wood Energy Systems in Serbia, FAO, Rome, 2010
[16] Danon, G., *et al*, Woody Biomass as a Resource for Sustainable Development in Serbia, Ministry of Science and Technological Development TR 20070, Belgrade, 2008-2010
[17] Furtula, M., *et al*., Potential of Wood Biomass for Energy from Forestry and Wood Industry in Serbia, *Proceedings*, 17th International European Biomass Conference and Exhibition, Hamburg, Germany, 2009, pp. 315-319
[18] Furtula, M., *et al*., The Possibility of Substitution of Fossil Fuel with Wood Biomass in the National Parks Kopaonik and Tara, *Proceedings*, 18th International European Biomass Conference and Exhibition, Lyon, France, 2010, pp. 283-287
[19] Danon, G., *et al*., Wood Biomass for Energy in Montenegro, *Thermal Science, 14* (2010), 3, pp.783-798
[20] Kadović, R., *et al*., The Study of Climate Change and its Impact on the Environment: Monitoring, Adaptation and Mitigation, III 43007, Ministry of Science and Technological Development, Belgrade, 2011-2015
[21] Medarević, M., *et al*., Sustainable Forest Management in Serbia – State and Potentials (in Serbian), *Glasnik Šumarskog Fakulteta, 97* (2008), pp. 33-56
[22] ***, Forestry Statistics for 2010 – Cutting of Trees in the Republic of Serbia, SRB128 ŠU20 200511, Statistical Office of the Republic of Serbia, Belgrade, 128, 2011
[23] Bajić, V., Assortment Tables for Beech Forests, PE "Srbijašume", Belgrade, 2009
[24] ***, Annual report 2010, LESY Slovenskej Republiky, Banska Bystrica, Slovakia, 2011
[25] Krstić, M., Stojanović, L., Melioration of Degraded Beech Forests in Order to Improve the Condition (in Serbian), *Šumarstvo, 1-2* (2003), pp. 39-58
[26] ***, Forestry Development Strategy of the Republic of Serbia, Government of the Republic of Serbia, Belgrade, 2006
[27] ***, Conversion of Coppice Forests into Height Silviculture Form, on the Areas Managed by Srbijašume (preliminary study), Republic of Serbia Ministry of Agriculture, Trade, Forestry and Water Management, Belgrade, 2011
[28] Dražić, M., *et al*., State of Coppice Forests and Silvicultural-Economic Effects of the Proposed Improvement Measures (in Serbian), *Šumarstvo, 4-5* (2000), pp. 13-23
[29] Aleksić, P., *et al*., Forest Fires – Ecological and Economic Problem in Serbia, *Botanica Serbica, 33* (2009), 2, pp. 169-176
[30] ***, The study of Evaluation of Forest Financing in Serbia, GCP/FRY/003/FIN, FAO, Belgrade, 2007
[31] ***, Stuck in the Past – Energy Environment and Poverty in Serbia and Montenegro, CESID, Belgrade, 2008, ISBN 978-86-83491-48-3

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