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Potentials, practice and prospects of energy utilization of solid BIOMASS in Serbia

POTENTIALS, PRACTICE AND PROSPECTS OF ENERGY UTILIZATION OF SOLID BIOMASS IN SERBIA

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1. INTRODUCTION

Serbian authorities, especially the Ministry of Mining and Energy, proclaimed a very clear intention to follow European policy in the field of utilization of renewable energy sources –RES. The most significant accepted documents are White Paper, followed by directives related to production of "green" electricity, and use of RES for energy for transportation. This was also followed by the acceptance and signing of the Memorandum of Understanding for the Regional Energy Market in South East Europe and its Integration into the European Community Internal Energy Market. In 2007, Kjoto Protocol was ratified as well. This enables a good base for activities in the field of RES production and utilization, but concrete activities are needed to fulfill declared policy and to achieve stated targets.

The policy is defined and promoted, but not followed by adequate measures to implement stated goals. The incentives are more or less declarative, without economic and financial support, not only for users, but for research and development institutions as well. There is also a lack on appropriated legislation, e.g. feed-in tariff for green electricity etc.

The modest R&D (research and development) funds have been used for few studies and projects aimed to create some kind of data bank and background for getting an impression about possibilities and problems.

Solid biomass has been estimated to have the biggest potential among all RES in the country. Here are presented some of results related to the solid biomass.

The following objectives have been stated:

1. To identify potentials of solid biomass in Serbia usable for energetic purposes.
2. To do survey of current utilization of solid biomass as energy source and estimate future development.
3. To identify the problems of solid biomass energetic utilization and to propose R&D and other activities aimed to overcome these problems.
4. To examine possibilities to solve the identified problems within an international cooperation, especially within the region and neighboring countries, including also long term investigations.

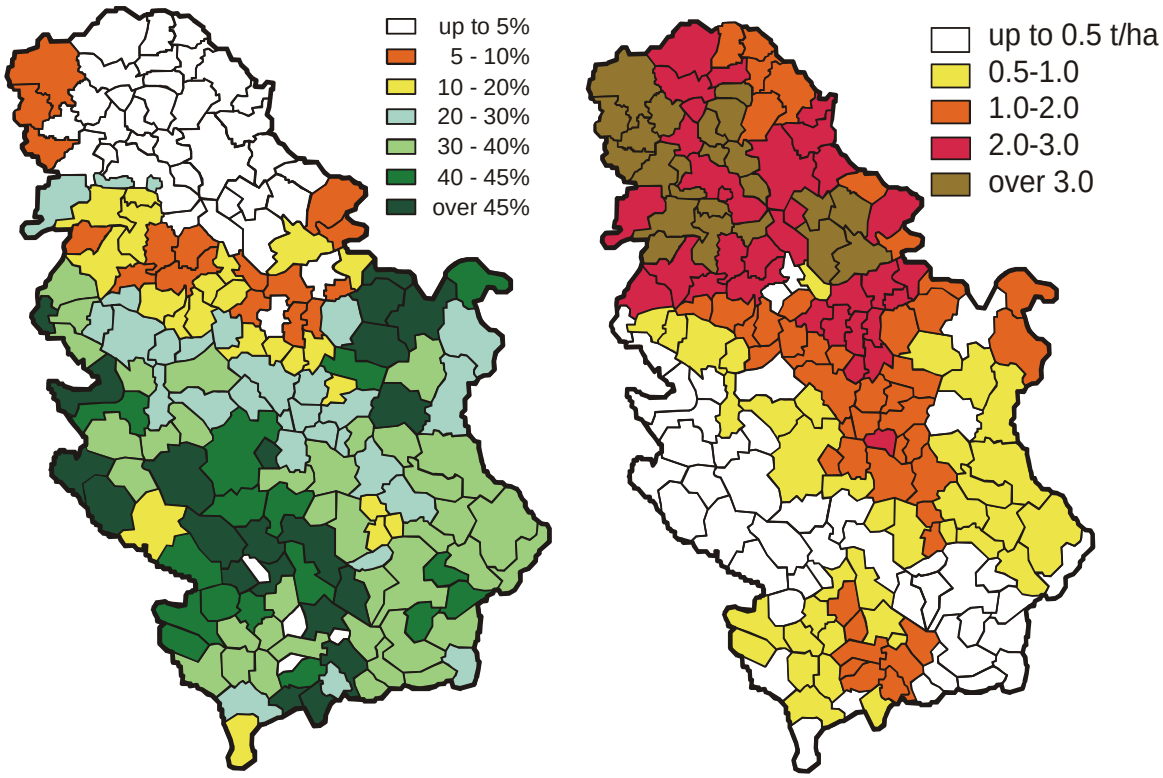
From the very beginning it was clear that the most potential of solid biomass is located in rural areas. That is why an additional objective was to check possibility of simultaneous support of solid biomass utilization and rural development. Hypothesis is: Using adequate policy can be coevally supported production / utilization of RES and sustainable rural development.

Further development of RES production and implementation is a typical multidisciplinary problem. Young researchers should be involved in all steps of its realization. This is also a trans-border issue, which means that world wide, EU or regional cooperation is needed.

2. POTENTIALS, NOW AND UP TO 2020.

Fossil fuels consumption in Serbia is estimated to be in 2008 about 15.5 Mtoe[1] (Mtoe – Million tons of oil equivalent, 1 Mtoe = 41,860 TJ) of primary energy per annum. Solid biomass potential is assessed to be about 2.7 Mtoe, whereby the crop residues are about 1.4 Mtoe[2]. Biomass may cover about 20% of primary energy needs.

The density of forest and crop production is presented in Fig. 1, as the representative of field crops, maize is given as most significant. Obviously, almost all regions are either wooden or crop residues of biomass available.



a) b)

Fig. 1 Density of forests - a), and maize production - b) in Serbia[1]

One new study[3] mentioned annual lumbering in Serbia is 2.6 million of m^3, forest residues are about 0.6 million m^3, and processing residues about 0.48 m^3. The wood processing residues were about 0.24 million of m^3. About 350.000 toe is used as fuel wood. This together makes about 1 Mtoe per annum. Another study[4] gives a very good survey of national forestry, but the data of wood available for energy purposes are not given explicitly.

[1] Energetski bilans Republike Srbije za 2008. godinu, Ministry of Mining and Energy of the Republic of Serbia, Official website www.mem.gov.rs (Accessed in November 2009).
[2] Ilic. M. et al. 2003. Energy potentials and characteristics of biomass residues and technology for its utilization in Serbia (in Serbian). Study financed by the Ministry of Science and Environment Protection of the Republic of Serbia. Belgrade.
[3] Anonym. 2008. Feasibility study on wood waste utilization in Serbia. Energy Saving Group, Belgrade.

Serbia has about 4.5 million ha of agricultural and within this 3.5 million ha of arable land. Field production is practiced on about 2.6 million ha, whereby about 20% belongs to big farms. According to local definition, small farms are, for field crops, these with up to 50 ha, medium ones 50 to 200 ha, and big over 200 ha. There is considerable difference of production technology, approach to energy production and utilization between small and medium (S/M), and big farms - and therefore they were treated here separately.

Future biomass source should be also short rotation coppices (SRC), whose will be primary grown on inferior soils. For this kind of production, locally specific plants, profitable harvesting and processing technology are needed.
In a frame of the study of biomass applicability for cogeneration (CHP)[5], the detailed calculation of available crop residues has been provided, but only for the province Vojvodina.

Based on the common technology, impact of tillage technology and other utilization of crop residues (e.g. bedding), the field crop residues have been calculated: harvestable and usable for energy purposes, Tab. 1.

Tab. 1 Calculated mass of field crop residues and potentials for energy in the province Vojvodina[2]

Crop	T[2]	Acreage, 1,000 ha	Big farms, 1,000 ha	S/M farms, 1,000 ha	Harvestable, 1,000 t		Potentials for energy purpose, 1,000 t	
					Big farms	S/M farms	Big farms	S/M farms
Wheat	↓	336	142	194	300	340	285	305
Ray	—	1.15	0.42	0.73	1	1.3	1	1.2
Barley	—	60	29	31	60	55	57	50
Maize	↑	627	114	513	s 114 c 10	s 310 c 360	s 110 c 10	s 280 c 330
Sunflower	—	166	65	101	0	0	0	0
Soybean	↑	111.5	56	55.5	120	115	120	115
Oil rape[1]	↑↑	15.4	12.3	3.1	30	8	30	8
TOTAL					635 1,824	1,189	613 1,702	1,089

s– maize stover; c– maize cobs; [1]data for 2006; [2]trends of growing

As shown, the amount of crop residues is bigger at S/M farms. The highest potential have maize cobs, with residual material remaining after natural drying of ears and threshing. Second one is wheat straw, and third, recently very popular, soybean straw.

Available biomass for energy purpose, in the province Vojvodina is about 1.7 million tons, or about 0.57 Mtoe. In addition, the pruning residues are about 0.3 million tons, or 0.1 Mtoe. The amount of crop residues is for whole Serbia 2.5 to 3 times higher, and for pruning residues at least 3 times higher. This means, formerly estimated available 1.4 Mtoe of total available crop

[4] Anonym. 2009. The National Forest Inventory of the Republic of Serbia – The Growing Stock of the Republic of Serbia. Ministry of Agriculture, Forestry and Water Management of the Republic of Serbia – Forest Dorectorate, Belgrade.
[5] Martinov. M., Djatkov. Dj. 2008. Possibilities of Use of Biomass for Cogeneration in Vojvodina. Faculty of Technical Sciences.

residues biomass for energetic use is very realistic, and could be treated only as underestimated.
The potential of SRC has been estimated also only for the province Vojvodina. It is about 0.16 Mtoe. For the whole Serbia, this should be at least tripled, i.e. about 0.5 Mtoe.

Potentials up to 2020.

In the future, it is expected increase of available biomass. This can be achieved through development of new energy oriented management of agricultural production and forestry. Significant future potential presents SRC. The same is expected for pruning and processing residues. In some sector, like SRC, potential up to 2020. could be doubled. Detailed forecasting has been done for province Vojvodina[2], and for the whole Serbia estimated. Of course, future development depends on policy and incentives.
Concluded: forestry biomass potentials could be up to 2020. about 1.5 Mtoe, crop residues about 2.5 Mtoe and SRC about 1 Mtoe[6]. Total is about **5.0 Mtoe**, or more than one third of primary energy needs in the country. It is expected that one part of solid biomass will be used for production of LCB (Lignocelluloses Bio-ethanol).

3. CURRENT PRACTICE, STATUS

Wooden biomass and crop residues are traditionally used as energy sources. It is very difficult to find out how much of solid biomass is used for heating. Based on study of biomass utilization for heating purposes in three villages in Serbia[7], the rough estimation has been done for field crops residues, Tab. 2.
Tab. 2 Assessment of currently used crop residues for heating in Serbia[3]

Crop residue	Big farms, 1,000 t	S/M farms, 1,000 t
Cereal straw	150	400
Maize stover	–	60
Maize cobs	10	600
Soybean straw	20	10
Total	180	1,070
	Σ 1.250,000 t	

Comparing with potentials, 4.2 million tons of crop residues available for energetic use in Serbia, today is used about 30%, thereof over 85% from S/M farms.
Lots of forests are private owned, and there are no possibilities to estimate the amount of wood used for heating of owned buildings, or sold to other users. According to the official data of the Ministry of Mining and Energy, the total primary energy of biomass used for heating is 22,200 TJ. Previously presented crop residues energy, calculating with average net calorific value 14 MJ/kg (moisture content 15%), makes 17,500 TJ per year. For wooden biomass left about 5,000 TJ. Calculating net calorific value of wooden biomass15 MJ/kg, it makes only about

[6] Martinov. M. Scholz. V. Skaljic. S. Mihailov. N. Domac. J. Ilev. B. Fara. L. Ros. V. 2006. Prospects of Wooden Biomass Production in Southeastern European Agricultural Areas. Proceedings of 34th Symposium "Actual Tasks on Agricultural Engineering". 97-110. Opatija. 21-24 Feb. 2006.
[7] Martinov, M., Tesic, M. and B. Stepanov. 2005. Solid biomass for household heating in rural areas – Case study for a village in Pannonia region of Serbia and Montenegro. 27th International Conference of CIGR Section IV (The Efficient Use of Electricity and Renewable Energy Sources), Izmir, Proceedings of the Conference, 171-176.

330,000 t. This amount is in reality estimated to be at least four times higher, i.e. over 1.3 million tons. That means the biomass used for heating in Serbia is already now about 2.7-3.0 million of tons, or about 0.9-1.0 Mtoe.

The solid biomass today is mostly used for household heating. There are also big plants for heating of company rooms and for processing purposes. Typical example for utilization of biomass for process heat, but also heating in big farms, is use of maize cobs, residue of seed production.

There is no example for district or central heating in the country. The reason is need for good organization of very individual oriented farmers, and very expensive district heating pipelines. Concluded, the dominant facilities are aimed for household heating. Nominal thermal power is up to 50 kW, and majority under 15 kW. Primary energy of solid biomass used already now makes 6-6.8% of total primary energy used. Actually, the total RES used, is only slightly higher, while biomass is almost only renewable source used today.

Societal impact of energetic utilization of solid biomass

Almost all solid biomass is located in rural areas. This is well-known that the utilization of RES is supported by the society. The good planned policy could simultaneously support both societal goals: to increase production and utilization of RES and to support development of rural areas. One study considered activities in the field of RES and their applicability in rural areas of Serbia[8]. The results are presented in Tab. 3.

Tab. 3 Activities of RES production and utilization that could be performed in rural areas[4]

Renewable energy	**I**	**II**	**III**	**IV**
Solar energy – heaters	–	+	–	0
Solar energy – photo voltage	–	+	–	–
Solid biomass – heating, small units	++	++	++	+
Solid biomass – heating, big units	++	+	++	0
Solid biomass – CHP	++	++	+	0
Solid biomass – co-firing	++	–	0	–
Solid biomass – BtL[1]	++	0	0	–
Plant oils – CHP	++	+	+	–
Biodiesel	++	+	0	–
Biogas – heating and process heat	++	++	0	–
Biogas – CHP	++	0	0	–
Bio-ethanol	++	0	0	–
Wind energy – small scale	–	++	–	0
Wind energy – big scale	–	+	–	–
Thermal water – heating and CHP	–	0	–	–
Thermal water – balneology	–	+	–	–

I- production, II- utilization, III- processing for own use or other users, IV- production of facilities; ++ very intensive, + intensive, 0 possible, – none; [1]- Biomass to Liquid

[8] Martinov, M., Tesic, M. and V. Ros. 2007. Simultaneous Support of RES Production/Utilization and Development of Rural Areas. Second International Round Table: Agricultural Engineering and its Contribution, CIGR Working Group „Rural Development and the Preservation of Cultural Heritages“, Kosjeric, 17-20 of September 2007, Book of Proc: 30-37.

Obviously, most of the activities applicable in rural areas are related to production, processing and utilization of solid biomass.

Within one Eureka project the survey of domestic manufactures of solid biomass facilities, boilers and furnaces, has been done. In this time were 14 of them, Tab. 4, and today it can be expected to be up to 20, including those producing in cooperation with reputable foreign manufacturers. The number of producers illustrates the domestic interest for utilization of solid biomass for heating purposes.

Tab. 4 List of producers of solid biomass heating facilities in Serbia, status 2007

Manufacturer	**Products**
ABC PROIZVOD	Small and medium boilers
ALFA PLAM	Stoves, cookers
EKO PRODUKT	Boilers 120 do 400 kW
KIRKA-SURI	Medium and large boilers
METALAC	Boilers 20 to 80 kW
MINEL KOTLOGRADNJA	Big boilers for waste wood
NIGAL	Medium and large stoves and boilers
Podvis term	Small and medium boilers
RADIJATOR INZENJERING	Boilers 18 to 250 kW, cookers
RAZVOJ	Boilers 40 kW to 1 MW
SUKOM	Boilers 100 kW to 1 MW
TEHNOSERV	Boilers 25 to 120 kW
TERMING	Boilers 40 kW to 1 MW
TERMOMONT	Small and medium boilers
TERMOPLIN	Small and medium boilers
TIPO-REMONT-KOTLOGRADNJA	Medium and big boilers

Most of producers are located in villages and small towns, close to rural areas.
Recently, the production of briquettes and pellets of solid biomass, wood and crop residues, is in expansion. Until now, these forms of biomass are preferably aimed for export.

Problems

The problem of wider use of crop residues as an energy source is also its importance for the preservation of soil fertility. This problem has been considered in Serbia[9], but also world-wide[10]. Preservation of soil is an important issue. Until now there is no scientifically confirmed statement about amount of crop residues that may be removed without consequences and used as an energy source. This amount, of course, depends on climatic and agro-pedological conditions, crop rotation, manure applied and other influences. This is important objective for future investigations that should be performed on European and wider level. The outcome of

[9] Kastori. R. Tesic. M. 2005. Use of Harvest Residues as Alternative Fuel – Advantages and Disadvantages. Agricultural Engineering – Reports for Southeastern Europe. 11(1-4): 22-27.
[10] Powlson, D. 2006. Cereal straw for bioenergy: Environmental and Agronomic Constrains. Workshop: Recourses for Bioenergy in the European Union, Pamplona, Spain, 18-19 October 2006, Book of Proc: 61-67.

such a project should be the background for international and national decisions on sustainable crop residues use as bio-energy.

The next problem is the low technical level of currently used facilities with the economic and environmental consequences. The efficiency of all tested facilities is low, fewer than 60% for boilers and about 50% for stoves, and emission of pollutants high[11]. That means, current practice contribute reduction of fossil fuel consumption and supply security, but in the same time causes pollution of environment by high emission of undesirable compounds.

There is clear defined lack of legislation in this area. Latest regulation *Pravilnik o graničnim vrednostima emisije, načinu i rokovima merenja i evidentiranju podataka*, was purchased in 1997 (Official gazette of the Republic of Serbia). This has mentioned the small facilities, less than 1 MW, only in one paragraph, without giving concrete data on emission limits. The creation of legislative should be followed by establishing of at least two legal and well equipped stations able to provide all needed measurements and deliver certificates. The limits for emission should also be stated to enable its fulfillment in this moment, and fixed for the certain period, i.e. five years. After this period, there should be stated lower limits. So, step by step, there should be reached European standards in this field.
Subsidies for technologically advanced solution should be introduced, to enable incentives for producers to improve their products, as well as consumers to invest in environmental sound solutions.

4. VISIONS AND PROSPECTS

Biomass type

The price of the fuel plays an important role for the consumers. In the following table, the calculations for net and gross kWh prices of diverse biomass are given. Obviously, the prices for crop residues are more attractive for consumers.
Tab. 5 Prices of biomass per kWh of primary energy and net energy for maximal efficiency of primary conversion (combustion), status 2008[2]

Biomass	Price, € t^{-1}	In €c $(kWh)^{-1}$		Approximate net heating value, MJ kg^{-1}
		gross	net	
Crop residues[1], straw, MC ca. 15%	38	1.0	1.7	14
Maize cobs[1], MC ca. 15%	35	0.9	1.5	14
Wood chips[2], MC ca. 15%, TD up to 50 km	62	1.5	1.9	15
Wood chips[2], MC ca. 35%, TD up to 20 km	50	1.6	2.0	11.5
Wood processing residues[2], MC ca. 10%	25	0.6	0.8	15.5
Plant oil[3]	600	5.3	6.2	41

[1]Efficiency 60% [2]Efficiency 80% [3]Efficiency 85% MC– moisture content TD– transport distance

[11] Brkic. M. Martinov. M. 2006. Efficiency and Emission of Solid Biomass Combustion Facilities in Vojvodina. Proceedings of the CIGR World Congress: Agricultural Engineering for Better World. Archive number 440119580733. ISBN 3-18-091958-2. Bonn 03-07 Sept. 2005. Proceedings CD. VDI Verlag GmbH. Düsseldorf.

Obviously, the prices of crop residues are lowest, with exception of wood processing residues. Some constrains of its wide use are related to preservation of soil fertility and the low bulk density, that impacts the costs of transportation and storage.
In the other hand, crop residue characteristics relevant for the combustion technique are considerably different in comparison with wood, fig. 2.

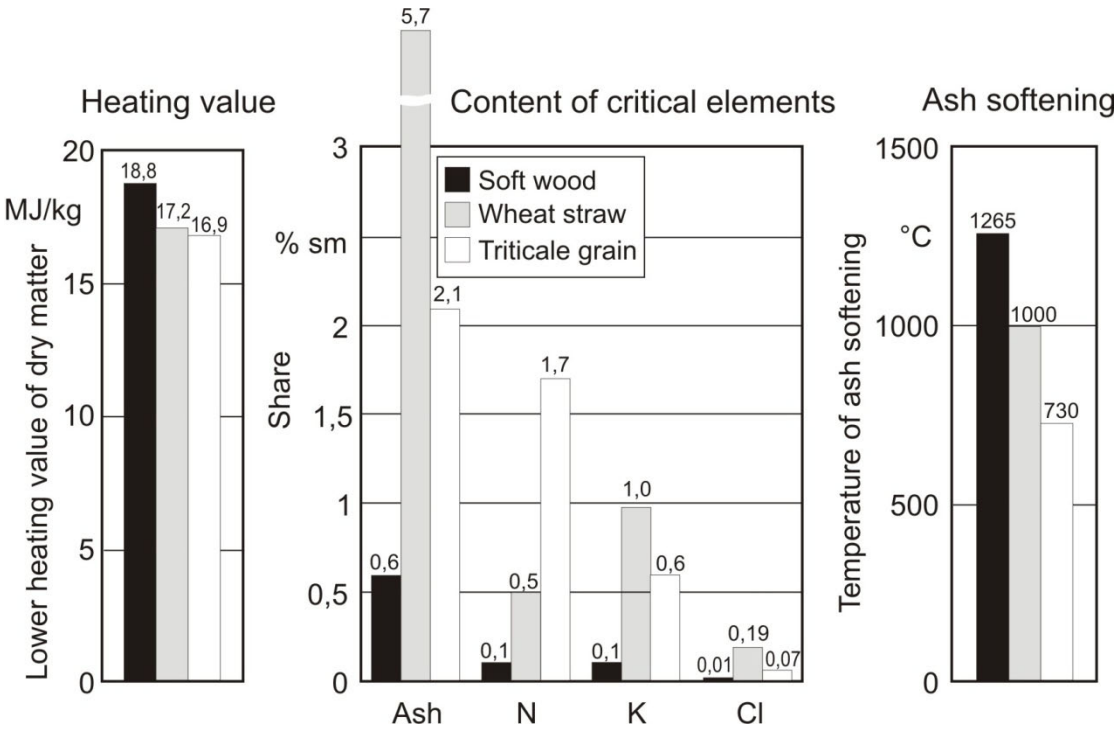


Fig. 2 Comparison of wood, crop residues and grain characteristics as a fuel[12]

The lower heating value of dry matter is little bit lower, but the ash content much higher, as well as content of critical elements. This is why additional measurements for exhaust gas purification are needed. Until now,they have not developed low-cost solutions for this, e.g. electro filters. Investment in these filters is payable first for bigger boilers, thermal power 500 kW and more. There is need for further development of gas purification to achieve proper solutions that can enable acceptable values of emissions.

The ash softening point of crop residues is also much lower, what can causes problems in combustion chamber. The combustion process should be clearly divided into two phases, gasification, with lower temperature, and secondary combustion of generated gases.
That means, crop residues will be attractive as solid biomass also in the future, firstly for the small facilities, aimed for household heating. Those should be improved to bring higher efficiency and lower emission of pollutants, but it is not realistic to expect introduction of obligatory testing for the power range up to 15 kW in the next ten years. The improvements could be introduced by the development of design of advanced stoves that can be constructed by users or by small workshops. The documentation for its construction should be available for them free of charge. The other possibility is to ensure subsidies for the buyers of advanced and

[12] Hartmann, H., Reisinger, K., Thuneke, K. 2007. Handbuch Biogenergie-Kleinanlagen. Fachagentur Nachwachsende Rohstoffe e.V. (FNR), Gülzow.

tested stoves and boilers, manufactured by companies. This is some kind of technological support for both manufacturers and users.

The increase of efficiency of used biomass facilities has been estimated to be an important task for future R&D activities. Adoption of legislation related to efficiency and emissions from developed European countries should be done, but step-by-step in next six to ten years. In parallel, new low cost facilities have to be developed and should be offered to the users in rural areas.

It will be much easier to improve wooden biomass facilities. In next period the following objective should be stated: to have efficiency of wooden logs and wood chips boilers over 80%, and for wood pellets over 85%. This can be realized by appropriate legislation and bonus, subsidies for most advanced solutions.

Big boilers for central and district heating, over 500 kW, should have, for crop residues, efficiency over 80% and for wooden biomass over 85%. This should be accompanied with strength limits of pollutants and solid particles.

Cogeneration and electricity production

Cogeneration and electricity production will be also implemented. CHP is most suitable if the heat energy would be used for processes, or, if they are situated close to bigger settlements, with potential consumers. Adoption of feed-in tariffs for privilege electricity producers is expected to be provided in next six months. This should be followed by adequate regulations, but it is already known that it will be much easier to get approval for units with electric power up to 10 MW.

Province Vojvodina is faced with lack of electricity producers. It is reasonable to use crop residues as energy sources, but these plants can be only exceptionally located in the vicinity of bigger settlements. That means, it is better to built power stations. Four crop residues power stations, with electrical power 10 MW each, can produce (about 8,000 operation hours per year) about 320 GWh per year. They will need about 300,000 t of straw. Similar is expected also for SRC that will be produced in the future. Total electricity production from biomass could cover about 10% of today consumption in the province.

Construction of CHP plants and power stations for wooden biomass is possible in the forestry regions of Serbia. The total electricity production in whole country could be five to six times higher, up to **2 TWh**, and this is only about 8% of electricity consumption in the country, but higher than assessed potential of small hydro (about 1.6 TWh).

Production of pellets and briquettes and co-firing

Production of pellets and briquettes is more and more popular. This is a typical added value activity that could be provided for rural areas. This can not ensure higher potential of biomass, but can make possible use of biomass also in urban areas, due to much better transportation and storage ability of compressed biomass. Production of briquettes of forestry and wood processing residues and co-firing of it in central heating facilities is already in progress, and more such examples are expected.

Pellets made of straw are still to expensive for domestic users, 100 to 120 €/t, and most of them try to export them. There is no laboratory in the country equipped for full testing of pellets in accordance with European standards, and this is obstacle for business development.
Co-firing of crop residues is now heavily profitable why the most of coal power stations are located out of agricultural areas with big plots. By 2020. it could be expected the utilization of up to 0.3 Mtoe of crop residues. The potentials of wooden biomass are bigger, up to five times, but its utilization depends on prices and national policy.

Energy utilization of urban and other wastes is now at the beginning phase. One study, done for the province Vojvodina, showed that only the use of landfill gas can be profitable. Unfortunately, obviously by mistake, energy from municipal wastes is not included in proposed feed-in tariffs for privilege producers of electricity. This must be changed, and survey of potentials of this solid biomass energy source elaborated.

5. CONCLUSIONS

Already, solid biomass is a dominant renewable energy source in Serbia, and makes about 6% of total primary energy used. The current potential for energetic utilization is estimated to be about 2.7 Mtoe, or about 20% of total primary energy used. Obviously, it is now used less than one third of potentials.

By 2020. this potential by application of proper policy and incentives, accompanied with adequate R&D activities, can increase up to 5.5 Mtoe. This can cover up to one third of primary energy in Serbia.

First objective in the next period is to increase efficiency and reduce the emission of all biomass facilities. The desirable minimal thermal efficiency of small units, up to 100 kW, should be: for crop residues 70%, for wood logs and chips 80%, and wood pellets 85%. For big units, aimed for district or central heating and processing minimal efficiency should be 80% for crop residues and 85% for wooden materials. Regulations are needed urgently for this issue, followed by establishment of adequate testing and certification institutions. For support of improvement of small facilities, professional instruction is needed for manufacturers and users, as well as some subsidies for technological advancements.

Biomass CHP plants and power stations can produce up to 2 TWh per annum, up to 2020, but firstly must be feed-in tariffs for privilege electricity producers put into legislation.
The energy production from municipal wastes must be more focused, and energy use of landfill gas seems to be realistic up to 2020.