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Review and analysis of renewable energy perspectives in Serbia

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Abstract
Nowadays, Serbia needs to disengage from the broad use of fossil fuels and turn to the "attractive" Renewable Energy Sources (RES) for energy production, since the Kyoto Protocol ratification, so as to resolve systematically the problem of energy demand. In addition, research indicates that Serbia is a country with high potential and favourable conditions for RES energy production, as the country's potential could supply almost half of its primary energy needs. The paper provides an overview of Serbia's energy sector status quo, so as to emphasize the necessity for RES implementation in order to balance the country's energy deficit. The aim is to investigate and present the country's prospects in the RES sector, revealing the proven RES potential and pointing out that the unexploited RES potential together with an adequately well structured energy sector would create great possibilities and conditions for a new market.

Keywords: Energy sector, Renewable energy sources, Serbia.

1. Introduction

The Republic of Serbia is located in South-Eastern Europe, in the heart of the Balkan Peninsula. The country of Serbia is characterized by an energy deficit, which continues to grow. Serbia is an energy-wise medium-dependent country, as the annual consumption of all types of energy is greater than the domestic production, with a total dependence of around 40% [1].

After the institutional changes occurring in the year 2000, Serbia initiated an ambitious program aiming in the reform and stabilization in all sectors, also including the energy sector. Within this framework, in 2004 the country adopted the Energy Law, while in 2005, the Ministry of Mining and Energy (MoME) developed the Energy Development Strategy up to 2015. In 2007, Serbia ratified the Kyoto Protocol, taking over the responsibility to increase the portion of energy produced from Renewable Energy Sources (RES) up to 20% until 2012 [2]. Moreover, in line with the Energy Law and the Strategy, the MoME prepared the Energy Strategy Implementation Programme - ESIP 2007–2012, which defined conditions, methods and time schedule for the implementation of the Strategy in all the major parts of the energy sector.

Towards this direction, among the priorities of Serbia's energy policy in the near future, as foreseen by the Energy Development Strategy up to 2015, are to exploit RES, including biomass, geothermal, solar, and wind power, as well as to retain hydroelectric potentials which, utilization is technically possible and

economically feasible, especially on smaller rivers [3]. Furthermore, the Strategy targets the increase of RES share in the total energy production from 1,5% (2006) to 4,5% (2010), the increase of RES share in total energy consumption to 1,5-2% by 2015 and a 20% decrease of the specific energy consumption by 2020, while it includes directives for biofuels, which are in line with EU Directives [4, 5].
Currently, as officially registered in the Serbian Energy Balance, the only RES utilized for electricity generation is hydropower [6], while non-commercial use of biomass and geothermal energy also occurs [7]. On the other hand, researches point out that Serbia will be capable to respond adequately to Kyoto Protocol demands and to the European rules, regarding the substitution of certain amounts of fossil fuels by RES [4], due to large potentials in all types of RES and especially from geothermal sources, wind and biomass [2].
Regarding all these factors, scope of this research is to investigate the RES potential existing in the country of Serbia in order to identify the most promising ones for their implementation and integration in the country's energy mix, towards the achievement of the RES targets and the country's disengagement from fossil fuels.
Apart from the introduction, this paper is structured along three sections. Section 2 presents a description of Serbia's energy sector, its electricity and heat transmission and distribution characteristics and its energy production and consumption features. Section 3 provides a detailed analysis of the RES potential in Serbia, while Section 4 summarizes the main results drawn up from this paper.

2. Energy sector current situation

In Serbia there is one main energy state-owned company, the Electric Power Utility of Serbia (EPS), which encompasses coal mines, electric power sources (hydroelectric power plants, thermal power plants, heating plants) and grid distribution systems. The Oil & Gas Company (Naftna industrija Srbije - NIS) that controls the production, refining and distribution of crude oil and oil derivatives, was a state-owned company up until 2005, but during that year the Serbian Government started its privatisation process and in 2006 the government accepted NIS's privatization strategy. Moreover, the Public Enterprise for electric energy transmission and transmission system, which was established in July 2005, controls "Elektromreža Srbije - EMS", the Serbian Transmission System and the Market Operator. As it can be observed, no private companies, involved in generation (only few small private producers for their own purposes), transmission and distribution of energy exist [8].

2.1 Electricity transmission and distribution

The electric power transmission system of Serbia consists of a high voltage system amounting to 400 kV, 220 kV, and 110 kV (part of the system) as well as the other power plants, telecommunication system, information system and other infrastructure facilities necessary for the power system's operation. The total length of the transmission lines (excluding Kosovo) is 8.864 km. In the last 5-6 years the efficiency of the transmission network has significantly improved. Transmission system losses have decreased from values around 4% in 1998-99 to 2.8% in 2007, as the amount of delivered energy continuously increases. EMS has six regional transmission units, namely Belgrade, Bor, Valjevo, Krusevac, Novi Sad and Oblic. The electricity supplied to the distribution subsidiaries and the structure of electricity sales for 2009 is presented in Tables 1 and 2 correspondingly.

Table 1. Electricity Available in 2009

Distribution Company	GWh	%
Elektrovojvodna ltD, Novi Sad	8.799	27,48
Elektrodistribucija ltD, Beograd	7.963	24,87
Elektrosrbija ltD, Kraljevo	7.387	23,07
Jugoistok ltD, Nis	4.889	15,26
Centar ltD, Kragujevac	2.985	9,32
Total	32.023	100

Source: [9]

Table 2. Electricity supplied in 2009

Voltage Level/ Category of Consumption	Electricity Supplied		Number of Buyers/ Measuring Points
	GWh	%	
High Voltage – 110kV	2.052	7,56	32
Middle Voltage – 35kV	729	2,69	158
Middle Voltage – 10(20)kV	4.397	16,19	3.946
Low Voltage (0,4kV I Level)	3.144	11,58	45.956
Consumer Spending (0,4kV II Level)	1.944	7,16	302.095
Consumer Spending - Households	14.412	53,07	3.092.470
Public Lighting	479	1,76	23.736
Total	27.158	100	3.468.393

Source: [9]

2.2 District heating

District heating (DH) systems are an important part of the country's energy sector. There are a total of 45 cities and towns that have DH, provided by about 55 DH companies. DH companies are in the jurisdiction of local government, resulting in a great diversity of conditions, in regard to the companies' operating efficiencies, quality of services provided, financial conditions, etc. Most district heating systems are characterized by low efficiency and by generation and distribution losses that exceed 20 % of generation. The transmission system losses during 2008-2009 are presented in Table 3. The main characteristics of Serbia's heating plants are low operating readiness due to insufficient maintenance and outdated equipment, financial exhaustion and an inability to perform urgent intervention on sources and grids. There is a need for additional capacity. As a considerable part of the population uses electricity for heating, it is a strategic consideration to connect more consumers to the DH network, in order to alleviate the burden on the electricity grid. Additional capacity for this goal is expected to be achieved through DH revitalization and modernisation.

Table 3. Transmission system losses during 2008-2009

Month	GWh	%	Month	GWh	%
Jan 08	133.305	2,94	Oct 08	92.456	2,58
Feb 08	114.293	2,83	Nov 08	100.172	2,58
Mar 08	116.628	2,84	Dec 08	121.854	2,88
Apr 08	99.660	2,87	Jan 09	120.691	2,78
May 08	89.841	2,76	Feb 09	106.302	2,85
June 08	82.905	2,75	Mar 09	106.501	2,73
July 08	98.213	2,97	Apr 09	73.115	2,55
Aug 08	94.590	2,89	May 09	71.169	2,54
Sep 08	80.062	2,54			

Source: [10]

2.3 Energy production and consumption

Serbia has a diverse energy supply sector, composed of coal extraction, oil and gas production, imports of crude oil, oil products and gas, coal and hydro electricity generation, district heating systems and industrial energy systems.

Total Primary Energy Supply (TPES) in Serbia reached 17.6 Mtoe in 2008 [11], a 7.5% rise from the previous year. Serbia imports about 40% of its energy needs, mainly in the form of crude oil, gas and petroleum products. Energy intensity is 0.33 ktoe/US$(2000) the highest among all Energy Treaty parties, indicating that energy is not produced and/or used efficiently.
As presented in Table 4 the power generation installed capacity was 8.359 MW in 2008 (including Kosovo A and B plants), of which 5.171 MW correspond to coal-fired TPPs; 353 MW to CHP plants (dual gas-mazut fired); and 2.831 MW to HPPs. It must be mentioned that, since 1991, Serbia is not operating the two TPPs located in Kosovo (Kosovo A and B). Without these plants, the total installed capacity is 7124 MW. Due to lack of regular maintenance in the period 1990-2000, TPPs' availability was low and threatened the power system operational security. However, reliability of Serbian TPPs improved significantly since 2000. Forced slowdowns were reduced from 19.5% in 2000 to 5.3% in 2008.
The total electricity production in 2008 reached about 40 TWh, of which 30 TWh were produced by TPPs (including CHP) and the remaining 10 TWh by HPPs.

Table 4. Installed capacity of power generation facilities in 2005 and 2008

Power Plant	**Net Output Capacity (MW)**	
	2005	**2008**
TPP Nikola Tesla A	1.502	1.502
TPP Nikola Tesla B	1.160	1.160
TPP Kolubara	245	245
TPP Morava	108	108
TPP Kostolac A	281	281
TPP Kostolac B	640	640
TPP Kosovo A	617	617
TPP Kosovo B	618	618
Thermal Power Plants	*5.171*	*5.171*
TPP-HP Novi Sad	208	208
TPP-HP Zrenjanin	100	100
TPP-HP Sremska Mitrovica	45	45
Thermal Power Plants – Heating Plants	*353*	*353*
HPP Djerdap I	1.058	1.058
HPP Djerdap II	270	270
HPP Vlasina	129	129
HPP Pirot	80	80
HPP Bajina Basta	364	364
PUMPED-STORAGE PP Bajina Basta	614	614
HPP Zvornik	92	96
HPP Elektromorava	13	13
HPP Limske	211	211
Hydro-Power Plants	*2.831*	*2.835*
Power Plants Owned by EPS	*8.355*	*8.359*
HPP Piva	342	342
HPP Gazivode	35	35
Other Power Plants	*377*	*377*
Total	8.732	8.736

Source: [6, 12]

Serbia has a small oil production capacity, which covers about 17% of total oil supply. The country has two refineries with total installed processing capacity of 7.8 million tons a year (4.8 million tons in Pančevo and 3 million tons in Novi Sad). Since 2007, the oil refineries are operating at 84 % capacity only (at 6.6 million tons total: 4.8 million tons in Pančevo and 1.8 million tons in Novi Sad). The length of the oil pipeline network within Serbia is 177 km [12]. The current capacity of the refineries is not sufficient to cover local demand, therefore Serbia imports oil products. Finally, there is also a small gas production, which covers about 10% of total gas demand. The rest is imported from Russia by Srbijagas, a company for trading in and processing natural gas. The total annual consumption of natural gas in 2006 was 2.349 mil m^3.

Regarding the energy consumption, Serbia consumed 15 Mtoe of energy in 2007. The structure of the TPES was as follows: 52% coal (mostly local lignite), 27% oil, 12% natural gas, and 7% hydro [4]. The Final Energy Consumption (FEC) was 10 Mtoe, of which 35% was accounted by industry, 32% by the residential sector and 18% by the transport sector.

In 2007, the total amount of electricity delivered to consumers in Serbia was 28.749 GWh, while the household sector had the greatest share in consumption (52,5%). In 2007 the average selling price of electricity for EPS consumers was 3.699 RSD/kWh or 4,62 €c/kWh, calculated at the average exchange rate of RSD 80,09 for 1€ in 2007. [13, 14]

Changes in the volume and structure of energy consumption per sector reflect the overall tendencies in Serbian economy, as presented in Table 5. Total consumption is still below the 1990 level.

Table 5. Energy consumption per sector (Mtoe)

Year	Industry		Transport		Households & Other		Total Consumption
	Total	%	Total	%	Total	%	
1990	3,92	43	1,82	20	3,29	36	9,03
2002	2,42	35	1,58	22	2,94	42	6,94
2005	2,25	30	1,98	27	3,17	43	7,40
2006	2,59	35	1,77	24	3,00	41	7,36
2008	2,67	35	1,92	25	3,02	40	7,62

Source: [14]

As one can observe, energy consumption has increased within the period 1990-2006, as the overall economic activity and living standards of households raised [15, 16]. The household sector accounted for 43% of energy consumption in 2005, while industry, had a share of about 30% in 2005 [12]. In 2008, the energy consumption seems to stabilize. The household sector accounted for almost 40% of the electricity consumption, which overcame the industry sector that accounted for 35% of the electricity consumption [17]. Finally, the final electricity and heat consumption, for the years 2004 -2006 and the electricity generation structure and gross consumption for 2009 are presented in Table 6 and Figures 1 and 2 respectively.

Table 6. Final electricity and heat consumption

Year	Final Electricity Consumption (TWh)	Final Heat Consumption (TJ)
2004	22,7	32.093
2005	25,6	44.854
2006	26,2	41.387

Source: [11, 18]

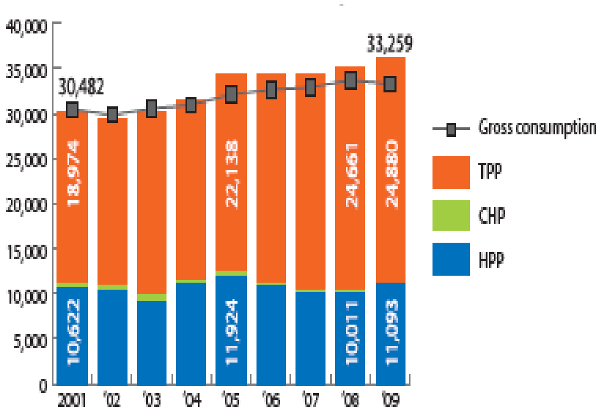

Figure 1. Generation structure and gross consumption, GWh, 2009 (Kosovo & Metohija excluded)

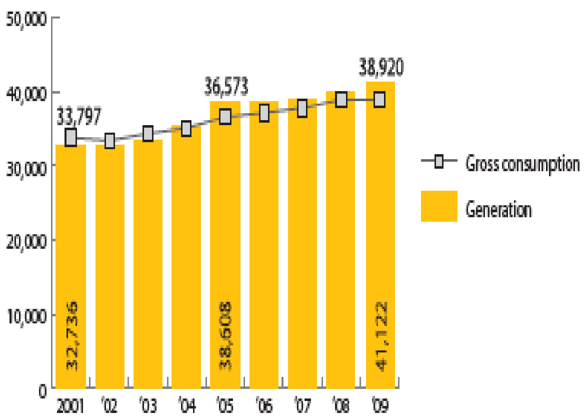

Figure 2. Generation structure and gross consumption, GWh, 2009 (Kosovo & Metohija included)

Source: [9]

3. Renewable energy sources potential

Renewable energy sector in Serbia is in the process of establishment. As mentioned earlier, the utilization of RES is currently limited to hydropower plants, which are also the only RES exploited for electricity, and non-commercial use of biomass and geothermal energy.

According to the data available, total potential of the RES in Serbia, as depicted in Table 7, (considering only small hydro plants up to 10MW) is estimated to 3,83 million toes annually, while a detailed analysis of the potential of each RES occurs in the following sections. Renewable energy potential in Serbia can cover almost half of its primary energy needs. Utilization of this potential is currently 18%, but it is almost entirely based on production of electricity in large HPPs [2].

Table 7. RES technical potential

Type of RES	Technical Potential (Mtoe)
Biomass	2,40
Small Hydro Plants	0,40
Solar	0,64
Geothermal	0,20
Wind	0,19
Total	3,83

Source: [17]

Apart from the RES mentioned in Table 7, Serbia also has potential in energy sources like landfill gas, sewage treatment plant gas, biogas and biofuels, although this potential is neither mentioned, nor actually used, in the country's energy mix, provided by official documentation. This potential will also be investigated in the following subsections.

3.1 Biomass

Energy produced from biomass was traditionally used in Serbia for heat generation, but sporadically, in an organised and very old fashioned way, technically lagging behind.

Assumption is that the non-commercial biomass share in total primary energy production is about 4-5%, and that non-commercial wood consumption in Serbia ranges between 0,46 and 0,54 Mtoe. Biomass is not currently used for electricity generation. However, new facilities are being installed in food and food processing industry. Belgrade municipal heating company plans to develop a new plant in Krnjaca with two boilers of 5 MW, each using biomass (soy and wheat straw). There have also been some initiatives to develop a biomass-fuelled district heating project in Eastern Serbia (Negotin), but the feasibility study concluded that the project was not justifiable [14].

Every year the country produces around 12,5 million tons of biomass (60% from agricultural production and 40% from forests) and most of it is not used effectively. Ultimately, the production of the current waste material could be equivalent at about 19% of Serbia's fossil fuel consumption. Among the alternative energy options, biomass provides the most cost effective source and would be the quickest to implement.

The county's biomass potential is around 2,4 Mtoe annually, (63% share in the total RES potential), where more than 1 Mtoe represents the wood biomass potential (woodcutting and wood mass refuse produced in its primary and/or industrial processing) and more than 1,4 Mtoe constitutes agricultural biomass (agricultural and farming cultivation residues, including also liquid manure) [9, 19-21]. Production of pellets is also considered as very promising, with a potential of 250-350 kt per year from sawmill waste [22].

With 55% of its territory being arable land, and 25% under forests, Serbia has high biomass potentials. Northern Serbian province of Vojvodina has the highest potential in agricultural waste, providing 8-12 Mtoe of biomass annually. Energy potential of biomass is concentrated in the waste from forests and wood processing industry (98% from agriculture, 1,5% from forest production, and 0,5% waste from wood production). The popularity of the use of briquettes and pellets is increasing, similarly to other countries with good forest resources. [14]

The main constraints on realisation of biomass capacity potential are the lack of experience, the lack of a fully developed market, and the fact that most of the domestic production is exported [17].

3.2 Hydro power

The total technical hydropower potential in Serbia is about 17.000 GWh (1,5 Mtoe), out of which about 60% is currently utilized. The unused potential (0,9 Mtoe) is situated mainly in the catchments of Drina and Morava rivers and it can be utilized for large as well as for small HPPs. According to the electricity utility company Elektroprivreda Srbije, this potential may be used in 52 large HPPs that would have average capacity of around 25 MW. There are still no final plans for establishing any of the defined large HPPs [14].

Around 0,4 Mtoe annually are found in small streams, where the smaller hydro-electric power stations could be built. This estimation is based on the land register of small hydro-electric power stations where 856 locations are suitable for building small power stations of 90 kW to 8,5 MW, of the total power of 450 MW and 1.590 GW by which around 90% of locations have the technical potential under 1 MW [1, 4].

Almost all hydro energy produced in Serbia is from plants with installed capacity above 10 MW. Currently, large hydropower plants produce around 10,3 TWh/year (32% of Serbia's total annual electricity production). A smaller part of hydropower potential is exploited using small hydropower plants (SHPPs) with installed capacity of up to 10 MW. With 39 SHPPs currently operating in Serbia (with a total installed capacity of up to 49 MW), the potential of SHPPs remains largely untapped [13].

The additional technical usable potential of hydropower amounts to 7.000 GWh. The corresponding locations for the construction of facilities with power over 10 MW and the annual production of about 5.200 GWh are in the Morava River basin (2.300 GWh), the Drina and Lim rivers (1.900 GWh) and the Danube (1.000 GWh). Approximately 900 locations are identified as appropriate for small hydropower plants. The technical energy generation potential of this SHPP is estimated at 1.500 GWh/year [23].

According to various studies, it is reasonable to assume around 1.000 potential locations for the construction or revitalization of SHPP, with a total power of 500MW and estimated annual production of 1,7-1,8 TWh/yr [23].

Unfortunately, the procedure for obtaining all the required licenses for launching one small hydroelectric power station is extremely complicated, but the state has declared an interest in simplifying the process. The government now recognizes that no investors will be interested in the field unless they are able to provide attractive prices for the sale of the energy generated.

3.3 Solar

Solar levels in the former Yugoslavia, including Serbia and Montenegro, are among the highest in Europe. The most favourable areas record a large number of hours of sunlight, with the yearly ratio of actual irradiation to the total possible irradiation reaching approximately 50% [6].

In particular, Serbia's solar energy exploitation potential is approximately 0,64 Mtoe a year. As previously mentioned, in Serbia the number of hours of sun is much higher than other European countries and it is around 2.000 h per year [1].

According to the available data, use of solar energy is currently almost negligible. Solar energy is used for water and space heating in the domestic and tourist sectors, but there are no figures on the extent of this use. Examples of this use are the installed solar panels for hot water production in the Special Hospital "Rusanda" in Melenci, a tourism school and two day-care centers in Cacak (donation of Greece). A study for installation of solar panels in Belgrades's municipal heating company-Cerak, with a 1,88MW capacity, is being investigated. Preliminary results have shown that over 160.000€ could be saved per year in natural gas costs, while the investment would pay off in 5,6 years [2].

Based on the country's potential, the use of solar thermal energy for heating water or rooms in public buildings and households should be promoted through demonstration projects and economic incentives, such as soft loans and tax releases [13].

Due to the high costs of solar collectors and the accompanying equipment, more intensive solar energy use will depend primarily on the social incentives for the establishment and implementation of the national Renewable Energy Sources Program [14].

When the main electricity is available at power grid, generation of electrical energy by PVs is currently not economically viable for Serbia (Belgrade). To spread use of solar energy for generation of electricity, it would be necessary to subsidize this kind of energy production.

3.4 Geothermal

Geothermal energy potential in Serbia is relatively well investigated. There is data on 160 geothermal springs, with temperature ranging from 15°C to 96°C, which could be used for both electricity and heat production. Evaluated potential of geothermal energy is 185 ktoe, which is currently utilized in balneology, agriculture, and space heating. Exploitation of the hydro geothermal resources, which is mostly used for therapeutic and recreational purposes, is depicted in Table 8.

Table 8. Exploitation of hydro geothermal resources, according to function type

Function	**Installed Thermal Power (MW)**	**Produced Heat (TJ/year)**
Residential & Commercial areas (direct use)	18,5	575
Spas & Recreation	36,0	1.150
Grain Drying	0,7	22
Greenhouses	8,4	256
Fishing and Cattle Breeding	6,4	211
Industrial Processes	3,9	121
Heat Pump Heating	12,0	80
Total	86,0	2.415

Source: [1]

The geothermal potential in Serbia is estimated at almost 2,2 TWh (0,2 Mtoe/yr) and is mainly located on the territory of Vojvodina [23, 24]. The territory of Vojvodina, as part of the Pannonian basin, belongs to the large European geothermal zone, which has favourable conditions for researches and utilization of geothermal energy [1]. There is currently some 80 MW_{th} of installed capacity. Approximately 160 locations have been investigated and some 50 of them have potential over 1 MW_{th} [22].

Furthermore, geothermal flow density represents the main parameter used to estimate the geothermal potential at a certain location. This parameter represents the amount of thermal energy flowing each second through the area of 1 m^2 of the earth's interior and reaching the surface of the earth. The value of this parameter in Serbia is mostly higher than 60MW/m^2, which represents the average value of flow density in Europe [1].

Moreover, research is provided regarding 73 geothermal drills, deepest at 2.520m and shallowest at 305m. General picture of important and relevant parameters of geothermal water in Serbia are [1, 2]:

- Drills are mainly self-outflow operated and most frequent water profusion is 10-20 l/s.
- Most frequent outflow temperature is 40-60 ^oC.
- Geothermal gradients are 4,5 ^oC/100m to 7,5^oC/100m.
- Nearly all waters contain certain quantities of gases, mostly methane.
- Waters contain dissolved minerals in the range 0,42-13,94 g/l.
- Mineral contents in drills bored for oil and gas are 0,40-40,18 g/l.

There is considerable potential of geothermal energy installations in Serbia that may be used for residential, institutional and industrial applications, which could replace the use of at least 500.000 tons of imported fuels annually; an amount proportional to 10% of today's heating system. [1].

3.5 Wind

Serbia is the area with significant wind energy potentials. According to research and measurements of wind, implemented by the Hydro-Meteorological Service of Serbia, the area is rich in wind energy, and the locations in southern and eastern Serbia, especially in the Pannonian Basin in southern Banat, are suitable for the construction of wind plants. Apart from its favourable natural potentials, the Pannonian Basin, north of the Danube, covering approximately 2.000km^2 is also suitable for the construction of wind generators, due to its good morphology necessary for the project implementation [25]. According to researches, the best locations regarding wind speed in Serbia are shown in Table 9.

Table 9. Best locations, regarding wind speed, in Serbia

Location	**Wind Speed (m/s)**
Midzor	7,66
Suva Mt.	6,46
Vrsacki breg	6,27
Tupiznica	6,25
Krepoljin	6,18
Deli Jovan	6,13

Source: [17]

The general perception is that the wind resource endowment is large. Some estimates for wind power potential, Table 10, cite figures of as much as 10.000 MW [23]. However these estimates relate to the physical potential, rather than the economic potential. The real potential of wind energy in Serbia is estimated about 1.300 MW installed power [16].

The assessment of the wind energy share in the total RES potential is approximately, 0,19 millions toe annually (around 5% of the whole potential), based on the long term data of the existent hydro-meteorological stations, which carry out the measuring on 10m altitude and on new data measuring, carried out on 100m altitude [2, 25].

Currently the Ministry for Science and Technology Development is producing a wind atlas of the country of Serbia. In the city of Vlasna, there is a 1 MW wind generator. Likewise, the municipalities of Kovin, Pancevo, and Bela Crkva have signed contracts in this area with private companies. However, the lack of a regulatory framework is holding up progress.

Table 10. Assessments of the wind energy potential

Source	Resource	Details
D. Mikicic, B. Radiecevic and Z. Duric, Wind Energy Potential in the World and in Serbia-Montenegro, Facta Universitarius Nis, Ser. Elec.Energ. Vol. 19, April 2006, 47-61	10.000 MW (20TWh/year)	Includes Montenegro
Liber Perpetuum	10.000 MW (26 TWh/year)	Technical potential, based on comparative analysis with Denmark &Germany
EPS Study: Putnik R., et al., Possibility of electricity production from wind energy (in Serbian: Mogućnost korišćenja energije vetra za proizvodnju elektriĕne energije), Studija, Elektropriveda Srbije, Beograd, 2002	1.316 MW (2,3 TWh/year)	Potential at annual wind speeds >5m/s
Wind Energy Barometer 2006, Directorate-General for Energy and Transport, EurObserver	1.300 MW	

Source: [23]

3.6 Landfill gas

Communal waste is not currently being used in Serbia. In 1990, a 20 million Euro investment was made in Kragujevac for waste water processing that included the use of landfill gas in electricity production. However, gas engines are now out of use. Since Serbia's ratification of the Kyoto Protocol, there is a rising interest for these projects. A Feasibility Study conducted in 2007 by the Royal Haskoning for Duboko dump site included the development of a landfill gas project for electricity production with capacities up to 5.625 MWh per year.

On average, 200 Nm^3 of landfill gas is formed per ton from communal waste for about 20 years. For a total yearly amount of 2,2million tons (the whole Serbia) and landfill filling times of 20 years, about 8,8 billion m^3 of landfill gas would be formed. If only about 10% of this gas was collected, 880 million Nm^3 of landfill gas would be available, i.e. an average yearly amount of 44 million Nm^3, i.e. 5.500 Nm^3/h. Using combined gas engines this amount of gas would enable a yearly production of 88 GWh of electricity and approximately 100 GWh of heating energy. Such an electricity production would save over 20 million Nm^3 of natural gas [23].

3.7 Sewage treatment plant gas

The rate of urban/rural sewage system coverage is 88% to 22%. Rural areas rely primarily on septic tanks for sanitation. The degree of sewage treatment is very low. Thus far, only a very small number of Serbian communities have sewage treatment plants, less than 10%, and the majority of them are not functioning properly.

The installed capacity of these plants is about 1.000.000 PE (Population Equivalent). Sewage treatment plants are also available in certain parts of cities, tourist resorts, and weekend zones, but there is no reliable information on most of these with regard to operation and effectiveness.

3.8 Biogas

During the 1980s, 9 biogas facilities were constructed on large pig and cow farms in Serbia (7 in Vojvodina region), none of which is now operational. The Energy Development Strategy estimates that, by 2015, about 7% of the evaluated 3.183.000 Nm^3/yr could be exploited for electricity generation. The first stage of such a program would be the rehabilitation of the six large-scale biogas operations at 6 existing farms [23].

Energy potential from agricultural wastes is also suitable for biogas production and is estimated about 42,2 ktoe/yr [17].

3.9 Biofuels

Serbia is not exploiting its great potential in producing biofuels, particularly biodiesel. Serbia has the capacity to produce 200.000 tons of biodiesel per year, which exceeds national demand and opens the possibility of exports, especially to Southeast Europe [4].

Unfortunately, current market and regulatory conditions do not favour production of this form of RES. Victoria Oil’s biodiesel factory in the town of Sid shut operations in 2008 because of its inability to turn a profit. This factory produced around 26.000 tons of pure biodiesel (B100) [4]. According to the current legal system, Serbian producers can only manufacture pure biodiesel because there is no regulatory framework for the production of biodiesel blends with petroleum diesel. Allowing the sale of diesel fuel with a blend of at least 5% from bio sources could make the production of biodiesel feasible.

Serbia also has the capacity to produce bioethanol from various crops and cellulose waste products. However, as with the production of biodiesel blends, the lack of a regulatory framework blocks progress in this area and little is being accomplished at the moment.

Production of ethanol in Serbia today is based on molasses (about 50%) and cereals (about 50%). The total generation capacity of 10 sugar factories is about 200.000 tons molasses per year. From this quantity, about 150.000 tons can be considered for bioethanol production. According to estimates, in Serbia there are about 100.000 hectares of land that can be used for bioethanol production, able to produce about 3 million tons bioethanol a year [17].

There are also some attempts to utilize cooking waste for energy production. Company “Bio-energy Oil” installed capacities for production of 10t of bio-diesel per day, using waste cooking oil as raw material. They expect full production to be in place after a planned law on waste cooking oil disposal is passed (planned for 2009). There is 1 primary bio-fuel processing plant is Serbia, built in 2007 [14].

The Rubin Company, one of Serbia’s largest producers of alcoholic and non-alcoholic beverages, is planning to build a factory in the town of Krusevac to produce 30 tons of biofuel. Without strong state support, individual entrepreneurs would not be able to make any headway in this area.

4. Conclusions

In Serbia, RES utilization is currently limited to hydropower plants and non-commercial use of biomass and geothermal energy. Hydropower is the only RES utilized for electricity generation and registered in the official Serbian Energy Balance. Nevertheless, Serbia has great RES potential, especially with regards to geothermal energy, wind energy, and biomass. In particular, several studies indicate that despite the country’s large dependence on fossil fuels (93%), though minor adjustments in the regulatory system RES could easily raise to one-third of overall primary energy consumption.

Key obstacles for RES deployment lay in the area of regulatory and institutional capacity. The lack of an effective regulatory environment makes it hard to implement existing laws and largely blocks entrepreneurs from implementing their own projects. While several laws are in place, often there are no sub laws or regulations on how to implement these laws. Serbian legislation also does not create incentives to encourage RES production.

Beyond the regulatory sphere, a variety of institutional issues makes it difficult to promote RES. Serbia suffers from underdeveloped institutions, a general lack of expertise at all levels of government and insufficient cooperation among the various energy agencies. Human capital issues are particularly problematic. Most important is a lack of qualified personnel to run Serbia’s energy programs. Other problems include: a dearth of experience with RES usage and equipment development, insufficient awareness among the general public about the benefits to be derived from RES, and weak buying power among Serbian consumers and within the economy as a whole.

Serbia’s endowment of RES is substantial, however the realization of the country’s RES potential require Governmental action. In this context, energy production from RES is recognised as a priority and initial efforts are made so as to establish a clear institutional and regulatory framework. In addition, sufficient data exist providing a clear technical potential of RES, in contrary to the insufficient information available regarding RES economical potential.

To sum up, it could be observed that the RES energy production sector in Serbia is in its initial stage. Although further enhancement, in the institutional and regulatory framework, is required, the government and state level institutions, through their current actions seem to have set the RES energy production as their main concern. The exploitation of the RES potential, regarding not only the geothermal sources, biomass and wind, would mean the effective direction and achievement of, not only the targets set by the Energy Development Strategy up to 2015 (4,5% in total energy production until 2010, 1,5-2% in total energy consumption by 2015, 20% reduction of energy consumption by 2020), but also, the targets derived from the Kyoto Protocol ratification (20% until 2012).

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