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THE POTENTIALS OF SOLAR ENERGY IN THE REPUBLIC OF SERBIA : CURRENT SITUATION, POSSIBILITIES AND BARRIERS

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Aleksandar Ašonja[1,2], Veljko Vuković[3]

[1]Energy Agency City of Novi Sad, Novi Sad, Serbia
[2]University Business Academy, Faculty of Economics and Engineering Management, Novi Sad, Serbia
[3]University for Business Engineering and Management, Banja Luka, Bosnia and Herzegovina

Abstract:
Although the potential of solar energy in the Republic of Serbia is up to 30% higher than in the countries of the European Union that lead to the implementation of these technologies, the Republic of Serbia is ranked among the countries with the lowest production in the region with the production of 10 MV solar PV capacities.
The aim of the paper was to present the current balanced capacities, related to solar PV energy, in the Republic of Serbia and countries in the region. In order to present better the material and conclude why the results in the Republic of Serbia are not better, in the paper are analyzes the possibilities for installing such capacities as well as the barriers that need to be eliminated.

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1. INTRODUCTION

Energy is a key factor for the existence of modern society and the legal regulation of its exploitation has economic and strategic-political effects [1]. Reducing imported energy and energy products dependency is the goal of EU energy policy that promotes energy efficiency measures and renewable energy sources (RES) integration [2,3].

Due to accelerated technological development, energy consumption is growing much faster than the increase in the number of population. World energy consumption at the end of the 20th century increased by 10 times compared to the beginning of the 20th century, while industrial activities increased by 20 times [4]. For three decades just at the end of XX century average total consumption of primary energy was growing at average annual rate of 2.1%, growth rate of global population was 1.6%, while growth rate of world gross domestic product (GDP) was 3%. This shows the fact that despite reduction of energy intensity, primary energy consumption is still growing faster than population [5].

According to data from 2012 Republic Serbia have population: 7,223,887, Surface Area: 88,360 km², but she had RE Share od 0,5 (Total Installed Electricity Capacity 7,124 MW, therefrom 33.5 MW installed RE capacitis) [6]. The Republic of Serbia's carbon intensity per GDP is over ten times higher than the OECD average.

2. THE SOLAR ENERGY

Solar radiation is a major driving force of the physical, biological, hydrological and agricultural processes [7,8]. Solar energy potentials are unlimited. This energy is evenly available at every place [9,10]. For example, in less than 9 minutes, the earth is shone with as much of solar energy as the amount needed by the mankind in a year [11].

The solar radiation potential on the CEE and SEE countries territory is considerable despite the large differences in the sunlight intensity between the various countries. The average annual sunshine

CONTACT: Aleksandar Ašonja, e-mail: asonja.aleksandar@fimek.edu.rs

duration is roughly 2,130 hours and the average solar radiation resource is between 1,080 kWh/m^2 and 2,200 kWh/m^2 [12]. The average solar radiation in Republic of Serbia is about 30% higher than the European average, but the use of solar energy for electricity generation is far behind the EU states [9,41].

The average yearly value of the global solar irradiation for the territory of the Republic of Serbia ranges from 1,200 kWh/m2/year in the north to 1,550 kWh/m2/year in the south. This values shows that Republic of Serbia has favorable conditions for the use of solar energy and its conversion into thermal and electrical energy [13-15].

The study of solar radiation is particularly important recently in the context of climate change [16]. So, for example, solar energy, unlike biofuel, emits 0 kg of CO_2 per atmosphere per 1 kWh [17]. For 1 kWh of PV solar plant generated electrical energy emission of 0.568 kg CO_2 into the atmosphere is reduced [18,19].

According to research [20] it was executed the classification of various solar PV Installations:

- *Ground mounted solar project* – they are placed mainly on the barren land;
- *Roof top solar project* – are placed on the roofs of public buildings (capacity to 100 kW) and other objects (capacity to 20 kW);
- *Canal top solar project* – are placed above smaller waterways in width because they do not occupy the land and do not cut the forests for their installation;
- *Offshore solar project* – due to the growth of the number of inhabitants on the planet earth and the lesser occupation of the earth's surface, it is used to install such installations on waterfront land. A good feature is better cooling of the panel, preventing the appearance of algae, etc.;
- *Floating solar project* – Suitable for all water surfaces, such as rivers, lakes, fishponds, etc. The efficiency coefficient of these panels is 11% higher than the other types [21].

3. MATERIALS AND METHODS

The aim of the work was to show the currently installed capacities with RES in the Republic of Serbia and countries in the region, especially those capacities related to the production of electricity from solar PV. In order to present better the matter and conclude why the results in the Republic of Serbia are not better, in the the paper are analyzed the possibilities for installing such capacities as well as the barriers that need to be eliminated.

4. RESULTS AND DISCUSSION

4.1. Installed solar capacities in the Republic of Serbia and region

For the Republic of Serbia and other countries in the region in Table 1 is shown percentage of RES in gross final energy consumption for 2009 and target percentage of RES in gross final energy consumption for 2020 year. Table 1 shows that projections of grow RES in final consumption are based on ~ 6% in this period. Bosnia and Herzegovina should have 40% of RES in final consumption in 2020, Albania 38%, Montenegro 33%, Macedonia 28%, Serbia 27%, etc.

Table 1. Energy Community RES 2020 targets [22]

Contracting Party	Percentage of RES in gross final energy consumption, 2009	Target percentage of RES in gross final energy consumption, 2020
Albania	31.2%	38%
B&H	34.0%	40%
Montenegro	26.3%	33%
Macedonia	21.9%	28%
Serbia	21.2%	27%
Croatia	12.6%	20%
Moldova	11.9%	17%
Ukraine	5.5%	11%

Although the region of EU does not have a great potential for the production of solar energy, EU is the world leader in electricity generation from solar PV. In 2015, the total installed capacity in EU was 94,570 MW. The country's leader in solar energy production is Germany with 39,700 MW installed capacity (42% of total EU capacity), followed by Italy 18,920 MW, UK 8,780 MW, etc. The first 10 countries in EU after installing solar PV capacities are shown in tab.2.

The total installed solar PV power in the electricity structure for 2000 in the EU was 0.02%, ie 125 MW, and for 2014. year it was 9.7% ie 88 GW [23]. Many European countries have already reached their national 2020 targets for solar PV. This is explained by swift deployment of PV systems, at a much faster rate than expected, but also the fact that most countries (except Germany and Spain) have set modest national targets for solar PV – thus markets have been underestimated in their national action plans [24]. Renewable

energy (including large HPPs) already plays a significant role in the final energy supply in some countries: Montenegro (52%), Albania (43%), Serbia (29%), Bosnia and Herzegovina (24%) and FYR Macedonia (12%).

Solar PV projects in Republic Serbia quickly filled out the quota defined by the Government, (6 MW for installations on the ground and 4 MW for roof-top installations). A number of projects currently under development exceed the quota for solar PV set by the Government [24].

Table 2. Top 10 solar PV countries in Europe, in terms of installed capacity, in 2015

Country	Installed capacity
Germany	39,700 MW
Italy	18,920 MW
UK	8,780 MW
France	6,580 MW
Spain	5,400 MW
Belgium	3,250 MW
Greece	2,613 MW
Czech Republic	2,083 MW
Netherlands	1,570 MW
Switzerland	1,360 MW

Table 3 shows the installed solar PV capacities in 2015 in the Republic of Serbia and in the surrounding countries The leader is Romania with a capacity of 1.3 GW, followed by Hungary with 96 MW, Bulgaria 1.04 GW, etc. The Republic of Serbia is at the bottom of the table with then installed 6 MW [25,26], it is only Albania below with 1 MW and Montenegro for which there are no available data.

Tabela 3. Solar PV installed capacity in Serbia and the surrounding countries

Country	Solar installed capacity
Serbia	6 MW
Bosnia and Herzegovina	11 MW
FYR Macedonia	16 MW
Bulgaria	1,04 GW
Croatia	44 MW
Albania	1 MW
Hungary	96 MW
Romania	1,3 GW

The current installed solar PV capacities in the Republic of Serbia amounts 10 MW (solar power plants on the earth - 6 MW, solar power plants on the facility up to 30 kW - 2 MW and solar power plants on the facility up to 30 to 500 kW - 2 MW).

The Government of the Republic of Serbia adopted the Decision of the Ministerial Council of the Energy Community on the promotion of the use of renewable energy by means of transposition of the EU Directive 2009/28/EC on renewable energy. This decision sets a mandatory target for Serbia to increase the percentage of renewable energy in gross final energy.

Table 4. shows basic information about solar energy (solar irradiation, average of sun annually hours, and average solar irradiation per day) for the Republic of Serbia and surrounding countries. In Fig. 1-3, basic information about solar energy is shown (direct normal irradiation, global horizontal irradiation and photovoltaic power potential) for the Republic of Serbia [27].

Table 4. Basic information on solar energy for the Republic of Serbia and the surrounding countries

Country	Solar irradiation (kWh/m^2)	Average of sun annually hours (h)	Average solar irradiation per day (kWh/m^2/day)
Serbia	1,100-1,700 [28]	1,500-2,200 [29,30]	3.4-4.2 [31]
B&H	1,240-1,600 [6,32]	1,841 – 2,353 [6]	3.4-4.4 [32]
FYR Macedonia	1,250-1,530 [33]	2,000-2,400	3.4-4.2 [33]
Bulgaria	1,400-1,600	2,100-2,500	4.0-4.25 [34]
Croatia	1,150-1,600	2,000-2,550	3.1-4.3 [35]
Albania	1,185-1,690 [35]	2,100-2,500	3.2-4.6
Hungary	1,150-1,340	1,900-2,200 [36]	-
Romania	1,300-1,500	1,600-2,300	4.0-5.0 [37]

4.2. The possibilities of solar energy in the Republic of Serbia

During the 1990s the Republic of Serbia went through civil war in former Yugoslavia, NATO bombing, United Nations sanctions and blockade, hyperinflation, and, inclose relation to all this, devastation of the energy sector [38]. This is the main reason why the Republic of Serbia today has significantly less installed capacity with RES from individual countries within the EU.

Technically usable energy potential of the abovementioned RES in the Republic of Serbia is very significant, and it is estimated to be over 4.3 Mtoe per year – of which around 2.7 Mtoe per year is produced from biomass exploitation [39]; 0.6 Mtoe per year in unexploited hydro potential; 0.2 Mtoe per year from the existing geothermal springs; 0.2 Mtoe per year in wind energy and 0.6 Mtoe per year in the exploitation of solar radiation [29]. The potential of solar energy is 14% of total of

useful potential of RES in the Republic of Serbia [40]. Although the energy potential of solar radiation in the Republic of Serbia is higher than in Central Europe, at the moment, the Republic of Serbia uses about 35% of the total available technical potential of the renewable energy [42]. Technically usable energy potential of RES in Republic of Serbia is estimated to over 3.83 Mtoe (in Autonomous province of Vojvodina it is 1.293 Mtoe).

The technically usable energy potential for converting solar energy into heat energy (for hot water preparation and other purposes) is 0.194 Mtoe per year, assuming the use of solar collectors on 50% of available plants in the country. While this potential for converting solar energy into electricity is 0.046 Mtoe per year, the biggest problem is the impossibility of the electricity system to accept this energy in the summer months due to variable production [5].

Characteristics of solar energy in the Republic of Serbia are:

- Total exploitable potential of solar energy is assessed up to approximately 0.64 Mtoe/year,
- Total annual solar energy for the whole territory of Serbia is estimated at 1.2×10^5 TWh [31],
- Number of sunny days: 267 s.d/year [4],
- The means of daily solar energy vary between 3.4 kWh/m^2 in the north-west region (from 1.1 kWh/m^2/per day - during January to 5.9 kWh/m^2/per day during July) and 4.2 kWh/m^2 in the south-east region (from 1.7 kWh/m^2/per day - during January to 6.6 kWh/m^2/per day during July) [30],
- It has been established that average annual energy influx of global solar radiation on horizontal surface in Serbia is 1,387 kWh/m^2 [9],
- Annually, average value of radiation energy is from 1,200 kWh/m^2/per year in the north-west to 1,550 kWh/m^2/per year in the south-east, while in central part it is about 1,400 kWh/m^2/per year [5].

On the Fig. 1-3 for the territory of the Republic of Serbia are shown values: direct normal irradiation - Fig.1, global horizontal irradiation - Fig.2 and PV power potential - Fig.3.

Solar irradiance varies during the daytime, from season to season, from year to year, but it is mainly dependent on the geographic latitude [43].

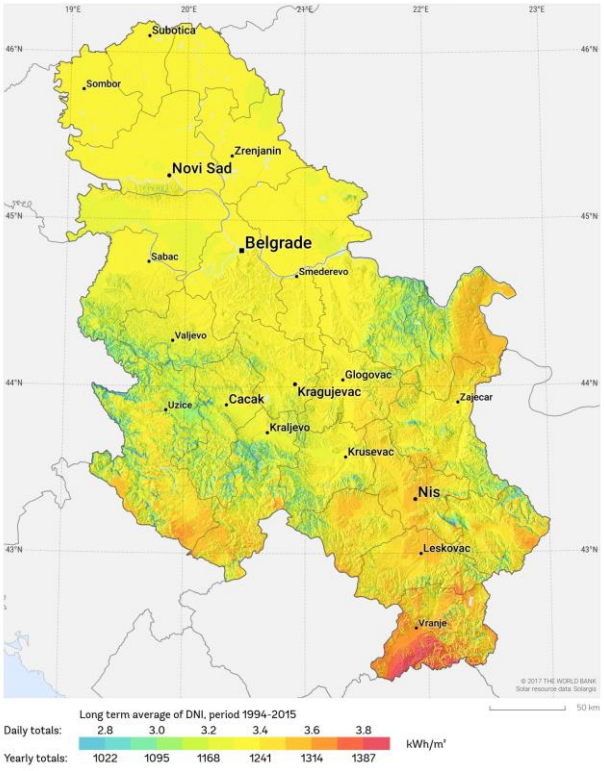

Fig. 1. Direct normal irradiation - Republic Serbia

Fig. 2. Global horizontal irradiation - Republic Serbia

Heat solar systems are often used for heating of sanitary water, heating of technical water, heating of water in pools, etc. [44]. Solar energy can cover 50–70% even more of annual energy demand for water heating in households, during summer and transitional periods can be substitute almost

completely, while during the winter period it is enough for pre-heating purposes [45].

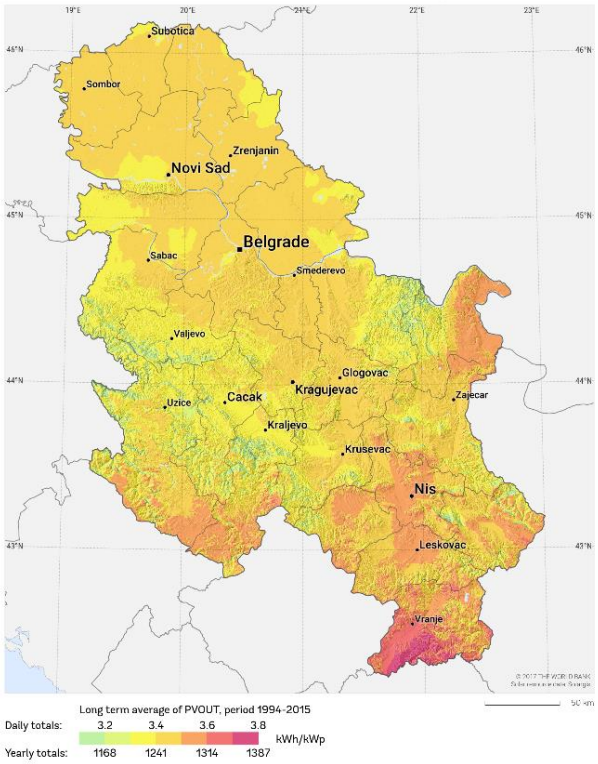

Fig. 3. Photovoltaic power potential - Republic Serbia

Solar energy represents important energy potential of the Republic of Serbia that can be used for the generation of heating energy or electricity [46,47].This potentional can be used for creating new jobs. According to Serbia's current alternative energy capacity could to create 24,000 new jobs by 2020. Of these new positions, 18,000 would be in designing and producing new renewable energy, 4,000 would focus on maintaining the newly built installations, while 2,000 would be deal with other related activities [48].

4.3. The barriers of solar energy in practis in the Republic Serbia

Based on previous research, as a major barrier in the small volume of installed solar units in the Republic of Serbia, there is a low price of electricity in the Republic of Serbia, a low purchase price for producers who do not have the status of privileged producers, etc. All these shortcomings lead to the fact that the return period of investments in PV systems is considerably longer.

Barrieres for solar PV (panels):

- The necessary building permit for solar power plants over 50 kW,
- There are no incentive measures/feed-in tariffs for wider use, (housing sector),
- For privileged producers, feed-in tariffs are divided;
- Long wait time for installation permissions of the grid power plant due to the complex regulation of the issuance of design conditions etc.
- Very low purchase price of 0.033 €c/kWh for suppliers who are not privileged manufacturers
- Low electricity prices in the Republic of Serbia, which amounts to a blue zone for a two-digit measurement of 0.075 €c/kWh;
- Rough estimate indicates that 1.7-2 ha of surface/ground would be necessary for 1 MW of installedcapacity. Thus the coefficient is 1:2, although, bearing in mind the above, it should be mentioned that the coefficient 1:3 is also sustainable in practice, i.e. that 3 ha of the ground surface would be needed for 1 MW of installed capacity [49].

In the research [50] on the benefits of photovoltaic systems, it is noted that the most important criteria for installation are:

- Solar radiation for the particular region;
- Topographic parameters. A percentage of slope ranging from 16 and 30 was considered poorly suitable while greater than 30 was considered technically unviable;
- Population. The locations of solar PV plants 0.5 km away from the cities are considered acceptable;
- Transportation network – necessary for daily maintenance of installations is acceptable up to 5 km;
- Electricity grid. The higher the proximity to the existing electricity grid, the lower transmission costs and power losses.

Technically usable energy potential for electricity production is a variable and depend on the dynamics of the development of transmission and distribution network of electric power system of the Republic of Serbia [46].

Barieres for solar collectors:

- There are no incentive measures / feed-in tariffs for wider use,
- Low prices of alternative fuels in the Republic of Serbia (for example, prices of

natural gas are amounts 0.31 €c/m^3 ie. 0.034 €c/kWh);

- Larger systems require greater maintenance and better management, which is why most of these plants are not in working condition, etc.

5. CONCLUSION

The Republic of Serbia has very significant natural potentials for the production of electricity from the PV system. However, these potentials were not exploited to the extent that it was used by other countries in the EU and countries in our environment. The Republic of Serbia currently produces only 10 MW from solar PV system, which is very little. The reasons of small power generation from PV systems should be sought in: a very cheap electricity price, no (currently) incentive feed-in tariffs; very low purchase prices of electricity from PV systems (which are not privileged producers) from 0,033 €c/kWh, complex conditions for obtaining technical documentation for solar power plants on-grid over 50 kW, etc.

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