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ANALYSES OF PV SYSTEMS OF 1 kW ELECTRICITY GENERATION IN BOSNIA AND HERZEGOVINA

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Abstract: The paper focuses on the analysis of PV systems of 1 kW electricity generation in Bosnia and Herzegovina. At the beginning, some information about solar energy and PV systems, renewable energies policies and physical-geographic position and climatic characteristics in Bosnia and Herzegovina are provided. Based on PVGIS program, the results of calculation of the yearly average values of the optimal panel inclination, solar irradiation on the horizontal, vertical and optimally inclined plane, ratio of diffuse to global solar irradiation, associated turbidity, average daytime temperature and 24 hours average of temperature for 27 cities in Bosnia and Herzegovina are shown. The paper also outlines the total yearly sum of global irradiation per square meter received by the modules of the optimally inclined fixed 1kW PV system, optimally inclined one-axis and dual-axis tracking 1kW PV systems as well as total yearly electricity production of different types of PV 1kW system for 27 cities in Bosnia and Herzegovina, obtained by PVGIS. The comparison is provided for the total yearly electricity production of different types of 1kW PV system with monocrystaline silicon, CdTe and CIS solar modules, respectively, for 27 cities in Bosnia and Herzegovina. Calculations performed by PVGIS program have shown that irrespective of the type of PV systems, most electrical energy in Bosnia and Herzegovina can be generated by means of PV systems with CdTe solar cells. Some practical data and considerations given in this paper can be used by a customer or company interested to invest in the PV sector in Bosnia and Herzegovina.

Keywords: solar energy; PV systems; climatic characteristics and PV in Bosnia and Herzegovina.

1. INTRODUCTION

Solar energy is the most abundant, inexhaustible and cleanest of all renewable energy resources to date. The power from the Sun intercepted by the Earth is about $1,8 \times 10^{11}$ MW, which is by many times bigger than the present rate of all the energy consumption. Solar energy is one of the best renewable energy sources with the least negative impacts on the environment [1].

One of the most popular techniques of solar energy generation is the installation of photovoltaic (PV) systems using sunlight to generate electrical power. There are many factors affecting operation and efficiency of the PV based electricity generation systems, such as PV cell technology, ambient conditions and the selection of required equipment. There is scarce study that presents all factors affecting efficiency and the operation of the entire PV system [1−3].

Electricity from photovoltaic cells can be used for a wide range of applications, from power supplies for small consumer products, to large power stations feeding electricity into the grid. PV solar system can function independently of the electric power network (off grid) or it can be connected to it (on grid). Depending on the components that comprise it, an off-grid PV system can supply the consumers with DC current or AC current. An off-grid PV system that gives consumers DC current is

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composed of solar cells, batteries and batteries charge controllers. An off-grid PV system that provides consumers with AC current consists of solar cells, battery charge controllers, batteries and DC to AC inverter. On- grid PV systems consist of solar cells, inverter, monitoring system, distribution boxes, switches and related connections. On-grid PV systems are most frequently used for PV solar plants, residential and office buildings, etc.

PV solar plants mostly use solar modules made of monocrystalline and polycrystalline silicon, and rarely, modules made of thin film materials such as amorphous silicon, CdTe and Copper-Indium-Diselenide (CIS, $CuInSe_2$). Depending on the climate conditions of the given location, fixed PV solar plants, one-axis and dual–axis tracking PV solar plants are being installed worldwide. Fixed PV solar plants are used in regions with continental climate and tracking PV solar plants are used in tropical regions [1−8]

Different countries have different solar energy policies to reduce dependence on the fossil fuels and increase domestic solar energy powered energy production. The solar energy sector in Bosnia and Herzegovina is not developed yet [1,4,9].

This paper focuses on the possibilities of generating electrical energy by means of on-grid 1kW PV solar systems in Bosnia and Herzegovina.

2. RENEWABLE ENERGIES POLICIES IN BOSNIA AND HERZEGOVINA

The Constitution of Bosnia and Herzegovina is an integral part of the Dayton Peace Agreement and has created a specific State comprising two entities, the Federation of Bosnia and Herzegovina and the Republic of Srpska. Under this constitutional set-up, Bosnia and Herzegovina is a sovereign state with a decentralized political and administrative structure. In addition, a separate District, Brcko, was established within Bosnia and Herzegovina's borders [10].

Coal and hydropower represent a backbone in terms of energy sources in Bosnia and Herzegovina. In 2001, 62% of the total consumption of primary energy was derived from those sources in Bosnia and Herzegovina, this clearly pointing to the alarming fact that Bosnia and Herzegovina heavily depends on the import of energy, since local energy sources are obviously not sufficient to fulfill the energy demands [10−11].

Bosnia and Herzegovina satisfies its electric power needs in total with the production of electricity from its own power stations (10,8 TWh in 2002), using for that its available hydro potential and coal resources. The scope of domestic consumption enhances the export of the part of generated electricity, which in 2002 amounted to 1,1 TWh. About 60% of electricity has been generated in thermo power plants, and the other 40% in hydro power plants. The available hydro potentials have been estimated in terms of possible annual production of approx. 22 000 GWh, while the coal reserves are over four billions of tons. The electric energy output in Bosnia and Herzegovina meets the demands on a short-term basis [10−11].

Bosnia and Herzegovina ratified the UN Framework Convention on Climate Change on September 7, 2000, and the UNFCCC entered into force on December 6, 2000. The Kyoto Protocol on the Greenhouse Gases Reduction was ratified in 2007 [9−11].

As far as the official promotion documents for RES in Bosnia and Herzegovina and the corresponding increase of the energy efficiency, there are none.

The Decision on purchase pricing methodology of RES generated electric power, with installed power up to 5 MW, was adopted and published (Of. Gazette of the Federation of Bosnia and Herzegovina 32/2002, Of. Gazette RS 71/2003).

Two power utility companies in Bosnia and Herzegovina and one in the Republic of Srpska were assigned to take over RES generated electricity. Based on these decisions, the tariff systems for RES generated electricity are:

- Small Hydro plants: 3,96 € cents/kWh
- Landfill biogas and biomass plants: 3,81 € cents/kWh
- Wind and geothermal plants: 4,95 € cents/kWh
- Solar power plants: 5,44 € cents/kWh

In terms of RES, there are no incentive economic tools, specialized institutions, training or education activities in Bosnia and Herzegovina.

Certain projects (USAID, UNDP), associations of citizens (CETEOR, COOR, CENER, CEET) and centers dealing with this issue can be found within the Faculties of University in Sarajevo, Banja Luka, Tuzla, and Mostar [9−13].

The level of energy efficiency, i.e. energy intensity in Bosnia and Herzegovina is among the lowest in Europe. This calls for considerable improvements in the area of RES generated electricity. Another area to tackle is the lack of the institutional and legal framework.

The primary aim of sustainable development of energy sector of Bosnia and Herzegovina is to reduce energy intensity in the entire life cycle ranging from the primary energy production, raw material processing and production and all the way down to conversion of product and final energy forms into money and quality of life.

Secondly, it is imperative to increase the energy efficiency of fossil fuel usage (small energy cogeneration, use of the condensing boilers, use of the fuel gases heat). The next step is to strive for gradual transition towards the unconventional energy sources (biomass use, passive use of solar energy, more extensive use of hydro potential for small power plants). Currently, the most important step is to develop the energy sector strategy, which implies outlining the priority directions of the energy sector development, decision to use RES, and the instruments and dynamics for its implementation will be established. It is also vitally important to develop Feasibility Studies on RES use (wind and solar energy). It is necessary to simplify the procedure for obtaining the concession and license for the construction of RE installations. Last but not the least is to encourage the private sector to invest in and develop all segments of energy infrastructure [9−13].

3. PHYSICAL-GEOGRAPHIC POSITION AND CLIMATIC CHARACTERISTICS OF BOSNIA AND HERZEGOVINA

Bosnia and Herzegovina is situated between 42°26' and 45°15' of the north geographic latitude and 15°45' and 19°41' of the east longitude. It is placed in the western part of the southeastern Europe and occupies a central position of the Balkan peninsula. Its total surface is 51129 km^2. Border length amounts to 1537 km, of which land border is 762,5 km, river 751 km and sea 23,5 km. Bosnia and Herzegovina shares its border with the Republic of Croatia (931 km), Serbia (375 km) and Montenegro (249 km). Northern parts of Bosnia and Herzegovina face the Sava river, while its southern parts reach the Adriatic Sea at Neum city. Bosnia and Herzegovina is extremely mountainous, with average altitude of 500 m. 5% of the country is lowland, 24% is hills, 42% mountains, and 29% is covered with karst (NEAP, 2003). Forests and forest type of soils in Bosnia and Herzegovina cover 2 709 769 ha (which is about 53% of its territory), out of which woods cover 2 209 732 ha (about 43%), while barren land covers 500 037 ha (about 10%). Bosnia and Herzegovina has been arranged by the Dayton Agreement, according to which it is constituted of the Federation of Bosnia and Herzegovina (10 cantons), the Republic of Srpska and Brčko District.

Bosnia and Herzegovina is exposed to the exchanging influences from the southern part of the North temperate belt and northern part of the North subtropical belt. Most of the young mountain chains (western part), the Dinaric Alps, are situated in our territory. Chains of the Dinaric Alps descend gradually in the northern direction toward the Sava river, while in the southern direction they descend suddenly, directly into the lowland of Herzegovina and the Adriatic coastline. Bosnia and Herzegovina owes its predominantly mountainous character to the western part of the Mediterranean mountain chains.

The climate of Bosnia and Herzegovina is moderate, but more extreme than one could expect based on its geographic position. The Mediterranean impact here is substantially reduced. Hence, the Mediterranean climate occurs only on the Adriatic coastline and in low Herzegovina. Dinaric alpine region strongly modifies the Mediterranean currents coming from the South, whereas it prevents the penetration of cold air from the inland to the coast. But, the Mediterranean influences still penetrate deep inland across the Neretva river valley. The climate of Bosnia and Herzegovina is highly diverse. Between the areas of moderate continental and modified Mediterranean (Adriatic) climate, there are areas with continental, pre-alpine and alpine climates.

The highest mountain peaks are characterized by lowest temperatures. The average temperature on Bjelašnica Mountain, in January, is -7,2°C, while in Neum city it is 6,5°C. Annual precipitation in Bosnia and Herzegovina is unevenly distributed, whereas it increases from the South towards Dinaric massifs, and declines again towards peripannonian margin. Snow occurs regularly in winter, covering mountain peaks over 6 months per year [14−16].

In the climate of Bosnia and Herzegovina it is possible to differ three distinctive climate types, with more or less obvious borders:

– In the southwest- Mediterranean, i.e. Maritime climate

– In central part - Continental-Mountains, i.e. Alpine climate and

– In the north - moderate Continental, i.e. Mid-European climate.

In southwest parts of Bosnia and Herzegovina, due to the vicinity of the Adriatic Sea, which in winters radiates heat accumulated in the summer period, middle January temperatures are high and range from 3°C to 5°C, while summers are hot and dry with the absolute maximal temperatures ranging from 40°C to 45°C. Medium annual precipitation ranges from 1000-2000 l/m^2, and medium annual temperatures range from 12°C to 15°C. Snow is rare although not impossible in this region [15].

In the central part of Bosnia and Herzegovina prevails the continental-mountain climate, of the alpine type. Basic characteristics of this climate is harsh winters with the absolute minimal temperatures ranging from -24°C to -34°C, while summers are hot with the absolute maximal temperatures ranging from 30°C to 36°C. Average annual precipitation ranges from 1000 l/m^2 to 1200 l/m^2. Snow falls are heavy, especially in higher places.

The dominant climate in the north of the country is moderate continental climate with harsh winters and hot summers, but in relation to the alpine area, ranges between winter and summer temperatures are lower. The hottest areas are in the northeast part, while mean temperatures decrease in the southwest, following the rivers towards the central part. Annual precipitation ranges from 700 l/m^2 to 1100 l/m^2. Snow is also present but to a lesser degree than in the central part.

The average annual temperatures, annual precipitation, number of overcast days, number of clear days, for two towns for each mentioned climate areas, for the period 1961-1990 are presented in Table 1 [15].

Depending on the altitude, apart from these climate areas, there are transitional zones so we are dealing with the area of moderate continental climate of pre-mountain type, then the area of the Mediterranean climate of the pre-mountain type, etc [15].

Monthly average values of the meteorological data of Bosnia and Herzegovina are shown in Table 2 [16].

Table 1. Average annual temperatures, annual precipitation, number of overcast days, number of clear days, for two towns for each cited climate areas, for the period 1961-1990 [15]

Some cities in Bosnia and Herzegovina	Average annual temperatures (°C)	Annual precipitation (mm)	Number of overcast days	Number of clear days
Bihać	10,6	1308	139	48
Tuzla	10,0	895	125	63
Zenica	10,1	778	125	45
Sarajevo	9,5	932	126	61
Mostar	14,6	1515	98	90
Livno	8,9	1114	107	77

Table 2. Monthly average values of the meteorological data of Bosnia and Herzegovina [16]

Weather in Bosnia and Herzegovina	Average minimum temperatures (°c)	Average maximum temperature (°c)	Average temperature (°c)	Average rainfall/ precipitation (mm)	Wet days (>0,1 mm)	Average sunlight hours/ day	Relative humidity (%)	Average wind speed (beaufort)	Average number of days with frost
January	-4	3	-0,5	66	16	2,0	80	0	25
February	-3	5	1	64	14	3,4	74	1	20
March	0	10	5	62	13	4,5	70,0	1	15
April	5	15	10	64	13	5,4	66	1	3
May	8	20	14	90	16	6,0	67	1	0
June	12	24	18	88	14	7,5	66	0	0
July	13	26	20	71	12	8,7	64	0	0
August	13	27	20	70	8	8,9	61	1	0
September	10	23	17	78	9	6,9	67	1	0
October	6	16	11	103	12	4,4	74	1	2
November	3	10	7	91	15	2,2	78	0	9
December	-1	6	2,5	85	15	1,7	80	0	20

4. RESULTS AND DISCUSSION

The quantity of sun radiation intake on the surface of earth is influenced by numerous factors such as: geographical latitude of the given place, season of the year, part of the day, purity of the atmosphere, cloudiness, orientation and surface inclination, etc. This data is very important from the point of view of its use in calculations of the cost effectiveness of equipment using sun radiation. Very reliable data can be found in PVGIS database (Photovoltaic Geographical Information System) [2,8,17−19].

This section shows the results obtained from the study of the solar irradiation and electricity generated by optimally inclined fixed PV solar plants, optimally inclined one-axis and dual-axis tracking 1kW PV solar plants with monocrystalline silicon, CdTe and CIS solar modules in 27 cities of Bosnia and Herzegovina, processed by the PVGIS programme, [17,19].

4.1. Solar irradiation in Bosnia and Herzegovina

The aim of this section is to introduce and identify local solar resources in Bosnia and Herzegovina. Bosnia and Herzegovina can be counted among more favourable locations in Europe with solar irradiation figures on horizontal surface of 1240 kWh/m^2 in the north of the country, and up to 1600 kWh/m^2 in the south [9,13,17].

The yearly sum of the total solar irradiation incident on horizontal PV modules in kWh/m^2 and yearly electricity generated by 1 kWp system with performance ratio 0,75 (kWh/kWp) for the territory of Bosnia and Herzegovina obtained by PVGIS, are shown in Figure 1 [17].

Yearly sum of total solar irradiation incident on optimally inclined south-oriented PV modules in kWh/m^2 and yearly electricity generated by 1 kWp system for the territory of Bosnia and Herzegovina obtained by PVGIS, are presented in Figure 2 [17].

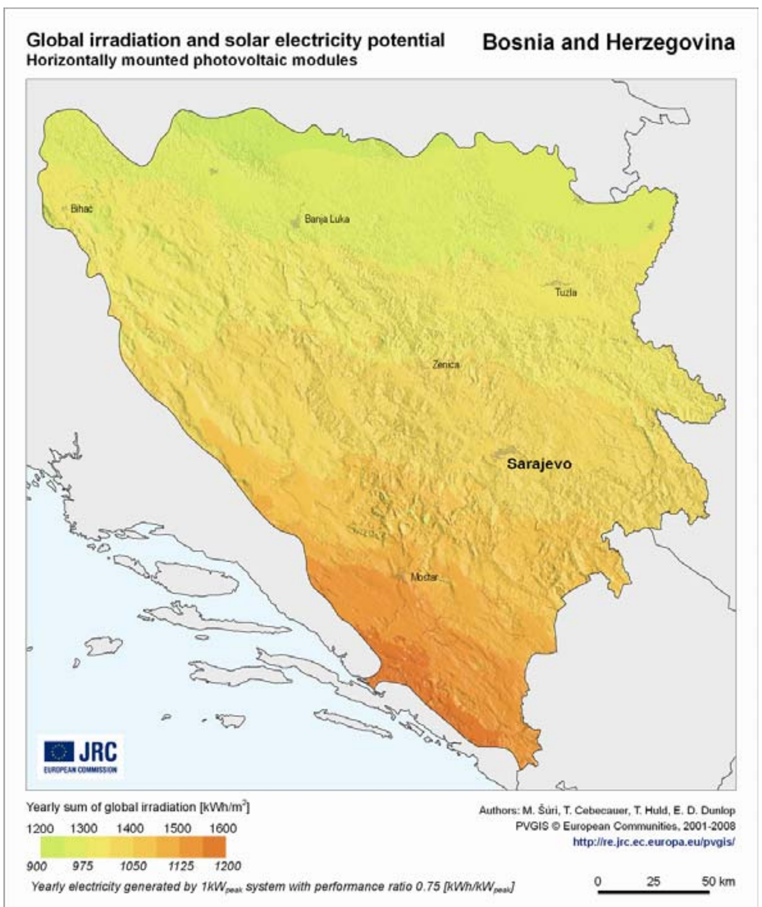

Figure 1. Yearly sum of total solar irradiation incident on horizontal PV modules in kWh/m^2 and yearly electricity generated by 1 kWp system with performance ratio 0,75 (kWh/kWp) for the territory of Bosnia and Herzegovina obtained by PVGIS. Adapted for Bosnia and Herzegovina from PVGIS©European Communities, 2001-2008, http://re.ec.europa.eu/pvgis/

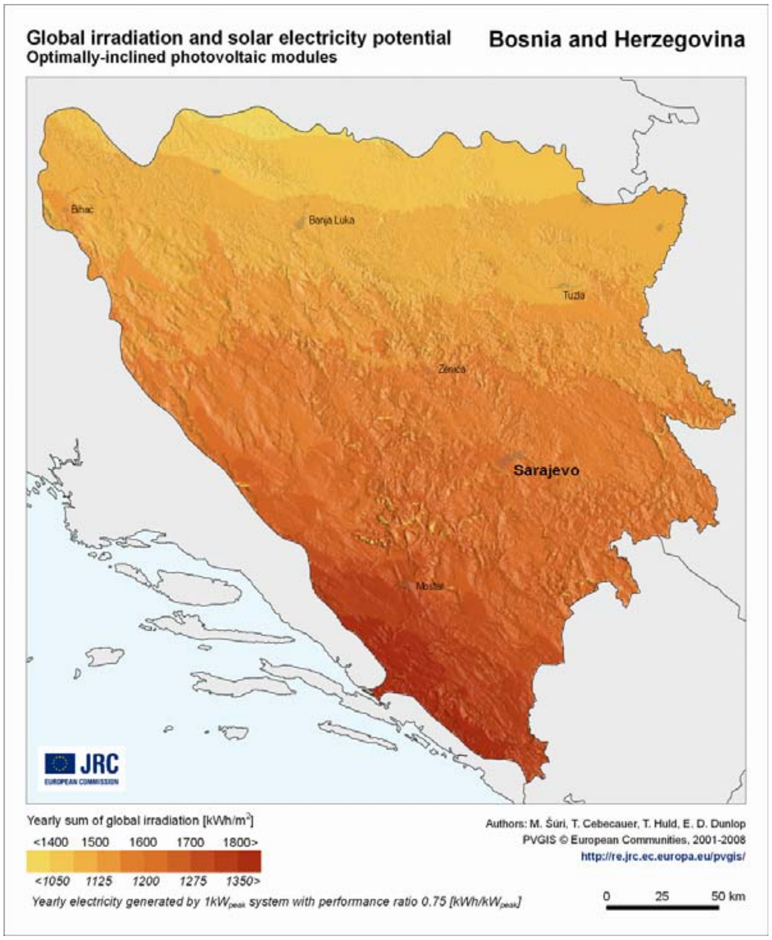

Figure 2. Yearly sum of total solar irradiation incident on optimally inclined south-oriented PV modules in kWh/m² and yearly electricity generated by 1 kWp system for the territory of Bosnia and Herzegovina obtained by PVGIS. Adapted for Bosnia and Herzegovina from PVGIS © European Communities, 2001-2008, http://re.ec.europa.eu/pvgis/

Table 3. Geographical position and the results of PVGIS calculation of the yearly average values of the optimal panel inclination, solar irradiation on the horizontal, optimally inclined and vertical plane, linked turbidity, ratio of diffuse to global solar irradiation, daytime temperature and 24 hours of temperature for some cities in Bosnia and Herzegovina [17]

SOME CITIES IN BOSNIA AND HERZE-GOVINA	**Geographi-cal position**	**Optimal panel inclination (°)**	**Solar irradiation**			**Linked turbidi ty**	**Ratio of diffused and global solar radiation**	**Average daytime tempera-ture (°C)**	**24 hour average of tempera-ture (°C)**
			On horizon-tal plane (Wh/m^2)	**On optimally inclined plane (Wh/m^2)**	**On verti-cal plane (Wh/m^2)**				
Gradiška Annual irradia-tion deficit due to shadowing (hori-zontal): 0,0 %	45°8'31" North Lati-tude and 17°15'10" East Longi-tude	33	3390	3830	2530	3,8	0,51	13,4	12,1

Velika Kladuša Annual irradiation deficit due to shadowing (horizontal): 0,0 %	45°10'57" North Latitude and 15°48'2" East Longitude	34	3490	3980	2660	3,8	0,49	13,5	12,1
Novi Grad Annual irradiation deficit due to shadowing (horizontal): 0,1 %	45°2'43" North Latitude and 16°23'4" East Longitude	34	3500	3960	2620	3,8	0,50	13,4	12,0
Orašje Annual irradiation deficit due to shadowing (horizontal): 0, 0%	44°58'42" North Latitude and 18°43'39" East Longitude	34	3500	3950	2620	3,3	0,50	13,3	12,0
Derventa Annual irradiation deficit due to shadowing (horizontal): 0,0 %	44°58'51" North Latitude and 17°54'34" East Longitude	33	3450	3900	2580	3,5	0,50	13,3	12,0
Prijedor Annual irradiation deficit due to shadowing (horizontal): 0,0 %	44°58'44" North Latitude and 16°42'13" East Longitude	34	3500	3980	2640	3,7	0,49	13,6	12,3
Brčko Annual irradiation deficit due to shadowing (horizontal): 0,0 %	44°52'11" North Latitude and 18°48'35" East Longitude	34	3520	3990	2650	3,2	0,49	13,3	12,1
Bijeljina Annual irradiation deficit due to shadowing (horizontal): 0,0 %	44°45'0" North Latitude and 19°13'0" East Longitude	34	3560	4040	2690	3,1	0,49	13,4	12,1
Banja Luka Annual irradiation deficit due to shadowing (horizontal): 0,0 %	44°46'0" North Latitude and 17°10'59" East Longitude	34	3540	4010	2660	3,7	0,50	13,1	11,8
Bihać Annual irradiation deficit due to shadowing (horizontal): 0,1 %	44°49'10" North Latitude and 15°52'14" East Longitude	34	3650	4170	2770	3,7	0,47	13,7	12,3
Doboj Annual irradiation deficit due to shadowing (horizontal): 0,2 %	44°44'26" North Latitude and 18°5'34" East Longitude	34	3530	4000	2650	3,4	0,50	12,9	11,7
Tuzla Annual irradia-	44°31'58" North Lati-	34	3590	4090	2720	3,3	0,48	12,6	11,5

tion deficit due to shadowing (horizontal): 0,1 %	tude and 18°40'13" East Longitude								
Zvornik Annual irradiation deficit due to shadowing (horizontal): 3,9 %	44°23'30" North Latitude and 19°6'20" East Longitude	33	3480	3930	2570	3,3	0,50	13,0	11,9
Drvar Annual irradiation deficit due to shadowing (horizontal): 1,1 %	44°22'6" North Latitude and 16°23'51" East Longitude	35	3700	4260	2840	3,7	0,46	12,8	11,5
Jajce Annual irradiation deficit due to shadowing (horizontal): 3,8 %	44°20'26" North Latitude and 17°15'26" East Longitude	33	3590	4050	2620	3,5	0,48	12,9	11,6
Travnik Annual irradiation deficit due to shadowing (horizontal): 1,1 %	44°13'20" North Latitude and 17°39'54" East Longitude	33	3650	4120	2690	3,6	0,48	11,1	9,9
Zenica Annual irradiation deficit due to shadowing (horizontal): 0,2 %	44°12'0" North Latitude and 17°55'59" East Longitude	35	3710	4270	2840	3,5	0,46	13,0	11,8
Kupres Annual irradiation deficit due to shadowing (horizontal): 2,2 %	44°0'15" North Latitude and 17°19'17" East Longitude	34	3700	4220	2800	3,3	0,48	8,5	7,6
Sarajevo Annual irradiation deficit due to shadowing (horizontal): 0,1 %	43°50'51" North Latitude and 18°21'23" East Longitude	35	3800	4380	2930	3,5	0,45	12,2	11,1
Višegrad Annual irradiation deficit due to shadowing (horizontal): 0,6 %	43°47'7" North Latitude and 19°17'35" East Longitude	34	3740	4270	2820	3,3	0,46	12,4	11,3
Pale Annual irradiation deficit due to shadowing (horizontal): 0,1 %	43°49'0" North Latitude and 18°34'0" East Longitude	35	3770	4350	2920	3,4	0,46	9,8	8,8
Livno Annual irradia-	43°49'35" North Lati-	35	3890	4500	3010	3,6	0,43	12,2	11,0

tion deficit due to shadowing (horizontal): 0, 3%	tude and 17°0'37" East Longitude								
Goražde Annual irradiation deficit due to shadowing (horizontal): 3,0 %	43°40'0" North Latitude and 18°58'59" East Longitude	32	3710	4180	2670	3,4	0,46	12,9	11,8
Konjic Annual irradiation deficit due to shadowing (horizontal): 1,7 %	43°39'16" North Latitude and 17°58'0" East Longitude	34	3870	4440	2900	3,7	0,43	14,4	13,3
Foča Annual irradiation deficit due to shadowing (horizontal): 0,4 %	43°30'14" North Latitude and 18°46'41" East Longitude	35	3850	4430	2950	3,5	0,46	11,4	10,3
Mostar Annual irradiation deficit due to shadowing (horizontal): 5,3 %	43°19'59" North Latitude and 17°48'0" East Longitude	30	3910	4350	2660	3,5	0,43	15,5	14,3
Trebinje Annual irradiation deficit due to shadowing (horizontal): 0,2 %	42°42'40" North Latitude and 18°20'33" East Longitude	35	4220	4890	3240	3,4	0,41	14,1	12,9

Table 3 shows that:

1. Yearly average of solar irradiation on horizontal plane ranges from 3390 Wh/m^2 (Gradiška) to 4220 Wh/m^2 (Trebinje);
2. Yearly average of solar irradiation on optimally inclined plane ranges from 3830 Wh/m^2 (Gradiška) to 4890 Wh/m^2 (Trebinje);
3. Yearly average of solar irradiation on vertical plane ranges from 2530 Wh/m^2 (Gradiška) to 3240 Wh/m^2 (Trebinje);
4. Yearly average of the optimal panel inclination ranges from 30° (Mostar) to 35° (Drvar, Zenica, Sarajevo, Pale, Foča, Trebinje);
5. Yearly average of the linked turbidity ranges from 3,1 (Bijeljina) to 3,8 (Bosanska Gradiška, Velika Kladuša, Novi Grad);
6. Yearly average of the ratio diffuse to global solar irradiation ranges from 0,41 (Trebinje) to 0,51 (Gradiška);
7. Yearly average of the daytime temperature ranges from 8,5°C (Kupres) to 15,5 (Mostar) and
8. Yearly average of the 24 hours temperature ranges from 7,6°C (Kupres) to 14,3 (Mostar).

Table 4. Total yearly sum of global irradiation per square meter received by the modules of the given PV system (optimally inclined fixed PV systems, optimally inclined one-axis and dual-axis tracking PV systems) of 1 kW in some cities in Bosnia and Herzegovina obtained by PVGIS [17]

SOME CITIES OF BOSNIA AND HER-ZEGOVINA	TOTAL FOR YEAR SUM OF GLOBAL IRRADIA-TION PER SQUARE METER RECEIVED BY THE MODULES OF THE OPTIMALLY INCLINED FIXED PV 1kW SYSTEM (kWh/m^2)	TOTAL FOR YEAR SUM OF GLOBAL IRRADIATION PER SQUARE METER RECEIVED BY THE MODULES OF THE OPTIMALLY INCLINED ONE-AXIS TRACKING PV 1kW SYSTEM (kWh/m^2)	TOTAL FOR YEAR SUM OF GLOBAL IRRADIA-TION PER SQUARE METER RECEIVED BY THE MODULES OF THE DUAL-AXIS TRACKING 1kW PV SYSTEM (kWh/m^2)
Gradiška	1400	1740	1780
Velika Kladuša	1450	1830	1870
Novi Grad	1440	1790	1840
Orašje	1440	1830	1880
Derventa	1420	1780	1830
Prijedor	1450	1820	1870
Brčko	1450	1850	1890
Bijeljina	1480	1890	1930
Banja Luka	1460	1830	1880
Bihać	1520	1920	1970
Doboj	1460	1810	1860
Tuzla	1490	1890	1940
Zvornik	1430	1670	1720
Drvar	1550	1900	1950
Jajce	1480	1760	1800
Travnik	1510	1850	1900
Zenica	1560	1960	2010
Kupres	1540	1880	1930
Sarajevo	1600	2040	2100
Višegrad	1560	1940	1990
Pale	1590	2010	2070
Livno	1640	2080	2140
Goražde	1520	1850	1890
Konjic	1620	1990	2040
Foča	1620	2000	2060
Mostar	1590	1940	1970
Trebinje	1780	2290	2360

Table 4 shows that:

1. Total yearly sum of global irradiation per square meter received by the optimally inclined fixed PV systems of 1 kW ranges from 1400 kWh (Gradiška) to 1780 kWh (Trebinje);
2. Total yearly sum of global irradiation per square meter received by the optimally inclined one-axis tracking PV systems of 1kW ranges from 1670 kWh (Zvornik) to 2290 kWh (Trebinje);
3. Total yearly sum of global irradiation per square meter received by the dual-axis tracking PV systems of 1kW ranges from 1720 kWh (Zvornik) do 2360 kWh (Trebinje);
4. In Zvornik, the optimally inclined one-axis tracking 1kW PV systems intake 16,78% more solar irradiation compared to optimally inclined fixed 1kW PV systems, dual-axis tracking PV 1kW systems intake 20,28% more solar irradiation compared to optimally inclined fixed 1kW PV system and dual-axis tracking 1kW PV systems intake 2,99% more solar irradiation compared to optimally inclined one-axis tracking 1kW PV systems , and
5. In Trebinje, optimally inclined one-axis tracking PV systems of 1 kW intake 28,65% more solar irradiation than optimally inclined fixed PV system of 1 kW, while dual-axis tracking PV systems of 1 kW intake 32,58% more solar radiation than optimally inclined fixed PV system of 1 kW and dual-axis tracking PV systems of 1 kW intake 3,06 % more solar irradiation than optimally inclined one-axis tracking PV systems of 1kW.

Total yearly sum of global irradiation per square meter received by the modules of the given PV system (optimally inclined fixed PV systems, optimally inclined one-axis and dual-axis tracking PV systems) of 1kW in some cities in Bosnia and Herzegovina, obtained by PVGIS, is given in Table 4 [17].

Geographical position and the results of PVGIS calculation of the yearly average values of the optimal panel inclination, solar irradiation on the horizontal, optimally inclined and vertical plane, linked turbidity, ratio of diffuse to global solar irradiation, daytime temperature and 24 hours of temperature for some cities in Bosnia and Herzegovina are presented in Table 3 [17].

4.2. Electricity production of different types of PV Systems of 1 kW in 13 cities in Bosnia and Herzegovina

Total yearly electricity production of different types of 1kW PV systems in some cities in Bosnia and Herzegovina, obtained by PVGIS, is shown in Table 5 [17].

Table 5. Total yearly electricity production of different types of 1kW PV systems in some cities in Bosnia and Herzegovina [17]

SOME CITIES OF B&H	TOTAL FOR YEAR ELECTRICITY PRODUCTION FROM THE OPTIMALLY INCLINED FIXED PV SOLAR PLANT OF 1 kW (kWh)			TOTAL FOR YEAR ELECTRICITY PRODUCTION FROM THE OPTIMALLY INCLINED ONE-AXIS TRACKING PV SOLAR PLANT OF 1 kW (kWh)			TOTAL FOR YEAR ELECTRICITY PRODUCTION FROM THE DUAL-AXIS TRACKING PV SOLAR PLANT OF 1 kW (kWh)		
	c-Si solar modules	CdTe solar modules	CIS solar modules	c-Si solar modules	CdTe solar modules	CIS solar modules	c-Si solar modules	CdTe solar modules	CIS solar modules
Gradiška	1060	1160	1080	1330	1440	1350	1360	1460	1380
Velika Kladuša	1100	1210	1120	1390	1510	1420	1410	1540	1450
Novi Grad	1090	1210	1110	1360	1490	1390	1390	1530	1420
Orašje	1090	1190	1110	1390	1500	1420	1420	1530	1450
Derventa	1070	1190	1090	1360	1490	1390	1380	1520	1420
Prijedor	1100	1220	1120	1390	1520	1420	1420	1560	1450
Brčko	1100	1200	1120	1400	1510	1430	1430	1540	1460
Bijeljina	1110	1230	1130	1430	1560	1460	1460	1600	1490
Banja Luka	1110	1230	1130	1400	1530	1420	1430	1560	1460
Bihać	1150	1260	1170	1460	1580	1490	1490	1610	1530
Doboj	1100	1220	1120	1370	1500	1410	1400	1540	1440
Tuzla	1130	1230	1150	1440	1550	1470	1470	1580	1500
Zvornik	1070	1200	1100	1250	1380	1290	1280	1410	1310
Drvar	1180	1290	1200	1440	1560	1470	1470	1590	1510
Jajce	1110	1220	1130	1320	1430	1350	1340	1450	1380
Travnik	1140	1250	1170	1410	1520	1440	1440	1550	1470
Zenica	1180	1290	1200	1490	1610	1520	1530	1640	1560
Kupres	1180	1280	1210	1440	1530	1470	1470	1560	1500
Sarajevo	1220	1340	1240	1560	1700	1590	1600	1740	1630
Višegrad	1180	1300	1200	1470	1610	1500	1500	1640	1540
Pale	1220	1330	1240	1550	1670	1580	1590	1710	1620
Livno	1250	1360	1270	1590	1710	1630	1630	1750	1670
Goražde	1140	1260	1170	1380	1500	1420	1410	1530	1450
Konjic	1220	1340	1250	1490	1620	1530	1530	1660	1570
Foča	1240	1350	1260	1530	1670	1560	1570	1710	1600
Mostar	1170	1310	1200	1330	1570	1480	1450	1590	1500
Trebinje	1350	1490	1370	1740	1900	1780	1780	1950	1820

Table 5 shows that:

1. Irrespective of the type of PV systems most electrical energy is generated if CdTe solar cells are used;
2. Total yearly electricity production by the optimally inclined fixed PV systems of 1 kW with solar modules of monocrystalline silicon ranges from 1060 kWh (Gradiška) to 1350 kWh (Trebinje), with CdTe solar modules from 1160

kWh (Gradiška) to 1490 kWh (Trebinje) and with CIS solar modules from 1080 kWh (Gradiška) to 1370 kWh (Trebinje);

3. Total yearly electricity production by the optimally inclined one-axis tracking 1kW PV systems with solar modules of monocrystalline silicon ranges from 1250 kWh (Zvornik) to 1740 kWh (Trebinje), with CdTe solar modules from 1380 kWh (Zvornik) to 1900 kWh (Trebinje) and with CIS solar modules from 1290 kWh (Zvornik) to 1780 kWh (Trebinje) and
4. Total yearly electricity production by the dual-axis tracking PV systems of 1 kW with solar modules of monocrystalline silicon ranges from 1280 kWh (Zvornik) to 1780 kWh (Trebinje), with CdTe solar modules from 1410 kWh (Zvornik) to 1950 kWh (Trebinje) and with CIS solar modules from 1310 kWh (Zvornik) to 1820 kWh (Trebinje).

5. CONCLUSION

The main reason for the research, development and use of solar energy is that the use of solar energy contributes to a more efficient use of a country's own potentials in generating electrical and thermal energy, reduction of "the greenhouse effects" emission, reduction of the import and use of the fossil fuels, development of the local industry and creation of new jobs.

In the light of all the aforementioned one can conclude that nowadays PV systems used worldwide mainly use solar cells made of monocrystalline, polycrystalline and amorphous silicon, CdTe and CIS solar cells. Based on climate and other conditions worldwide fixed, one-axis, and dual-axis tracking PV systems are installed.

Although the Bosnia and Herzegovina has very favourable climate as well as legal conditions for the installation and use of PV solar plants, up to now not a single PV solar plant has been installed to date and there are rare cases of the use of PV systems elsewhere. The solar energy sector in Bosnia and Herzegovina is not developed yet.

PVGIS-based maps and data for average annual solar irradiation for the specific location within the territory of Bosnia and Herzegovina are presented and analysed in order to achieve useful details and assessments for the potentials for solar PVs utilization in Bosnia and Herzegovina. The figures and tables (some examples are presented in this paper) can serve as guidelines for the basic necessary data for solar radiation and design of on-grid PV systems in Bosnia and Herzegovina.

The application of PVGIS program in 27 towns in the Bosnia and Herzegovina shows that the yearly average of the optimal panel inclination ranges from 30° to 35°; total yearly sum of global irradiation per square meter received by the optimally inclined fixed 1kW PV systems ranges from 1400 kWh (Bosanska Gradiška) to 1780 kWh (Trebinje); total yearly sum of global irradiation per square meter received by the optimally inclined one-axis tracking 1kW PV systems ranges from 1670 kWh (Zvornik) to 2290 kWh (Trebinje); total yearly sum of global irradiation per square meter received by the dual-axis tracking 1kW PV systems ranges from 1720 kWh (Zvornik) to 2360 kWh (Trebinje).

Total yearly electricity production by the optimally inclined fixed 1kW PV systems with solar modules of monocrystalline silicon ranges from 1060 kWh (Bosanska Gradiška) to 1350 kWh (Trebinje), with CdTe solar modules ranges from 1160 kWh (Bosanska Gradiška) to 1490 kWh (Trebinje) and with CIS solar modules it ranges from 1080 kWh (Bosanska Gradiška) to 1370 kWh (Trebinje).

Total yearly electricity production by the optimally inclined one-axis tracking PV systems of 1 kW, with solar modules of monocrystalline silicon ranges from 1250 kWh (Zvornik) to 1740 kWh (Trebinje), with CdTe solar modules it ranges from 1380 kWh (Zvornik) to 1900 kWh (Trebinje) and with CIS solar modules from 1290 kWh (Zvornik) to 1780 kWh (Trebinje).

Total yearly electricity production by the dual-axis tracking 1 kW PV systems with solar modules of monocrystalline silicon ranges from 1280 kWh (Zvornik) to 1780 kWh (Trebinje), with CdTe solar modules from 1410 kWh (Zvornik) to 1950 kWh (Trebinje) and with CIS solar modules from 1310 kWh (Zvornik) to 1820 kWh (Trebinje).

Irrespective of the type of PV solar plants, PVGIS program has shown that most electrical energy in Bosnia and Herzegovina can be generated by PV solar plants with CdTe solar cells.

The overall conclusion is that Bosnia and Herzegovina has favourable solar irradiation and climatic conditions for solar PV electricity generation; hence the utilization of solar PV electricity generation in Bosnia and Herzegovina can almost certainly be expected in the future.

Estimated losses in PV systems of 1 kW in some cities in Bosnia and Herzegovina, obtained by PVGIS, are given in Table 6 [17].

Comparison of total yearly electricity production of different types of PV systems with monocrystaline silicon solar modules of 1kW in some cities in Bosnia and Herzegovina is shown in Figure 3.

Comparison of the total for year electricity production of different types of PV system with CdTe solar modules of 1 kW in some cities in Bosnia and Herzegovina is shown in Figure 4.

Comparison of the total yearly electricity production of different types of PV system with CIS 1kW solar modules in some cities in Bosnia and Herzegovina is shown in Figure 5.

Table 6. Estimated losses in 1kW PV systems in some cities in Bosnia and Herzegovina, obtained by PVGIS [17]

SOME CITIES IN B&H	ESTIMATED LOSSES DUE TO TEMPERATURE (USING LOCAL AMBIENT TEMPERATURE) ON:			ESTIMATED LOSS DUE TO ANGULAR REFLECTANCE EFFECTS ON:			OTHER LOSSES (CABLES, INVERTER ETC.) ON:			COMBINED PV SYSTEM LOSSES ON:		
	c-Si solar modules	CdTe solar modules	CIS solar modules	c-Si solar modules	CdTe solar modules	CIS solar modules	c-Si solar modules	CdTe solar modules	CIS solar modules	c-Si solar modules	CdTe solar modules	CIS solar modules
Gradiška	9,1 %	0,7 %	7,6 %	2,9 %	2,9 %	2,9 %	14 %	14 %	14 %	24,1 %	17,0 %	22,9 %
Velika Kladuša	9,0 %	0,7 %	7,6 %	2,8 %	2,8 %	2,8 %	14 %	14 %	14 %	24,0 %	17,0 %	22,7 %
Novi Grad	9,2 %	- 0,3 %	7,7 %	2,8 %	2,8 %	2,8 %	14 %	14 %	14 %	24,1 %	16,2 %	22,8 %
Orašje	9,5 %	1,2 %	7,9 %	2,9 %	2,9 %	2,9 %	14 %	14 %	14 %	24,4 %	17,5 %	23,1 %
Derventa	9,3 %	- 0,1 %	7,8 %	2,9 %	2,9 %	2,9 %	14 %	14 %	14 %	24,2 %	16,3 %	22,9 %
Prijedor	9,2 %	- 0,2 %	7,7 %	2,8 %	2,8 %	2,8 %	14 %	14 %	14 %	24,1 %	16,3 %	22,9 %
Brčko	9,4 %	1,2 %	7,9 %	2,9 %	2,9 %	2,9 %	14 %	14 %	14 %	24,4 %	17,5 %	23,1 %
Bijeljina	9,5 %	0,2 %	8,0 %	2,9 %	2,9 %	2,9 %	14 %	14 %	14 %	24,4 %	16,7 %	24,4 %
Banja Luka	9,1 %	- 0,2 %	7,6 %	2,8 %	2,8 %	2,8 %	14 %	14 %	14 %	24,0 %	17,3 %	22,8 %
Bihać	9,3 %	0,1 %	7,8 %	2,8 %	2,8 %	2,7 %	14 %	14 %	14 %	24,2 %	17,2 %	22,9 %
Doboj	9,2 %	- 0,1 %	7,7 %	2,8 %	2,8 %	2,8 %	14 %	14 %	14 %	24,2 %	16,4 %	22,8 %
Tuzla	9,2 %	1,2 %	7,6 %	2,8 %	2,8 %	2,8 %	14 %	14 %	14 %	24,1 %	17,4 %	22,8 %
Zvornik	10,3 %	0,4 %	8,4 %	2,6 %	2,6 %	2,5 %	14 %	14 %	14 %	24,9 %	16,5 %	23,2 %
Drvar	9,1 %	1,0 %	7,5 %	2,6 %	2,6 %	2,6 %	14 %	14 %	14 %	23,9 %	17,1 %	22,5 %
Jajce	10,2 %	1,5 %	8,3 %	2,6 %	2,6 %	2,6 %	14 %	14 %	14 %	24,7 %	17,4 %	23,1 %
Travnik	8,8 %	0,7 %	7,1 %	2,7 %	2,7 %	2,7 %	14 %	14 %	14 %	23,7 %	16,9 %	22,3 %
Zenica	9,2 %	1,0 %	7,6 %	2,7 %	2,7 %	2,7 %	14 %	14 %	14 %	24,0 %	17,2 %	22,7 %
Kupres	8,1 %	0,9 %	6,4 %	2,6 %	2,6 %	2,6 %	14 %	14 %	14 %	23,0 %	17,0 %	21,6 %
Sarajevo	8,8 %	0,0 %	7,3 %	2,7 %	2,7 %	2,7 %	14 %	14 %	14 %	23,7 %	16,3 %	22,4 %
Višegrad	9,2 %	0,1 %	7,5 %	2,7 %	2,7 %	2,7 %	14 %	14 %	14 %	24,0 %	16,4 %	22,6 %
Pale	7,9 %	- 0,1 %	6,4 %	2,7 %	2,7 %	2,7 %	14 %	14 %	14 %	23,0 %	16,2 %	21,8 %
Foča	8,4 %	- 0,2 %	6,9 %	2,7 %	2,7 %	2,7 %	14 %	14 %	14 %	23,4 %	16,1 %	22,1 %
Mostar	11,4 %	1,8 %	9,2 %	2,6 %	2,6 %	2,6 %	14 %	14 %	14 %	25,7 %	17,7 %	23,9 %
Trebinje	9,5 %	0,3 %	7,8 %	2,7 %	2,7 %	2,7 %	14 %	14 %	14 %	24,2 %	16,5 %	22,9 %

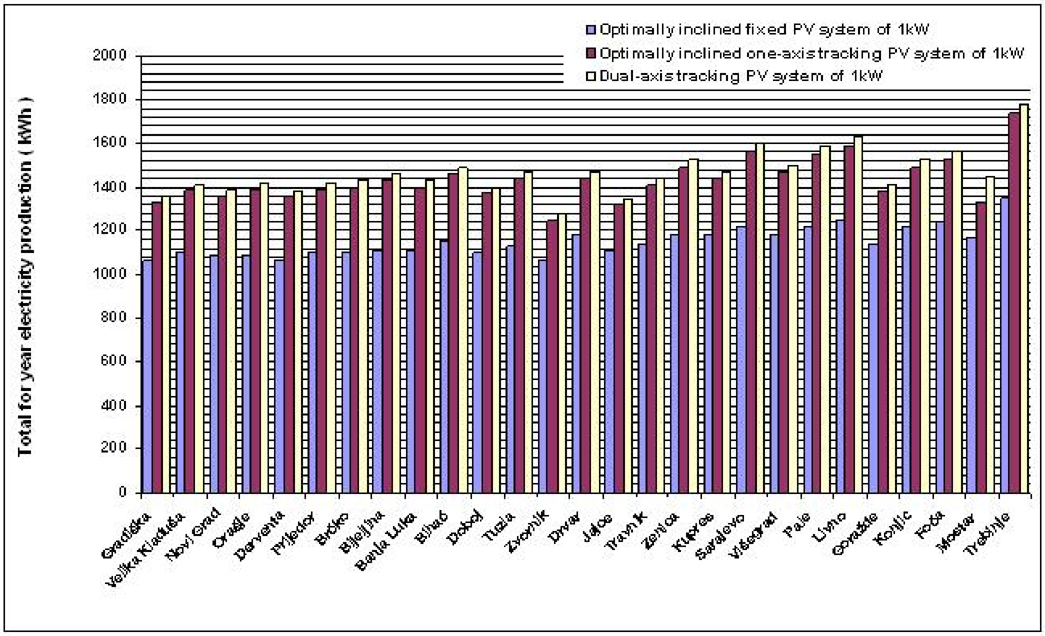

Figure 3. Comparison of the total yearly electricity production of different types of PV systems with monocrystaline silicon 1kW solar modules in some cities in Bosnia and Herzegovina

Figure 3 shows that

1. In Gradiška by means of dual-axis tracking 1kW PV system with solar modules of monocrystalline silicon, 28,3 % more electrical energy is generated compared to optimally inclined fixed 1kW PV systems with solar modules of monocrystalline silicon and 2,26 % more electrical energy is generated than in the case of optimally inclined one-axis tracking 1kW PV systems with solar modules of monocrystalline silicon and
2. In Trebinje by means of dual-axis tracking 1kW PV system with solar modules of monocrystalline silicon 31,85 % more electrical energy is generated compared to optimally inclined fixed PV system of 1 kW with solar modules of monocrystalline silicon and 2,29 % more electrical energy is generated than by means of the optimally inclined one-axis tracking PV systems of 1 kW with solar modules of monocrystalline silicon.

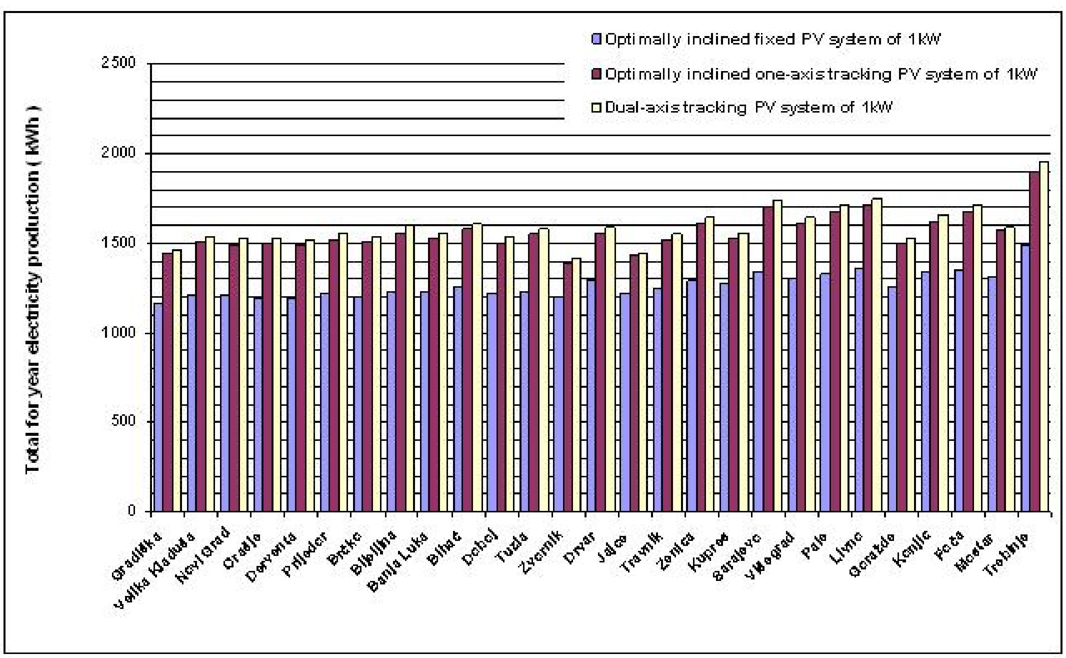

Figure 4. Comparison of the total for year electricity production of different types of PV system with CdTe solar modules of 1 kW in some cities in Bosnia and Herzegovina

Figure 4 shows that

1. In Gradiška by means of dual-axis tracking PV system of 1 kW with CdTe solar modules 25,86 % more electrical energy is generated than in the case of optimally inclined fixed PV system of 1 kW with CdTe solar modules and 1,39 % more electrical energy in comparison to the optimally inclined one-axis tracking PV systems of 1 kW with CdTe solar modules and

2. In Trebinje by means of dual-axis tracking PV system of 1 kW with CdTe solar modules, 30,87 % more electrical energy is generated than by optimally inclined fixed 1kW PV system with CdTe solar modules and 2,63 % more electrical energy is generated than by the optimally inclined one-axis tracking 1kW PV systems with CdTe solar modules.

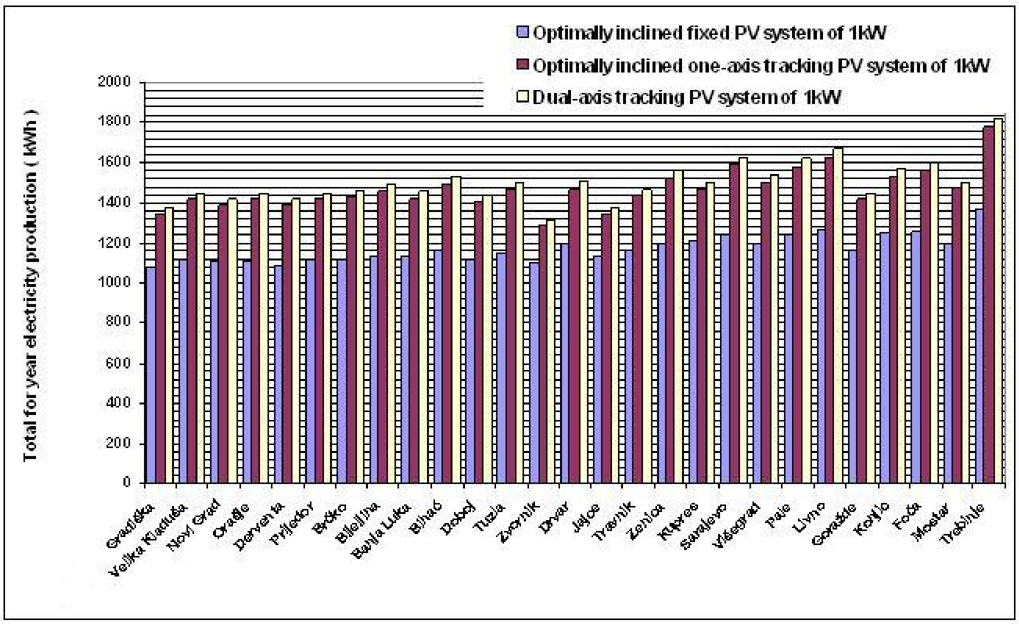

Figure 5. Comparison of the total yearly electricity production of different types of PV system with CIS solar1kW modules in some cities in Bosnia and Herzegovina

Figure 5 shows that

1. In Gradiška by means of dual-axis tracking 1kW PV system with CIS solar modules 27,78 % more electrical energy is generated than by the optimally inclined fixed 1kW PV system with CIS solar modules and 2,22 % more electrical energy is generated than by the optimally inclined one-axis tracking 1kW PV systems with CIS solar modules and

2. In Trebinje, by means of dual-axis tracking 1kW PV systems with CIS solar modules 32,85% more electrical energy is generated than by the optimally inclined fixed 1kW PV system with CIS solar modules and 2,25% more electrical energy is generated than by the optimally inclined one-axis tracking 1kW PV systems with CIS solar modules.

REFERENCES

[1] B. Parida, S. Iniyan, R. Goic, *A review of solar photovoltaic technologies*, Renewable and Sustainable Energy Reviews, 15−3 (2011) 1625−1636.

[2] T. Pavlović, D. Milosavljević, A. Radivojević, M. Pavlović, *Comparison and assessment of electricity generation capacity for different types of PV solar plants of 1MW In Soko Banja, Serbia,* Thermal Science, 15−3 (2011) 605−618.

[3] M. E. Meral, F. Dincer, *A review of the factors affecting operation and efficiency of photovoltaic based electricity generation systems*, Renewable and Sustainable Energy Reviews, 15−5 (2011) 2176−2184.

[4] F. Dincer, *The analysis on photovoltaic electricity generation status, potential and policies of the leading countries in solar energy*, Renewable and Sustainable Energy Reviews, 15−1 (2011) 713−720.

[5] R. Blinc, D. Najdovski, S. Bekteshi, S. Kabashi, I. Šlaus, A. Zidanšek, *How to achieve a sustainable future for Europe*, Thermal Science, 12−4 (2008) 19−25.

[6] D. Chiras, R. Aram, K. Nelson, *Power from the sun – achieving energy independence*, New society publishers, Canada, 2009.

[7] R. Messenger, J. Ventre, *Photovoltaic systems engineering,* CEC Press, Taylor & Francis Group, USA, 2010.

[8] D. Djurdjević, Perspectives and assessments of solar PV power engineering in the Republic of Serbia, *Renewable and Sustainable Energy Reviews*, 15−5 (2011) 2431−2446.

[9] Trama TecnoAmbiental, Deliverable 1: Inception Mission, Study on the possibilities use and development of solar energy in BiH, EDU/0724/07, Available online at: http://www.vladars.net/sr-sp-cyrl/vlada/ministarstva/mper/Documents/solarxenergyxstudyxeng.pdf

[10] www.fao.org/docrep/014/k9589e/k9589e06.pdf

[11] www.planbleu.org/publications/atelier_energie/BA_Summary.pdf

[12] D. Lalic, Kiril Popovski, V. Gecevskac, S. Popovska Vasilevska, Z. Tesic, *Analysis of the opportunities and challenges for renewable energy market in the Western Balkan countries*, Renewable and Sustainable Energy Reviews, 15−6 (2011) 3187−3195.

[13] D. R. Schneider, et all, *Mapping the potential for decentralized energy generation based on RES in Western Balkans*, Thermal Science, 11−3 (2007) 7−26.

[14] www.cbd.int/doc/world/ba/ba-nr-01-en.pdf

[15] http://www.fhmzbih.gov.ba/latinica/bihklima.php

[16] http://www.bosnia-herzegovina.climatetemp.info/

[17] PVGIS © European Communities; 2001–2008. Available online at: http://re.jrc.ec.europa.eu/pvgis/apps3/pvest.php

[18] M. Šúri, T. A. Huld, E. D. Dunlop, *PV-GIS: A Web-based Solar Radiation Database for the Calculation of PV Potential in Europe*, International Journal of Sustainable Energy, 24−2 (2005) 55−67.

[19] http://sunbird.jrc.it/pvgis/apps/pvest.php?europe=

АНАЛИЗА PV СИСТЕМА ЗА ПРОИЗВОДЊУ СТРУЈЕ ОД 1kW У БОСНИ И ХЕРЦЕГОВИНИ

Апстракт: Рад се фокусира на анализе PV система за производњу струје од 1 kW у Босни и Херцеговини. На почетку су дати неки подаци о соларној енергији и PV системима, политикама за обновљиве изворе енергије и о физичко-географском положају и климатским карактеристикама Босне и Херцеговине. На основу PVGIS програма, дати су резултати израчунавања годишњих просјечних вриједности оптималних нагиба плоча, исијавања сунца на хоризонтално, вертикално и оптимално нагнутој плочи, однос дифузног и глобалног зрачења сунца, повезане замагљености, просјечне температуре током дана и 24-сатног просјека температуре за 27 градова у Босни и Херцеговини. Дат је укупни годишњи збир глобалног исијавања по квадратном метру које приме модули оптимално нагнутих фиксираних PV система од 1 kW, као и укупна годишња производња електричне енергије различитих врста PV система од 1 kW, и укупна годишња производња електричне енергије различитих врста PV система од 1 kW за 27 градова у Босни и Херцеговини, добијених од PVGIS-а. Такође је приказано поређење укупне годишње производње електричне енергије различитих врста PV система од 1 kW од монокристалног силицијума, CdTe и CIS соларних модула, сваког понаособ, за 27 градова у Босни и Херцеговини. Израчунавања вршена уз помоћ PVGIS програма су показала да, без обзира на врсту PV система, већина електричне енергије у Босни и Херцеговини може бити произведена PV системима уз помоћ CdTe соларних ћелија. Неке практичне податке и разматрања који су дати у овом раду могу искористити клијенти или компаније који су заинтересовани за инвестирање у PV сектору у Босни и Херцеговини.

Кључне ријечи: соларна енергија, PV системи, климатске карактеристике и PV у Босни и Херцеговини.