

CURRENT STATE AND PROSPECTS FOR RENEWABLE ENERGY SOURCES WITH A SPECIAL EMPHASIS ON POTENTIAL OF SOLAR ENERGY IN THE WORLD, EUROPE AND BOSNIA AND HERZEGOVINA

Isak Karabegović¹, Vlatko Doleček²

¹ Technical faculty, University of Bihać, dr. Irfana Ljubijankića St.,
77000 Bihać, Bosnia and Herzegovina

² Academician, Academy of Sciences and Arts, Bosnia and Herzegovina,
Bistrik 7, 71000 Sarajevo, Bosnia and Herzegovina

Abstract: Energy security and stability are currently the main issues throughout the world. Applied research is carried out all over the world in order to increase a share of renewable energy sources in the overall task of energy generation. In near future environmentally friendly energy sources should be found that will enable the mankind to cover its energy needs. Renewable energy sources are currently offered worldwide as an environmentally friendly and acceptable solution; however, one may always wonder whether it is realistic to expect such energy sources to be developed at a level sufficient to meet the mankind's ever increasing energy needs. This caution is caused by the following facts associated with the renewable energy sources available today: the wind energy is not everywhere available in sufficient quantities, solar energy is not sufficiently used, hydropower (we refer to small hydro power plants), is not big enough for this quantity of energy, geothermal energy can be optimally used only at places where thermal energy from the inner core of the Earth is near the surface, tidal energy (energy of the waves) has great potentials but is very little used due to its scarcity and non-accessibility, bioenergy, as a substitute for conventional fossil fuels, is not completely environmentally friendly or acceptable due to the emission of greenhouse gases in the atmosphere. On the other hand, without implementing the adequate policies in the energy sector operation, it is not possible to have any industrial, economic or social progress in the world. Energy security and stability are only one part in achieving the ultimate goals: sustainable economy, clean environment, high standard of living, prosperity and health of the population. In the light of all the above, the paper will investigate the state and perspective of renewable energy sources with a special emphasis on the potential of solar energy.

Keywords: renewable energy sources, solar energy, current state of solar energy, perspectives of solar energy.

1. INTRODUCTION

Energy stability is an important factor for the development of any country in the world, because no country in the world is able to develop its economy or industry without energy stability; without it there is no high standards of living, clean environment, prosperity of the whole society or sustainable economy. Energy is a priority that needs to be dealt with in accordance with the policies of the world and the European Union set for 2030, through the use of renewable energy sources. Energy sources are limited, largely non-renewable and unevenly distributed. Energy generation and utilization present a threat in

terms of pollution of the environment on a large scale and the consequences of the environment pollution cannot be localized just to the territory of one country. International conventions and legal frameworks relating to the environment protection have become valid for and binding on all national energy systems.

The current trends in EU in terms of investments in renewable energy sources are in fact complementary with sustainable development. The investments in the energy efficiency in Bosnia and Herzegovina have a capacity of yielding multiple benefits considering the current state, and of guaranteeing returns on investment in a relatively short

* Corresponding author: isak1910@hotmail.com

time period. Bosnia and Herzegovina exploits its mountains and rivers with a special emphasis on electrical energy generation by means of hydro power plants and considerable coal reserves for thermo power plants construction. Renewable energy sources such as wind power plants, electrical and thermal energy are the types of production units that need to be introduced in electricity generation in order to comply with the national and international

requirements for the decrease of CO₂ emission. Based on Figure 1 one can conclude that the trend of utilization of renewable energy sources increases over the years, and that the solar energy shows an upward trend in recent years [curve (4) in Figure 1]. Renewable energy sources increase the sustainability of the power system even in cases of possible energy crises in electricity generation which is nowadays heavily dependant on the supply of coal, gas and oil.

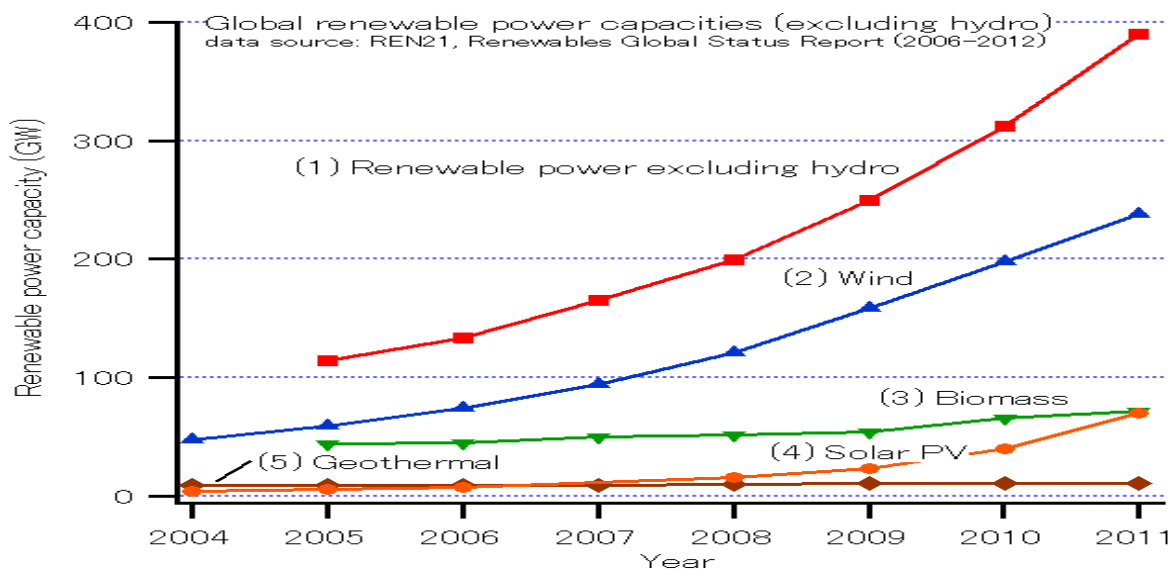


Figure 1. Trend of use of renewable energy sources in the period 2004-2011

The Document „REN21's 2011 Renewables Global Status Report (GSR)“, presents the fact that currently 16.7% of energy worldwide is generated from renewable energy sources. The strategic plan for energy production from renewable energy sources for the world was not fulfilled, because it envisaged the production of 20% of energy from renewable energy sources by 2011, while only 16.7% was produced. Furthermore, according to the World Electricity Generation, 28.0% of energy was planned to be produced from renewable energy sources by 2030. At the conference in Washington in March 2012, UN Secretary-General Ban Ki-moon suggested that by 2030 the world should produce 30% of energy from renewable energy sources [1,6,8,9,12,14,15]. The principal reasons for using renewable energy sources are the following: protection of the environment, requirement for reduction of greenhouse gases emission, reduction of hazards related to nuclear energy utilization, improvement of energy security, decreasing dependence on import of energy and decrease in fossil fuels consumption, improved economic competitiveness and creation of new jobs and promoting new technology advancements.

2. RENEWABLE ENERGY SOURCES POTENTIAL IN THE WORLD AND IN BOSNIA AND HERZEGOVINA WITH A SPECIAL EMPHASIS ON SOLAR ENERGY POTENTIAL

In order to implement the plans suggested by the UN Secretary-General Ban Ki-moon, put forward at the conference in Washington in 2012, additional financial means should be provided to invest in renewable energy sources. Investments in renewable energy sources worldwide during the period 2004-2012 are shown in Figure 2.

Figure 2 shows that during the period 2004 – 2012 investments in renewable energy sources on all continents are continuous and that the trend of investment is increasing. In China the investments in 2012 reached 66.6 billion U.S. dollars, and are higher compared to the investment in 2011, while in Europe and the USA investments in 2012 were lower than the sum of investments in renewable energy sources in 2011. Investments in renewable energy sources worldwide in 2012 are shown in Figure 3.

Figure 3 shows that the biggest investments in renewable energy sources in 2012 were in Europe amounting to 79.9 billion dollars, and that China was second ranked with 66.6 billion dollars. China shows an upward trend in the investment in renewable energy sources year in year out. The highest level of investments in renewable energy sources in China was in 2012. A share of renewable energy sources in electricity generation is shown in Figure 4.

Figure 4 shows the annual increase of renewable energy sources in the electrical energy generation worldwide. In 2012, 7% of electrical energy worldwide was generated from renewable energy sources and about 4,8% in the OECD countries. A share of renewable energy sources in the electrical energy generation and a cumulative increase from the previous year is presented in Table 1.



Figure 2. Investments in renewable energy sources in the world during the period 2004-2012 (billion dollars) [8]

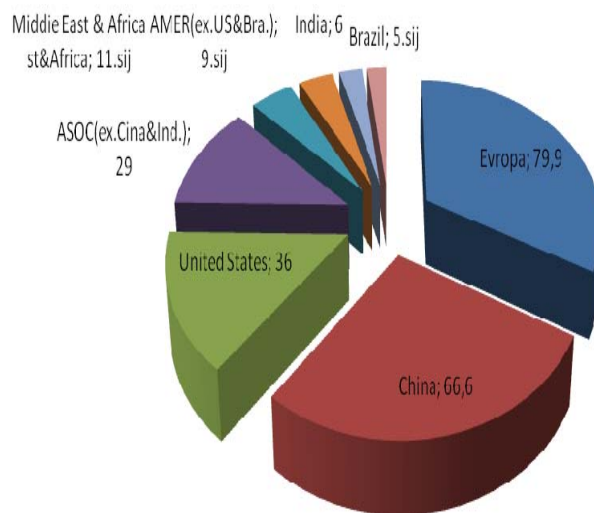


Figure 3. Investments in renewable energy sources in the world in 2012 (billion dollars) [8]

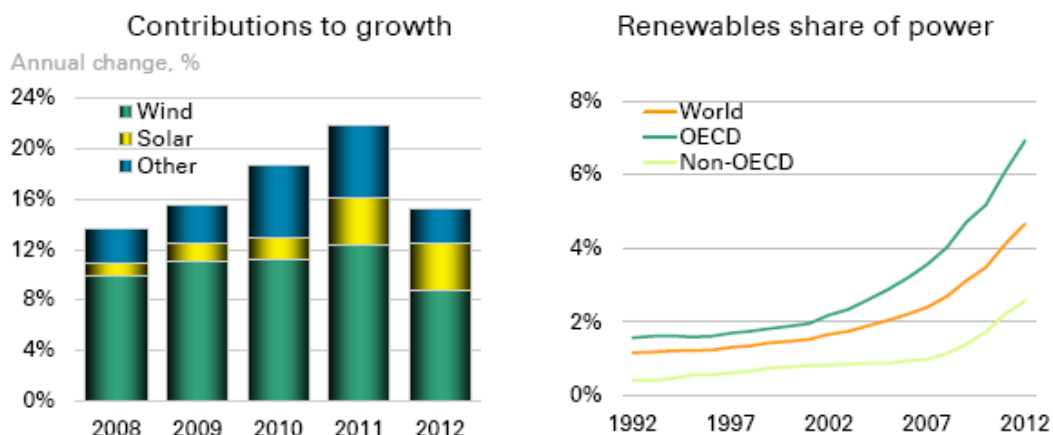


Figure 4. Share of renewable energy sources in the electrical energy generation [1]

Tab.1. Share of renewable energy sources in electricity generation and a cumulative increase compared to the previous year [2]

	Hydropower	Solar	Wind	Geothermal	Biomass	All Renewables
2000	275,573 (-13.8%)	804 (8.3%)	5,593 (24.6%)	14,093 (-5.0%)	60,726 (1.9%)	356,789 (-10.6%)
2001	216,961 (-21.3%)	822 (2.2%)	6,737 (20.5%)	13,741 (-2.5%)	49,748 (-18.1%)	288,009 (-19.3%)
2002	264,329 (21.8%)	857 (4.3%)	10,354 (53.7%)	14,491 (5.5%)	53,709 (8.0%)	343,740 (19.4%)
2003	275,806 (4.3%)	929 (8.4%)	11,187 8.0%	14,424 (-0.5%)	53,340 (-0.7%)	355,686 (3.5%)
2004	268,417 (-2.7%)	1,020 (9.8%)	14,144 (26.4%)	14,811 (2.7%)	53,073 (-0.5%)	351,465 (-1.2%)
2005	270,321 (0.7%)	1,145 (12.2%)	17,811 (25.9%)	14,692 (-0.8%)	54,160 (2.0%)	358,129 (1.9%)
2006	289,246 (7.0%)	1,312 (14.6%)	26,589 (49.3%)	14,568 (-0.8%)	54,759 (1.1%)	386,474 (7.9%)
2007	247,510 (-14.4%)	1,718 (31.0%)	34,450 (29.6%)	14,637 (0.5%)	55,539 (1.4%)	353,854 (-8.4%)
2008	254,831 (3.0%)	2,208 (28.5%)	55,363 (60.7%)	14,840 (1.4%)	55,034 (-0.9%)	382,276 (8.0%)
2009	273,455 (7.3%)	2,922 (32.4%)	73,886 (33.5%)	15,009 (1.1%)	54,493 (-1.0%)	419,755 (9.8%)
2010	260,203 (-4.8%)	4,505 (54.2%)	94,652 (28.1%)	15,219 (1.4%)	56,089 (2.9%)	430,668 (2.6%)
2011	325,074 (24.9%)	7,454 (65.5%)	119,747 (26.5%)	16,700 (9.7%)	56,732 (1.1%)	525,707 (22.1%)

- annual decrease | annual increase +

Based on the data shown in Table 1, it can be seen that there is a constant increase in share of renewable energy sources in electrical energy generation throughout the world. In 2011, compared to 2010, there was a 65.5% increase in electrical energy production using solar energy. A comparative overview of non-renewable energy sources reser-

ves and the potential of renewable energy sources on Earth are given in Figure 5.

Potentials for using of solar radiation on the Earth are shown in Figure 6.

Figure 7 shows a graphical presentation of solar energy utilization in the world during the period 2001-2011.

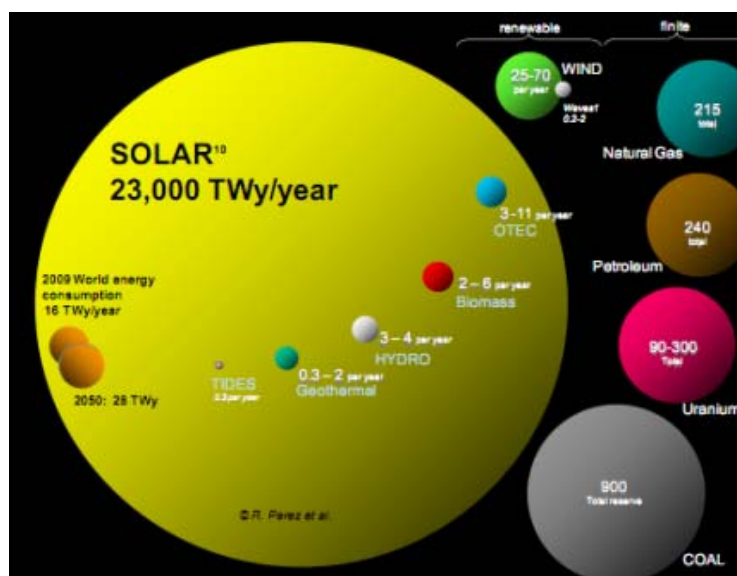
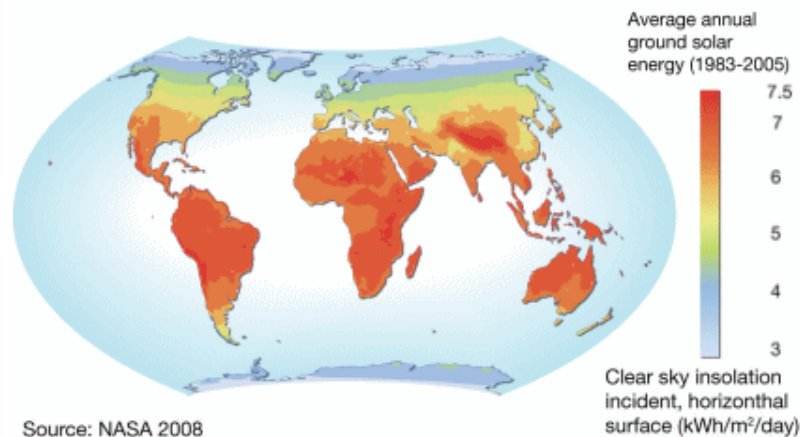


Figure 5. Comparative overview of non-renewable energy sources reserves and the potential of renewable energy sources on Earth (terawatt/year) [15]



Source: NASA 2008

Figure 6. World map of solar energy potential utilization [3]

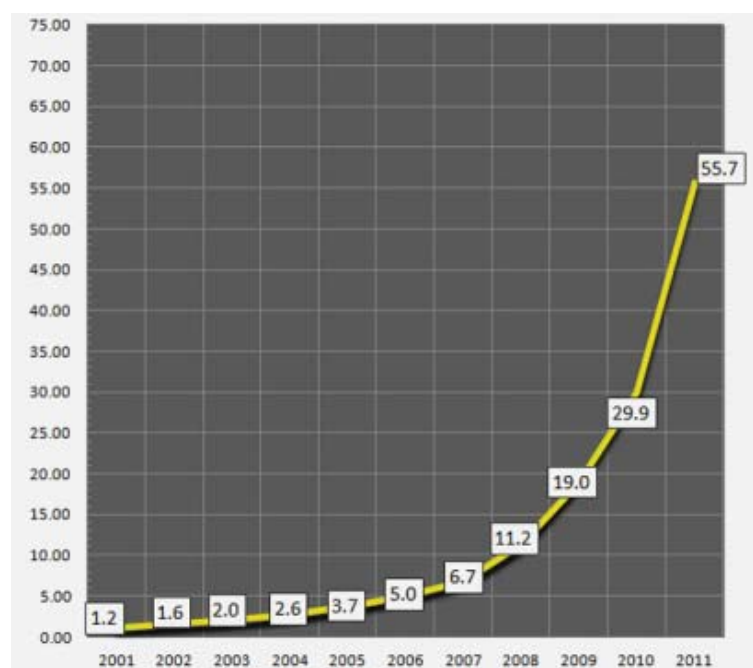


Figure 7. Graphical presentation of solar energy utilization in the world in the period 2001-2011 in TWh [16]

192,2 billion dollars were invested in 2011 in solar energy utilization in EU countries. A part of this investment was intended for the development, production and installment of solar energy utilization plants. A share of renewable energy sources in EU in 2010 (Figure a) and a share of renewable energy sources in gross final energy consumption in EU in 2011 (Figure b- green colour indicates the data for 2011, gray colour indicates the plan envisaged for 2020) are shown in Figure 8 [4,5].

EU has established a PV-net networking of the representatives of research institutions and companies dealing with the production of the facilities for solar energy utilization. The average annual solar radiation energy falling on the flat surface in Europe (kWh/m²) and the average annual generation of elec-

trical energy (kWh) in EU from using solar energy are presented in Figure 9.

17,3 TWh of thermal energy was generated in 2010 in EU in the plants using the energy of the sun, while the annual turnover in the field of solar energy production was 2.6 billion €. At that time the solar power sector had 33 500 employees. One new worker is employed on each 80 kW of installed new capacities for utilization of solar radiation in EU. Turnover is concentrated in local small and middle scale companies. 13,4 GW, 21.9 GW of photovoltaic systems were connected to the power grid in EU, in 2010 and 2011, respectively. The US industry for the utilization of solar radiation employs over 100 000 workers, which is more than in the coal and steel industry together. US industry for using solar

radiation is the fastest growing industry. New jobs are created in this industry 10 times faster than in the whole remaining American economy. US industry for using solar radiation includes over 5000 small and middle scale companies [1,2,3,4,8,9,13,16]. As for the investment in using the energy of the sun in the world three countries are leading the way: Germany with 15.0, Japan with 13.1 and Italy with

13.0 billion dollars. In 2012 Germany saw a decrease of the investments in solar radiation industry by 15%. On the other hand, in 2012 Greece increased the investments in the industry of using solar radiation by 195%. In China, 0.16\$ is earned for 1 kWh of electricity generated from photovoltaic systems, which is a good basis for a more extensive use of photovoltaic solar systems.

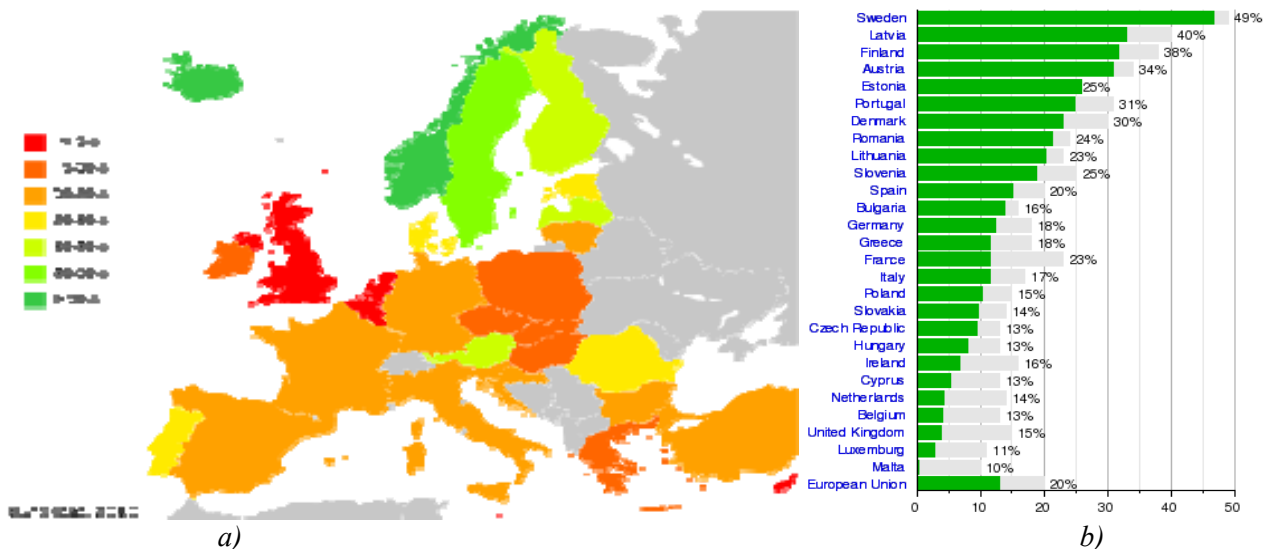


Figure 8. Share of renewable energy sources in EU in 2010 (Figure a) and share of renewable energy sources in the gross final consumption of energy in EU in 2011 (Figure b- green colour indicates the year 2011, gray colour indicates the plan envisaged to 2020) [4,5].

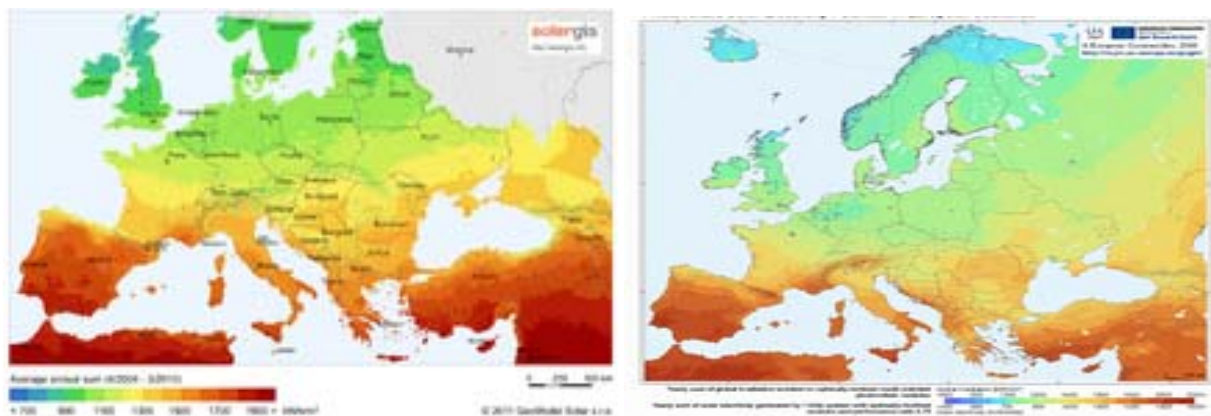


Figure 9. Average annual solar radiation energy falling on the flat surface in Europe (kWh/m^2) and average annual generation of electrical energy (kWh) in EU by using solar energy [17]

3. POTENTIALS OF SOLAR ENERGY AS A RENEWABLE ENERGY SOURCE IN BOSNIA AND HERZEGOVINA

Solar radiation reaching the Earth's surface depends on the geographical position of the given location and changes during the day and during the year. Besides, solar radiation intensity decreases

with the decrease of altitude and the increase of latitude.

The annual average of daily solar radiation energy reaching the horizontal surface in Bosnia and Herzegovina amounts to $3.4 - 4.4 \text{ kWh}/\text{m}^2$. In the northern part of Bosnia and Herzegovina 1240 kWh of solar radiation energy reaches 1 m^2 of horizontal surface, and in the southern parts this amount per 1 m^2 is 1600 kWh [17].



Figure 10. Exploitation of solar energy for different purposes



Figure 11. Cartographic illustration of annual radiation of flat surfaces by total solar radiation [10]

Theoretical potential for solar energy utilization in the territory of Bosnia and Herzegovina amounts to 74.65 PWh. Only in the previous few years has Bosnia and Herzegovina started using solar energy more extensively. Investments in installations for the solar energy utilization are characterised by high initial investment, but also very low running costs for the solar systems whose economic life is about 25 years. In order to encourage the use of solar radiation in Bosnia and Herzegovina, the federal and entity authorities should introduce adequate feed-in systems and other incentives in accordance with the European and world standards in this field. In Bosnia and Herzegovina, several photovoltaic systems with the installed power of around 800 kW are currently installed or in construction, which is insignificant compared to the available potentials of the solar radiation energy capacity of the country.

4. CONCLUSION

In line with all previously stated it can be concluded that the trend of renewable energy sources utilization worldwide is increasing each year. Renewable energy sources increase self-sustainability of the electro-energy system in case of possible energy crises in electrical energy generation, which is nowadays dependent on the supply of coal, gas and oil. The strategic plan for energy production from renewable energy sources for the world was not fulfilled, because it envisaged the production of 20% of energy from renewable energy sources by 2011, while only 16.7% was produced. The plan also envisaged 28.0% of produced energy from renewable energy sources by the year 2030. Solar energy is the most accessible renewable energy source on Earth. In 2011 three countries are leading

the way in investing in solar sources of energy and these are: Germany, Japan and Italy. In 2012 Germany decreased the investments in the systems for using solar radiation by 15%, while Japan increased the investments by 56 %, and Greece showed an increase in investments by 195%. More intensive utilization of solar radiation and other renewable energy sources was encouraged in China by means of adequate subsidies. Based on all the data and conducted analyses it can be concluded that there is a significant potential for solar energy utilization in the territory of Bosnia and Herzegovina. Until now, the installed power of photovoltaic systems in Bosnia and Herzegovina is 800 kW.

5. REFERENCES

- [1] BP Statistical Review of World Energy 2013.
- [2] Global renewable Energy Development, October, 2012.
- [3] Hugh Ahlenius , UNEP / GRID - Arendal Maps and Graphics Library]
- [4] Eurostat news release 65/2013, 26. April 2013.
- [5] M. Šuri, T. A. Huld, E. D. Dunlop, H. A. Ossenbrink, *Potential of solar electricity generation in the European Union member states and candidate countries*, Solar Energy, Vol. 81 (2007) 1295–1305.
- [6] F. Vanek, L. Albright, L. Angenent, *Energy Systems Engineering: Evaluation and Implementation*, Conveo Publisher Service, New York 2012.
- [7] D. Bago, *Solar energy in Bosnia and Herzegovina*, Association of entrepreneurs of Posušje 2011.
- [8] V. Doleček, I. Karabegović, *Renewable Energy Sources of Bosnia and Herzegovina: State and Perspectives*, 8th International Conference on Renewable Energy and Energy Efficiency, Montenegro Academy of Sciences and Arts, 7. October 2013, Podgorica, Montenegro, 2013.
- [9] I. Raguzin, *Model of costs and profits analysis in biomass utilization in electrical energy generation*, Master thesis, Mechanical engineering faculty, Slavonski Brod 2011.
- [10] D. Šljivac, Z. Šimić, *Renewable sources of energy*, AWERES, FER, Zagreb 2009.
- [11] M. Banjac, *Renewable sources of energy in Serbia*, SREM, Ruma 2012
- [12] Union of Concerned Scientists, *Benefits of Renewable Energy Use*, 1999.
- [13] G. Granić, M. Željko, *Study of energy sector in Bosnia and Herzegovina. Module 1, 2, 3, 4, 5, 6, 7, 8, 9, 10*, Sarajevo 2008.
- [14] J. Armstrong, J. Hamrin, *What are "Renewable Resources"?*, Chapter 1: Renewable Energy Overview, Cost-Effectiveness of Renewable Energy, Organization of American States, 2013.
- [15] <http://cleantechnica.com/solar-power/#%20amg0HUyXr5phZWE3.99,06.01.2014>.
- [16] www.gregor.us/dana:bp_statistical_review,08.01.2014.
- [17] <http://re.jrc.ec.europa.eu/pvgis/,14.01.2014>.



СТАЊЕ И ПЕРСПЕКТИВЕ ОБНОВЉИВИХ ИЗВОРА ЕНЕРГИЈЕ СА ОСВРТОМ НА ПОТЕНЦИЈАЛ СОЛАРНЕ ЕНЕРГИЈЕ У СВИЈЕТУ, ЕВРОПИ И БИХ

Сажетак: Данас у цијелом свијету главно питање је енергетска сигурност и стабилност. У цијелом свијету се врше примјењена истраживања у циљу повећања удјела обновљивих извора енергије у цјелокупној мисији производње енергије. У блиској будућности неопходно је пронаћи еколошки прихватљиве изворе енергије којима ће човјечанство покривати своје енергетске потребе. Тренутно у свијету се као еколошки прихватљиво рјешење нуди и предлажу обновљиви извори енергије, међутим питање се поставља да ли је реално очекивати да ће се ти обновљиви извори енергије развити тако да могу задовољити потребе човјечанства за енергијом које из дана у дан расту. Ова опрезност се јавља из разлога што у обновљиве изворе енергије убрајамо: енергију вјетра која није свугдје додатна у довољним количинама, енергију сунца која није довољно искориштена, хидроенергија (мисли се на мале хидроелектране) нису довољне за талику енергију, геотермална енергија која се може оптимално искоришћавати на мјестима гдје је топлотна енергија из унутрашњости Земље је близу површине Земље, енергија плиме и осеке (валова) која има велики потенцијал има мало искориштење због слабе доступности, биоенергија као замена за класична горива није еколошки потпуно прихватљива јер у атмосферу испуштају

разне штетне гасове. У свијету није могуће остварити индустријски, економски и друштвени напредак без адекватне политике у пословању енергетског сектора. Енергетска сигурност и стабилност, представља само један дио у остваривању крајњих циљева: одрживе економије, чисте околине, високог животног стандарда, просперитета и здравља становништва. У односу на све наведено у раду ће бити обрађено стање и перспективе обновљивих извора енергије са освртом на потенцијал соларне енергије

Кључне ријечи: обновљиви извори енергије, соларна енергија, стање соларне енергије, перспективе соларне енергије.