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RENEWABLE ENERGY SOURCES IN BOSNIA AND HERZEGOVINA: SITUATION AND PERSPECTIVES

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Abstract: Energy security and stability has become a major issue over the last few years in the whole world's economic and social development. Despite its high development and evolution of its approach to the issue of energy security, the European Union is also facing the problem of decreasing its role in reducing human impact on the climate. Energy is of essential importance for the development of any country, including Bosnia and Herzegovina. Without adequate policies in the energy sector bussines, industrial and economic progress is not possible either. However, regardless of how energy is important for the development, it is still only a mechanism for achieving an ultimate goal – sustainable economy, clean environment, high living standards, prosperity and population health. According to the official data, Bosnia and Herzegovina produces annually about 13.600 GWh (data from 2010), out of which 7.950 GWh in thermal power plants and 5.650 GWh in hydro power plants. Basic domestic energy sources in Bosnia and Herzegovina include coal and hydropower, while gas and oil are imported. This paper gives an overview of future of the European Union energy policy by 2020, together with the situation and outlooks for Bosnia and Herzegovina renewable energy sources: hydropower, wind power, solar energy, biomass and geothermal energy. The legislation of renewable sources in the Federation of BIH, as well as the European Union's legislative framework, are also presented.

Keywords: energy, renewable energy sources, hydropower, wind power, solar energy, Biomass.

1. INTRODUCTION

Energy is of vital importance for the development of any country in the world and Bosnia and Herzegovina as well. Without adequate policies in the energy sector bussines, industrial and economic progress is not possible either. However, regardless of how important energy is for development, it is still only a mechanism for achieving the ultimate goals – sustainable economy, clean environment, high living standards, prosperity and health of population. The current EU trends regarding investments in renewable sources of energy are essentially complementary with sustainable development. The investment in energy efficiency in Bosnia and Herzegovina has a potential of bringing multiple profits having in mind the actual situation, and securing big revenues in a relatively short time period. Bosnia and Herzegovina exploits its mountain springs and waters thus emphasizing the generation of electrical energy by hydro power plants; it also uses significant reserves of coal to construct thermal power plants. Basic sources of primary energy in Bosnia and Herzegovina include hydro power plants and thermal power plants (using coal), and cover more than 62% of total primary energy consumption [1−8]. A theoretical potential of Bosnia and Herzegovina in hydroenergy is about 8.000 MW, while the technical potential is about 6.800 MW, and the economic one is about 5.800 MW. The currently installed capacity for generation of hydroenergy is 2.052 MW (which is about 53% of the total generated energy), which clearly shows significance of Bosnia and Herzegovina hydropotential, regardless of the fact that it is to a great extent unused (the use rate is only about 37% of the total economic potential). In Bosnia and Herzegovina, coal has the most dominant place in the structure of the energy consumption with about 45,3%, followed by fluid fuels with about 21% and wood mass with about 20,5%. Other

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forms of energy (hydroenergy, natural gas, and imported electrical energy) participate with about 13,1% in the total energy consumption. Bosnia and Herzegovina has a big potential in terms of using of renewable energy sources, by using energy generated by wind, solar energy, energy of biomass and geothermal energy, all of which will be discussed in the following sections of this paper. The process of generating, distribution and consumption of energy in Bosnia and Herzegovina is characterized by big losses. The same quantity of energy yields four times lower gross domestic product compared to any other average European Union country, and at the same time causes twice as high pollution. Chances are that this is the right time to change the existing paradigm in the energy sector. The process of European integrations and international signed agreements represent a chance for Bosnia and Herzegovina to follow the current trends of the European Union and thus embrace the opportunity to administer reforms which will guarantee sustainable development.

2. USE OF RENEWABLE ENERGY SOURCES IN THE WORLD AND IN EU

A share of energy sources in the world's electrical energy generation is shown in Figure 1. As it can be seen in Figure 1, the biggest share of electrical energy generation comes from the fossil fuels (coal 40%, natural gas 20% and oil 7%), while as far as other sources are concerned, only nuclear and hydroenergy (participating with 16%) have a certain significant share and that is mainly due to the conventional big hydro power plants. All other non-conventional sources of energy (excluding hydro power plants), despite their significant growth and development in recent years, have only 2% of share in the world's electrical energy generation.

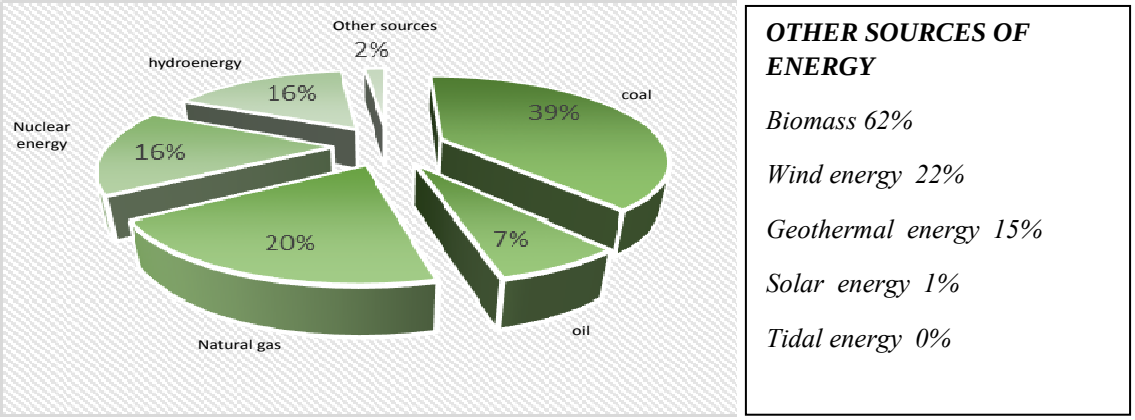


Figure 1. Percentage of energy sources in the world's electrical energy generation in 2004 [1, 3, 7, IEA, 2006].

In all other sources of energy biomass is by far most represented, with 62% of share, and is followed by the wind energy with a share of 22% and geothermal energy with a share of 15%. Direct use of solar radiation energy and tidal energy compared with other forms of renewable energy sources is almost insignificant at the present, yet one should emphasize the fact that a considerable body of scientific research studies is being conducted in order to accelerate technological development of phohotovoltaic cells – the aim is to reduce investment expenditures and to increase their use.

The European Union countries (especially Germany) place a special accent on further development of renewable energy sources. The trend of renewable sources of energy utilization is shown in the figures below, relating to the year 2005.

Based on Figures 2 and 3, it can be concluded that biomass has still the biggest share in primary energy generation, and this concerns primarily fuel wood which is used for heat generation; it is followed by hydroenergy which is almost entirely used for generation of electricity. Hydroenergy has the biggest share in electrical energy generation which is greatly contributed to by conventional large hydro power plants. From the point of view of the current trend of technological development, investment costs and manufacturing cost of electrical energy participating in the total electrical energy generation, the next biggest share is wind energy (wind power plants) and biomass (especially solid biomass power plants – wood and wood pellets, biogas from animal farms).

In recent few years more influences have appeared the combination of which gave rise to an increased interest in distributed production from renewable energy sources (reducing emission of CO_2, programs of energy efficiency, or more rational

use of energy, deregulation and competition, diversification of energy sources, requirements for more sustainable national energy systems…). The environmental impact is one of the significant factors in considering the connection of new generating installations to the grid. Based on the Kyoto Protocol many countries are required to reduce combined emission of greenhouse gases - in the developed countries it is by about 5%, while the European Union countries committed to reducing the emission of greenhouse gases by 8%. Renewable energy sources have considerably lower energy value when compared to fossil fuels, which is why their power plants are of smaller size, geographically widely distributed and connected mainly to the distribution grid.

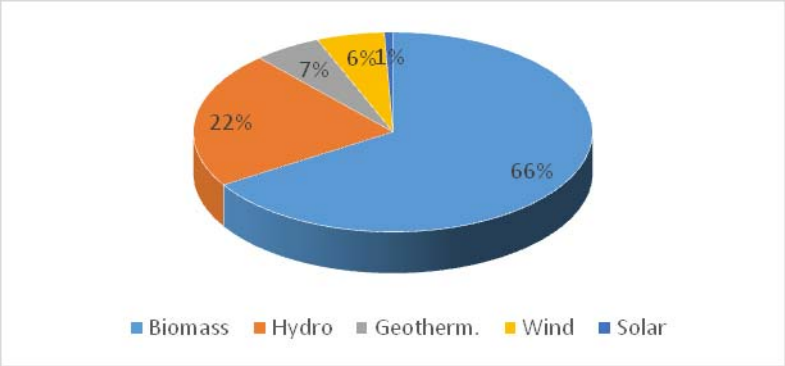


Figure 2. Share of some renewable energy sources in the total renewable primary energy generation in the EU countries EU [1, 3, 7, EUrObserver ER 2006, 2007]

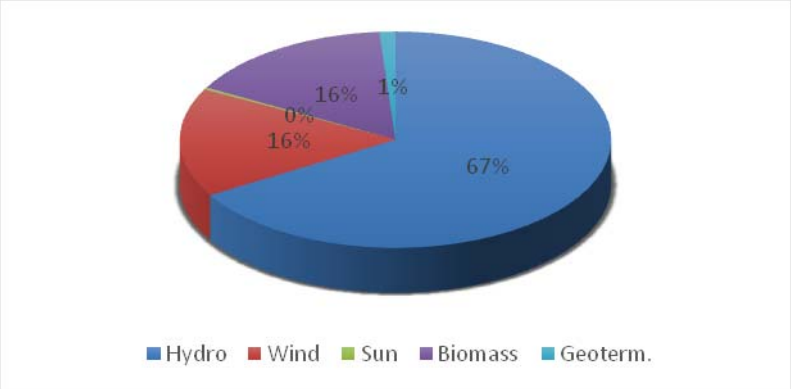


Figure 3. Share of some renewable energy sources in the total renewable electrical energy generation in EU countries [1, 3, 7, EUrObserver ER 2006, 2007]

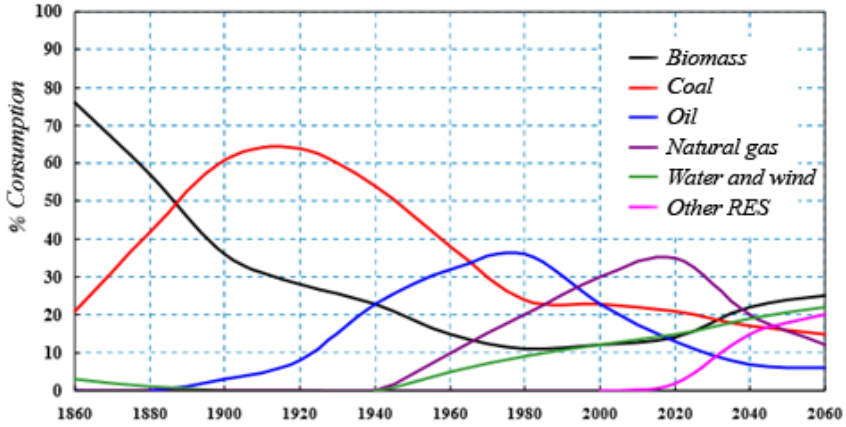


Figure 4. Needs for renewable sources of energy and "TRI VALA"fossil fuels [8]

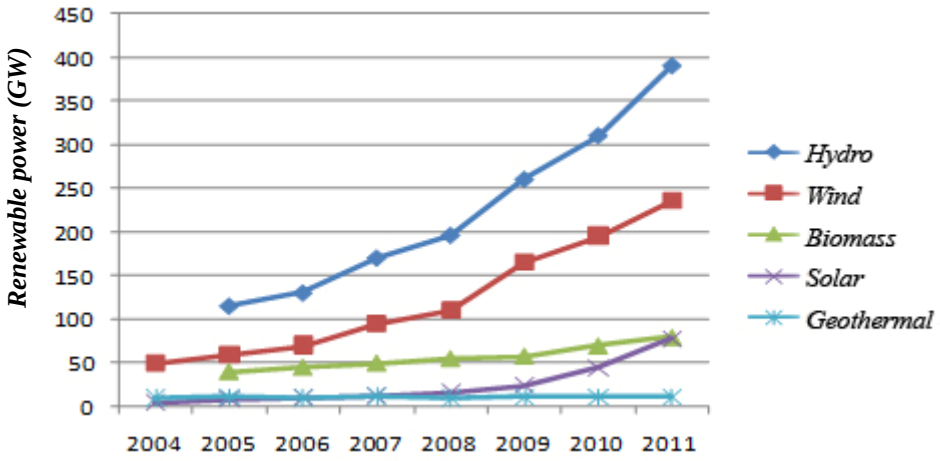


Figure 5. Trend of use of renewable energy sources from 2004–2011

Renewable energy sources such as wind power plants, electrical and thermal energy are the production units that should be included in the generation of electrical energy in order ensure compliance with the national and international demands and requirements for the CO_2 emission reduction. Figure 5 shows that we are right in saying that the trend of use renewable energy sources increases every year. Renewable energy sources enhance sustainability of electro-energy system even in the cases of possible energy crises in electrical energy generation which is nowadays dependant on the supply of coal, gas and oil.

3. HYDRO ENERGY AND THE POTENTIAL OF SMALL POWER PLANTS IN BOSNIA AND HERZEGOVINA

As already mentioned, hydro potential in Bosnia and Herzegovina is estimated to be 8.000 MW with the economically feasible potential of 5.800 MW. The production capacity of currently installed power plants is 2.100 MW, which represents 53% of total generated energy and only 37% of total economically feasible potential. With the annual hydro energy potential of 99,256 GWh, Bosnia and Herzegovina is ranked 8th in Europe. Out of this potential 700 MW relates to small hydro power plants. Previous small hydro power plants potential realization in Bosnia and Herzegovina is 4,4% according to the power realization, and 5,7% according to the available energy realization. The advantage of hydro energy installations is in the fact that their operation does not cause emission of the pollutants into the air, as is the case with thermo power plants.

Small hydro energy installations represent a significant component of the utilization and management system of water resources, especially in cases of flood dangers prevention, as they enable regulation of water flows. One should not neglect a contribution of such installations to the economy development, particularly in developing regions, where they can have a positive impact on the production increase and overall economic development. Bearing in mind the fact that the lack of research on water flows causes the lack of basic guidelines for all planned hydro power plants (objects with the installed power to 10MW), it is not possible to more thoroughly analyze small hydro power plants potentials, even though they represent the most important renewable energy source in Bosnia and Herzegovina. This is especially related to the data on hydrological strings of many years, at the same levels, for all potential locations for small hydro power plants, as well as to actual realization of the potentials (at the same time based on the environmental acceptability, financial profitability and social feasibility of the projects on the local level). Considering all these facts it is necessary to introduce a continuous hydrological system of water flow monitoring in Bosnia and Herzegovina so as to enable the soonest possible intensive utilization of this very important potential.

Figure 6. An example of a small hydroenergy plant [20]

4. WIND ENERGY POTENTIAL IN BOSNIA AND HERZEGOVINA

The total wind energy potential from the point of view of available space and utilization is estimated at about 900 MW. Total technical potential for utilization of wind energy in Bosnia and Herzegovina is significantly higher and estimated to be cca 2.000 MW, although it should be noted that the mentioned amount has come up as a result of the availability of suitable locations for wind power plants in Bosnia and Herzegovina without taking into account possible limitations (connection to the grid, environment protection, etc.).

Possible locations for wind power plants in Bosnia and Herzegovina are shown in Figure 7, and are as follows: Ivanjica, Valja Međa, Crkvina, Velika Vlaina, Mesihovina, Ploče, Borova glava, Mokronoge, Štitar-Poklečani, Kijev do, Planinica (Mostar), Srđani, Rilić-Gajevina, Kamešnica, Vitrenik, Podveležje, Livno and Kupreško polje. Measurements include the altitude of measuring of 10 meters above the ground and the measurement period of 1 year, as well as the locations which are going to be treated. For the area of Podveležje measurements started as early as in 2002 at the altitudes of 40 meters and at micro locations. For the time being these are the best locations in Bosnia and Herzegovina. According to our experts' research, over 1000 MW economically profitable wind energy installations could be installed in Bosnia and Herzegovina. Wind power plants can be installed in different locations on land or at sea, as shown in Figure 7. The project of wind power plant that currently has the biggest prospects in the territory of Bosnia and Herzegovina is the power plant Mesihovina, located in the territory of municipality Tomislavgrad. Total estimated cost of the project is 75 million euros. Project comprises 22 wind turbines with total installed power of 44 MW and with the production of 120.00 MWh, which should bring savings of about 100.000 t CO_2.

Figure 7. Farm of wind power plants with a map of possible locations in Bosnia and Herzegovina [9,22]

5. SOLAR ENERGY POTENTIAL IN BOSNIA AND HERZEGOVINA

The solar radiation reaching the Earth's surface, which can be used, changes during the day and during the year, and at the same time depends on the position of the surface on which radiation falls. The potential solar radiation energy is maximum energy reaching the Earth's surface through dry and clean atmosphere, and it depends on latitude and altitude – it decreases with a decrease of altitude and an increase of latitude (incident angle of radiation becomes smaller).

For the same altitude and the same meteorological conditions, potential radiation energy for 43° of latitude is about 2500 kWh/m^2, annually, and at latitude of 46° it is about 2400 kWh/m^2, annually. If we assume that the maximal radiation power is 0,9

kWh/m^2 and if this power was constant throughout the year, 7884 kWh/m^2 could be generated annually. There is also free available data, for example: NASA Surface Meteorology and Solar Energy for the period 1983–1993 in resolution of 10, and Photovoltaic Geographical Information System (PVGIS) for the grid of 1 to 2 km. Figure 9 shows illustration of PVGIS data for the horizontal plane.

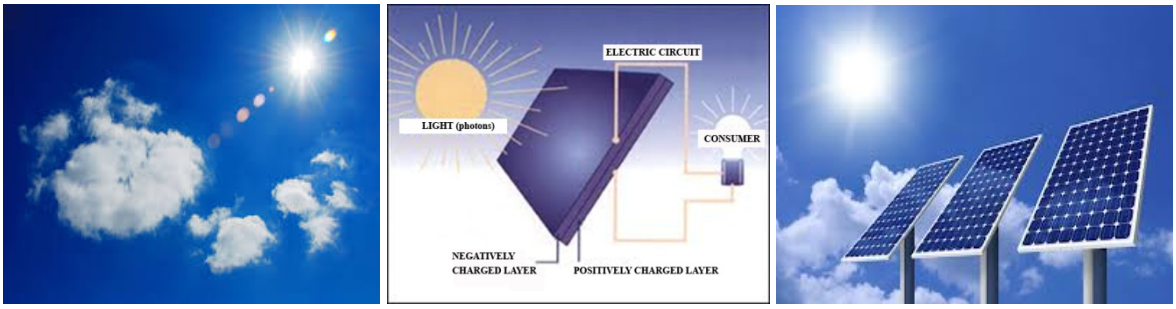
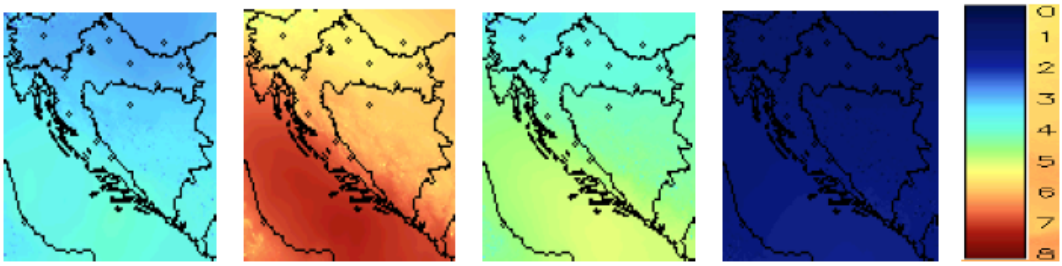
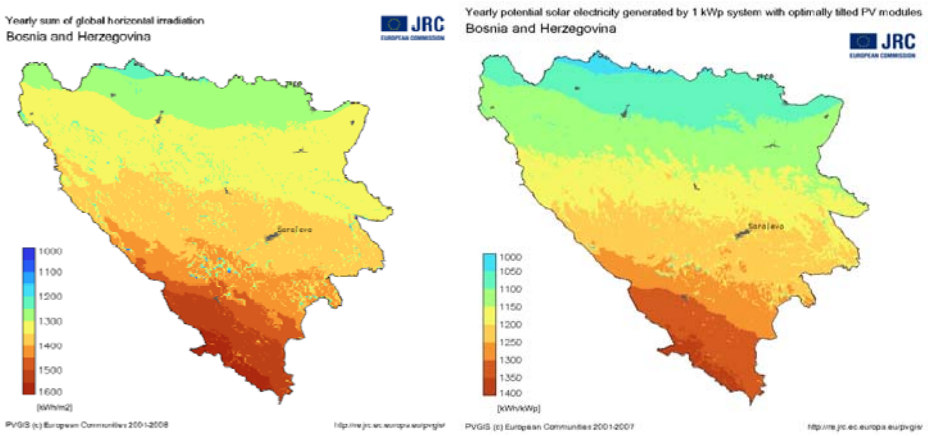


Figure 8. Solar Energy and its use [19]



March *June* *September* *December*

Figure 9. Average daily radiation on a flat surface [kWh/m^2]



a) *b)*

Figure 10. Map illustration a) Annul radiation of flat surfaces by total Solar radiation, b) Possible generation of electrical energy by photovoltaic installation power of 1 kW [8]

Based on all collected data and conducted analyses it can be concluded that there is a significant potential for solar energy use in the territory of Bosnia and Herzegovina, which amounts to 70,5 million GWh of radiated energy of total annual solar radiation (Figure 10.). Only in recent few years has Bosnia and Herzegovina started using solar energy more intensively. Investment into installations for the solar energy use is characterized by high initial investment, but also very low operating costs with the economic life of over 25 years.

Due to economic characteristics of photovoltaic systems one cannot expect their more significant application unless the state and entity authorities introduce a feed-in system, manifested by the guarantee of minimal subsidized cost, and the subsidy periods which should be in accordance with the European and the world standards. In Bosnia and Herzegovina, there are currently several photovoltaic systems either installed under in construction with an installed power of about 800 kW, which is insignificant compared to the available potentials.

6. POTENTIAL OF BIOMASS ENERGY IN BOSNIA AND HERZEGOVINA

Biomass is a renewable energy source, and can generally be divided into wood, non-wood and animal waste, within which one can further differentiate:

− wood cultivated biomass (fast growing trees),

− wooden biomass (remains from forestry, waste wood),

− remains and waste from agriculture,

− non-wooden cultivated biomass (fast growing algae and grass) and

− city and industry waste.

The main advantage of use of biomass as a source of energy is in abundant potentials of not just purposefully cultivated plants but also waste materials in agricultural and food industry. Gases produced while using biomass can also be used in generation of energy.

Figure 11. Some types of biomass for energy generation [21,22]

Production of biomass for the purpose of energy generation implies the use of large areas, which, combined with the usual manner of farming creates, significant influence on biodiversity and the way of its production. Therefore, the use of plant remainings for the generation of electrical energy, heat and biodisel, no matter whether it is from sugar cane, rice husk, or hay or similar crops waste, waste from forest activities or plant oils production, etc., is one of the best ways to generate sustainable energy, to the extent that it does not prevent other significant ways of using agricultural waste, such as, for example, conservation of soil.

Biomass in the form of fuel wood and charcoal is currently a growing source of energy in Bosnia and Herzegovina the consumption of which is estimated at 1.464.400 tons in 2003. Biomass consumption (such as fuel wood or wood processed into charcoal) prevails in households and areas outside of the towns of Bosnia and Herzegovina. Biomass consumption (mainly of fuel wood or wood processed into charcoal) in other sectors, such as agriculture, commerce, industry and mining, is insignificant. Biomass can be considered a renewable source of energy only providing that it is used in a sustainable manner, which in case of fuel wood means that wood cutting must be adjusted to the increase in wooden mass. Forests are the principal natural resource of Bosnia and Herzegovina, being one of the richest countries in Europe by the forest coverage and its diversity in relation to the total area of the country. Having in mind that 15-25% of the area is cultivated, fertile and with lots of pastures, Bosnia and Herzegovina has extraordinary favourable conditions to use biomass. Almost 50% of the area of Bosnia and Herzegovina is covered with forests (around 2,7 million hectares) and is estimated to have annually 1.785.000 m^3 of wood waste. The most important obstacle for the use of this waste is a high cost of its elimination and collection from forests.

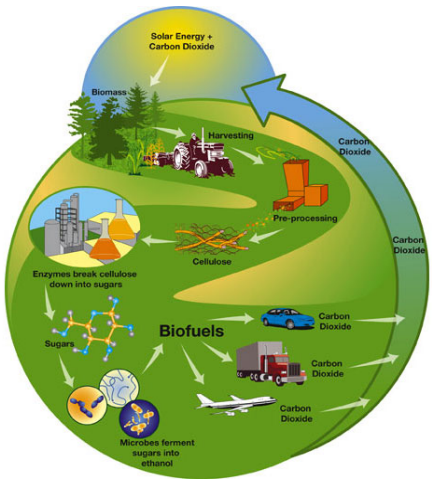


Figure 12. Environmentally friendly – if cutting down is proportionate to growing, we obtain cumulative CO_2 neutrality [21]

7. THE POTENTIAL OF GEOTHERMAL ENERGY IN BOSNIA AND HERZEGOVINA

With an estimated temperature of the inner core of the Earth of about 4000°C, at the depth of about 6.370 km, it gradually decreases to just a few degrees on the surface (with an important contribution of the energy of the sun). On the other hand, the crust of the Earth is only important in terms of using geothermal energy, and especially at the places where the-so called tectonic plates touch one another. This is so because there is no technological possibility to access greater depths. Borders of tectonic plates represent places of big risk of active volcanoes, earthquakes, and a good potential for the use of geothermal energy (Figure 13). The potential of an area in terms of the use of geothermal energy can roughly be estimated through the temperature gradient below the surface of the earth. An average increase of temperature is less than 30 degrees Celsius on 1 km. An area with especially favourable potential for the use of geothermal energy shows an increase in temperature of about 100°C on 1 km.

Dry hot rocks that are at the same time the most difficult to exploit, take a lead when it comes to the capacity of inner caloric energy. Available temperatures range from 150 and 300°C at the depth of 2,5 to 6 km. The biggest problem relating to their use is transfer of heat energy.

Figure 13. Sources and ways to use geothermal energy [24,25]

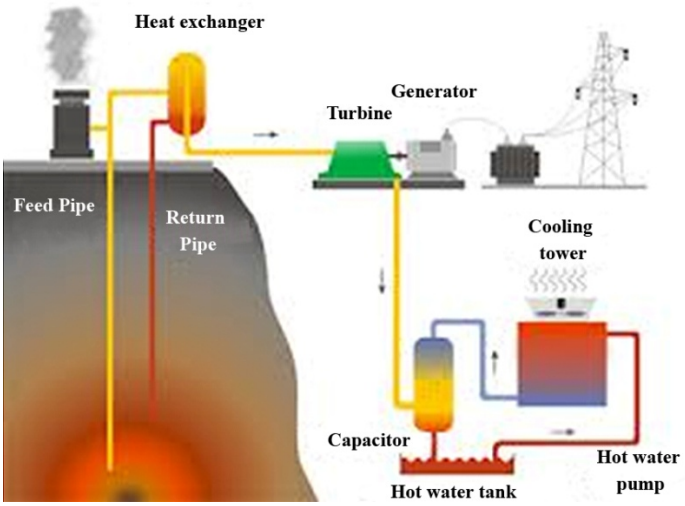


Figure 14. One of the ways to use geothermal energy [26]

Geothermal sources in Bosnia and Herzegovina are very poorly explored. According to the existing body of research it was found that about 25% of the territory of Bosnia and Herzegovina is considered to have a great potential of geothermal resources in three forms – hydro-thermal systems, geopressurized zones and hot dry rocks. These areas cover mostly central and north parts of Bosnia and Herzegovina, i.e. tectonic lines Zvomik-Doboj-Bosanski, Novi-Ilidža-Kiseljak-Busovača. Out of the above mentioned three forms of resources, the biggest focus is on hydro-thermal systems, because their exploitation is most developed and cheapest compared to two other forms. According to available data there are no prospects for generating electrical energy from geothermal resources, but there is a possibility to use their heat for other purposes (agriculture, municipal areas, medicine...), having in mind that the drilled wells of max 3.5 km of depths are used as exploitation objects. Since the use of hydrothermal springs for generation of electricity is not an option, the radius of negative impact on the

environment is already at the very surroundings of the spring. If recirculation systems are used, which implies returning the thermal water that is used once back into the hydro-geological systems, then the negative influence is reduced to the lowest (Figure 14). Maximal temperature determined in the north part of the Panonic region reaches 423°K at the depth of about 3.000 m. Research results point to the fact that in the "Panonic region" there might be hot waters with the temperature of 393°K at the depth of 2.000 to 2.500 m. This means that in that region one should not expect hot waters with high temperatures, so that possible generation of electricity from geothermal energy is not an option either. Development of technology reduces the cost of possible solutions of the mentioned problems, and the use of the closed cycle protects the environment as well. Transferring the used medium back to the original site is an important condition for that. If all dangerous substances are transferred back to the original site or are dealt with in some other way, the only problem posed for the environment is posed greenhouse gases. This is primarily related to CO_2, methane and the like. Emissions of CO_2 are almost 10 times lower compared to the conventional thermo power plant driven on coal.

8. LAWS AND REGULATIONS GOVERNING THE USE OF RENEWABLE ENERGY SOURCES

Insufficiently defined procedures for issuing certain licenses envisaged by the law and too long a period for processing applications are just some of the problems that the investors have to face in this sector. There are many obstacles on the way of a more extensive use of renewable energy sources in Bosnia and Herzegovina, while it is interesting to note that the lack of financial means for the identification of prospective projects or their development very often does not pose any problem at all.

The main obstacles preventing more extensive use of renewable energy sources in Bosnia and Herzegovina are:

− Extremely difficult political and economic situation in Bosnia and Herzegovina;

− The lack of clear political support, i.e. defining objectives regarding the use of renewable energy sources at the entity level;

− Disconnection and lack of cooperation between the relevant entity ministries;

− Lack of political consistency: although there is a declarative support for the use of renewable energy sources, there are no concrete measures;

− Incomplete or non-existent legal framework;

− Complex and lengthy project approval procedure as well as different procedures within the entity (in the Federation of Bosnia and Herzegovina each canton has its own procedures and rules). Rules on project approval often change, which further complicates the work of potential investors;

− Lack of systematic monitoring and data collection by the relevant entity and state institutions;

− Organizational and market barriers in Bosnia and Herzegovina.

Despite all this, we believe that the renewable sources sector in the Federation of Bosnia and Herzegovina has good prospects because, as we have already said, Bosnia and Herzegovina has a huge potential that has not been used yet, and as such represents an ideal opportunity for promotion of foreign investment in our country because, as it is well known, the level of utilization of renewable energy sources in individual countries reaches up to 98 % of the total potential both in Europe and worldwide. With better organization and promotion of renewable energy sources, there are great opportunities for development both in this sector and the entire country. This sector has a potential to provide a basis for the development of the country for future generations because of the long-term strategic development of the EU, the interest of foreign investors, positive impact on other sectors, such as tourism, environmental protection, improvement of agriculture and energy efficiency (especially heating in households), employment opportunities, importing new technologies, innovative small businesses and the cooperation between the private and public sectors.

EU legislative frame for the use renewable energy sources includes the following documents [11]:

− White Paper on renewable sources of energy

− Directive 2003/30/EC on the promotion of the use of biofuels in transport

− Directive 2001/77/EC on the promotion of electrical energy generated from renewable energy sources

− Communication on alternative fuels for use in road transport and a set of measures to encourage the use of biofuels

− Directive 2004/8/EC on the promotion of cogeneration

In the total production of electrical energy in 1997 the average share of renewable energy sources was 13.9%, which should increase in 2010 to 22.1% on the average. In the total shares under the directive large hydro power plants are also included, although

it is a conventional source of energy! In doing so, the tasks of individual countries are different, depending on the found situation, on objective possibilities for its faster or slower change and different responsibilities of each country in relation to the Kyoto Protocol. Table 1 shows the minimum share of renewable energy forms in electricity generation adopted by the Directive of 2001.

Table 1. Percentage of minimal renewable energy sources in the renewable electrical energy generation in the EU countries EU-15 complying Directive 2001/77/EC [8]

Countries	*Percentage in 1997 (%) of renewable energy sources*	*Percentage in 2010 (%) of renewable energy sources*
Austria	70,0	78,1
Belgium	1,1	6.0
Denmark	8,7	29,0
Finland	24,7	31,5
France	15,0	21,0
Greece	8,6	20,1
Ireland	3,6	13,2
Italia	16,0	25,0
Luxemburg	2,1	5,7
Holland	3,5	9,0
Germany	4,5	12,5
Portugal	38,5	39,0
Spain	19,9	29,4
Sweden	49,1	60,0
Great Britain	1,7	10,0
Total EU-15	13,9	22,1

Proposal of the Directive aims to establish a total share of 20% for the renewable sources of energy in energy consumption and a minimum share of 10% of biofuels in EU transport. We are currently working on harmonization of national goals: all member states should produce at least 5.75% more primary energy compared to the reference year of 2005, and the exact percentage of increase of any country is determined by the GDP with an aim to achieve a 20% increase in the share of renewable energy sources in end energy consumption at the EU level. With the accession to the EU, each country will be subject to regulations that must be complied with in the utilization of renewable energy sources, therefore Bosnia and Herzegovina will have to follow them as well. There are mechanisms that help each country achieve these goals including Bosnia and Herzegovina, and we will mention them below.

International funding mechanisms of the utmost importance for Bosnia and Herzegovina are as follows:

− Global Environment Facility (GEF),
− The United Nations Development Programme (UNDP),
− The United Nations Environment Programme (UNEP),
− The World Bank,
− The European Commission,
− Organization for Economic Cooperation and Development - OECD
− The International Energy Agency – IEA
− The European Bank for Reconstruction and Development - EBRD.

9. CONCLUSION

The use of renewable energy sources in Bosnia and Herzegovina is not widely known or promoted, and all activities that are conducted are exclusively within the professional and entrepreneurial circle [27]. It is necessary to create a suitable social framework so that experts can define which renewable energy sources, how many of them, and how they can become a part of an overall energy strategy; it is also necessary to incorporate the already existing entity strategies and laws to protect the environment in the future strategy of the energy sector (hereinafter Strategy), i.e. it is necessary to synchronize the state and entity level, ensure compliance of the strategy with the existing strategic documents and laws in Bosnia and Herzegovina (PRSP, Water Act, a set of environmental laws in

both entities, NEAP, etc.), i.e. provide multidisciplinarity and comprehensiveness; coordinate the plans of developing new energy facilities with the real needs of the country; coordinate planning and construction of the planned new plants in Bosnia and Herzegovina until the adoption of the Strategy for Energy Sector Development in Bosnia and Herzegovina, which is supposed to make recommendations for the future development of the sector and the construction of new facilities, ensure the realization and implementation of the adopted strategy, provide an active involvement of the public and representatives of non-governmental organizations in the process of developing the Strategy.

The mechanisms that are currently available include public debates, although they are not sufficient in terms of an adequate representation of the opinions and involvement of the civil society. One should make further efforts to provide constant flow of information and closer cooperation. The Strategy and practice as well should place an emphasis on improving energy efficiency, particularly in construction buildings and industry, where it is possible to achieve high cost savings earmarked for energy consumption without any major investments. Something that is also necessary is the ratification of the Kyoto Protocol and the implementation of the already adopted measures to mitigate climate changes, as well as the establishment of the CDM office at the state level with the ratification of the Kyoto Protocol. In all this, it is necessary to use the experience of neighboring countries (Croatia, Slovenia, Serbia, etc.) to the extent possible and appropriate. Continuous dissemination of information and education of the public must be carried out too, in order to achieve better cooperation with local communities, but also to raise environmental awareness. Renewable energy sources are getting closer to winning a race with the conventional sources of energy. The cost of the technologies used by renewable energy sources to convert energy into electrical energy is on a daily decline. Fuel for alternative sources of energy is free, while the cost of the conventional power plants fuel is variable and is subject to the laws of always precarious global energy market.

10. REFERENCES

[1] F. Vanek, L. Albright, L. Angenent *Energy Systems Engineering: Evaluation and Implementation*, Conveo Publisher Service, New York 2012

[2] Union of Concerned Scientists (1999) *Benefits of Renewable Energy Use*.

[3] G.Granić, M.Željko, *Study of energy sector in BiH. Module 1, 2, 3, 4, 5, 6, 7, 8, 9, 10*, Sarajevo 2008.

[4] J. Armstrong, J. Hamrin, *What are "Renewable Resources?"*, Chapter 1: Renewable Energy Overview, Cost-Effectiveness of Renewable Energy, Organization of American States 2013.

[5] B. K. Hondge, *Alternative Energy Systems and Applications*, Mississippi State University 2010.

[6] T. Buhrke, R. Wengenmayr *Erneuerbare Energie: Konzepte fur die Energiewende*, Wiley-VCH Verlag GmbH, Weinheim 2012.

[7] Ministero dello Sviluppo Economico *Report on the analysis of environmental technologies and renewable resources of energy in BiH,* Sarajevo 2012.

[8] D. Šljivac, Z.Šimić, *Renewable resources of energy*, AWERES, Zagreb 2009.

[9] M. Đonlagić, *Renewable resources of energy,* Center for ecology and energy, Tuzla 2010.

[10] N. Jenkis, R. Allan, P. Crossley, G. Strbac, *Embedded generation*, The Institution of Electrical Engineering, London 2000.

[11] European commission, Directorate-General for Energy and Transport: (2001) *COM 2001/77/EC Directive on Electricity production from Renewable Energy Sources*.

[12] N. Đereg, Z.Kolmar et al. *Renewable resources of energy in Serbia*, Subotica 2008.

[13] Ž. Knežiček, *Strategic directions of energy efficiency, TK*, Tuzla 2011.

[14] I.Dobrilović „Energy sector of Bosnia and Herzegovina", *INFOKOM* Sarajevo, vol. 6−55 (2013) pp. 24−27,

[15] http://www.wbdg.org (5. 6. 2013)

[16] http://www.inhabitat.com (8. 6. 2013)

[17] http://www.q-solar.com (22. 6. 2013)

[18] http://www.klubmamut-wordpress.com (12. 7. 2013)

[19] http://www.bpz.hr (20. 7. 2013)

[20] http://www.intrade.co.ba (24. 7. 2013)

[21] http://www.grejanje,com (2. 8. 2013)

[22] http://www.elastyc.net (15. 8. 2013)

[23] http://www.agroklub.com (16. 8. 2013)

[24] http://www.eko.zagreb.hr (20. 8. 2013)

[25] http://www.balkanmagazin.net (24. 8. 2013)

[26] http://www.sc-celje.si (28. 8. 2013)

[27] T. Pavlović, D. Milosavljević, D. Mirjanić, *Obnovljivi izvori energije*, Akademija nauka i umjetnosti Republike Srpske, Banja Luka 2013, str. 1−364 [*Renewable energy sources*, Academy of sciences and arts of the Republic of Srpska, Banja Luka, 2013, pp. 1−364].

ОБНОВЉИВИ ИЗВОРИ ЕНЕРГИЈЕ БОСНЕ И ХЕРЦЕГОВИНЕ: СТАЊЕ И ПЕРСПЕКТИВЕ

Сажетак: Енергетска сигурност и стабилност постала је главно питање у посљедњих неколико година цијелог свјетског економског, привредног и друштвеног развоја. Европска унија, и поред своје високе развијености и еволуције свог односа према питању енергетске сигурности, такође се суочава с проблемом опадања њене улоге у смањењу људског утицаја на климу. Енергија је од кључне важности за развој било које земље, па тако и Босне и Херцеговине. Без адекватне политике у пословању енергетског сектора није могуће остварити индустријски и економски напредак. Ипак, колико год енергија била важна за развој, она представља само механизам у остваривању крајњих циљева – одрживе економије, чисте околине, високог животног стандарда, просперитета и здравља становништва. Према званичним подацима, Босна и Херцеговина на годишњем нивоу произведе око 13.600 GWh (податак за 2010. годину), од тога 7.950 GWh у термоелектранама и 5.650 GWh у хидроелектранама. Основни домаћи извори енергије у Босни и Херцеговини су угаљ и хидроенергија, док се плин и нафта увозе. У раду је дат осврт на будућност енергетске политике Европске уније до 2020. године те стање и перспективе обновљивих извора енергије Босне и Херцеговине: хидроенергије, енергије вјетра, сунчеве енергије, енергије биомасе, геотермалне енергије. Дата је и законска регулатива обновљивих извора у ФБиХ са законодавним окружењем Европске уније.

Кључне ријечи: енергија, обновљиви извори енергије, хидроенергија, енергија вјетра, енергија сунца, енергија биомасе.