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Applications of Renewable Energy Sources in the World and the EU with a Particular Focus on Solar Energy

Isak Karabegovic

Department of Technical faculty, University of Bihać, Bosnia and Herzegovina

Abstract— *This Energy stability and security in the world have become important issues in almost every country. These are very important for the economic, social and economic development of each country. Getting energy is crucial for the development of any country, whether it comes to its industry or the economy. The paper presents the development and implementation of renewable energy sources, such as wind-power, solar energy, small hydro and biomass, both in the world and the EU. It elaborates and portrays an increasing trend of renewable energy sources in the total share of energy production, with the trend of reducing fossil fuels in energy production. The paper shows the trend of investments in renewable energy sources, with the trend of opening work posts and employment of workers who are working on the implementation of renewable energy sources, with a special emphasis on solar energy. We analyze the capacity to generate solar energy in the world for the period 2005-2015, as well as in the countries in which solar energy is used the most.*

Keywords— energy, renewable energy sources, solar energy, hydropower, wind energy, biomass

I. INTRODUCTION

The use of fossil fuels in the world resulted in an increase in carbon dioxide and other greenhouse gases. The effects of climate changes are already noticeable, so that we are witnessing the melting of glaciers, the polar ice and permafrost, as well as an increase in sea level - in other words, the change in the ecosystem. All these are the consequences of fossil fuels use in the world. All of humanity, i. e. governments of almost all countries, are obliged to seriously consider and make policy about the development and replacement of fossil fuels with renewable energy sources [1,2,4,6,7,8,10,11,12,13,16,21,22,23,36-39]. Nowadays, energy evolution is the most ambitious in the world, because it increases the renewable energy power generation. Energy efficiency measures are being introduced all over the world to reduce energy consumption to the lowest possible level with the same efficiency that we have had so far. World Energy Strategy to 2050 is such that renewable energy sources have the largest share of energy production. Renewable energy sources include: biomass (bio-fuels, bio-gas), hydro-power solar photovoltaic energy, solar thermal energy, wind-power, geothermal energy, sea energy (tides, waves and sea currents) [13,41,42]. Which of renewable energy sources should be used in a particular country depends on geographical situation of that particular country and its natural resources.

II. THE APPLICATION OF RENEWABLE ENERGY SOURCES IN THE WORLD

Currently, the world obtains most of its energy mainly from non-renewable energy sources, mainly fossil fuels – coal, oil and natural gas. The renewable energy sources produce far smaller share of power, while the smallest part of energy is produced by the nuclear fuel. The increase in the application of renewable energy sources will eliminate all negative consequences of the use of fossil fuels for energy production. In this way, climate issues and problems regarding the eco-system in the world will disappear, and we will receive energy from renewable sources, i. e. clean energy [14-38]. If you look at the use of all energy sources from 1860 (Figure II), you will notice three waves of fossil fuels: coal, oil and natural gas.

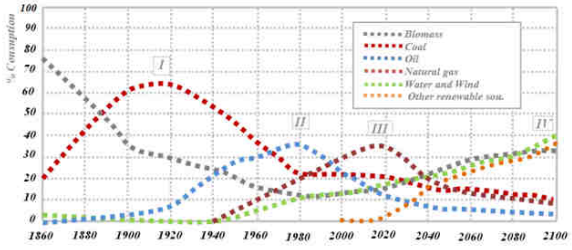

Fig. 1: The need for renewable energy sources and the "FOUR WAVES" scenario of fossil and renewable energy sources [1,2]

Figure 1 shows the „FOUR WAVES" scenario of fossil and renewable energy sources. The first wave of fossil fuels (Figure 1) is carbon in the period from1900-1930,

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the second wave was related to oil in the period from 1960 to 1990, and the third wave of fossil fuels is now dominant, and it is estimated its period will last from 2000-2030. According to the global energy scenario shown in Figure I on the use of renewable energy sources, it is estimated that the fourth wave will be the wave of renewable energy sources of the future and its onset is expected around 2080. The share of individual energy sources in the world's global final energy consumption in 2014 is shown in Figure 2. As it can be concluded from Figure 2, the largest share of energy sources in the world's global final energy consumption is from fossil fuels 78.3%, followed by renewable sources of energy 19.2% and nuclear energy 2.5%, which is in accordance with a comprehensive global energy scenario of renewable energy sources implementation for the period 1930-2090 [1-3].

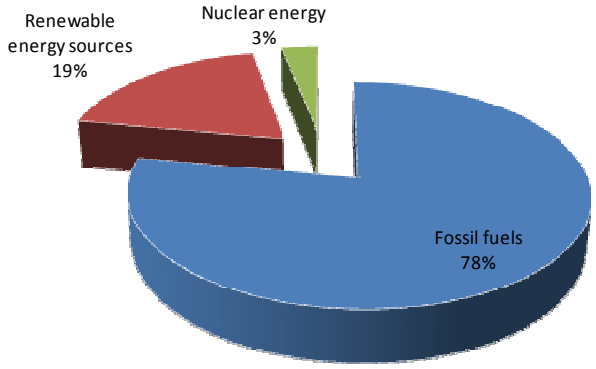


Fig. 2: The percentage of all energy sources in the global final energy consumption in the world in 2014 [6,43-45]

Renewable sources increase the sustainability of the power system in cases of a possible energy crisis, when it comes to power generation, which today is dependent on the delivery of coal, gas and oil. In order to gain a picture of energy production from renewable sources in the world, we display the capacity of energy production in the world in 2015 in Figure 3.

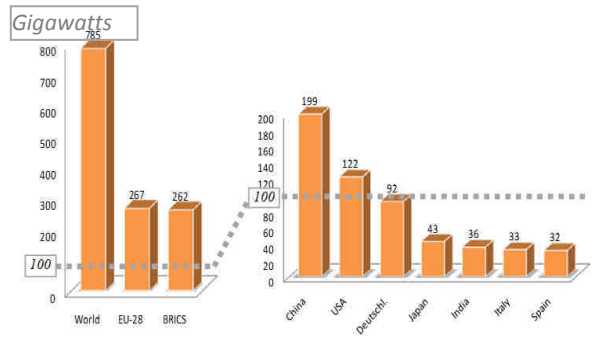
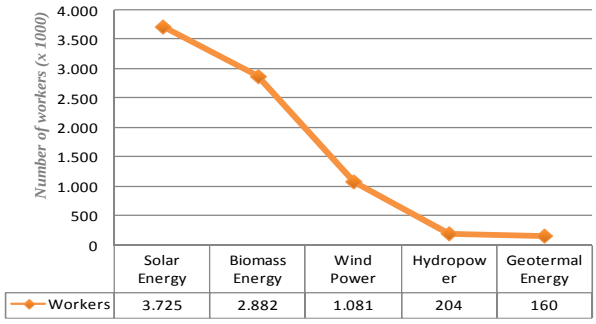


Fig. 3: The capacity of producing energy from renewable energy sources in the world, the EU-28, BRICS (Brazil, Russia, India and China) and seven top countries in late 2015 [6]

The analysis of Figure 3. shows that 785 GW of energy power in the world is produced from renewable energy sources, out of which 267 GW was produced by EU-28, and the countries BRICS (Brazil, Russia, India and China) produced 262 GW of energy power in 2015. If you perform an analysis of energy production from renewable energy sources by countries in the world, we see that China is number one with 199 GW of produced energy power. China is followed then by the USA, Germany, Japan, India, Italy and Spain. In the world nowadays, large investments will lead to greater participation of renewable energy sources in energy production; 286 billion dollars was invested in 2015. Investments in renewable energy sources in the world have resulted in job creation. Depending on the renewable energy sources and technologies in which that particular type of energy is applied, investments are not proportionate to the workplace, so that some renewable source of energy involves far more employees than other renewable energy sources, as shown in Figure 4.



When it comes to production from renewable sources, 8.1 million employees was hired in the world in 2015, of which the energy obtained by means of solar radiation is number one when it comes to the number of employees with 3,725,000 workers, as shown in Figure 4. The second place goes to the production of energy from biomass, where 2,882,000 employees is hired; the third place goes to wind energy with 1.081 million working places; fourth is hydropower (SHP) with 204,000 employees; and the last is geothermal energy with 160,000 employees in 2015.

III. THE USE OF SOLAR ENERGY IN THE WORLD AND THE EUROPEAN UNION

The sun is a renewable and unlimited source of energy and can be directly converted – into thermal energy, which is used for heating, hot water, as well as electricity obtained from the photo-voltage system. On the earth's surface comes 7,500 times more energy per year than the total annual energy consumption from all primary sources. Solar energy is a renewable and unlimited source of energy, and it can be directly converted into solar photovoltaic energy and solar thermal energy [3,4,14-35].

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This paper analyzes both of these. Figure 5 shows the energy production in the world with the help of photo-voltage cells in the period 2005 - 2015.

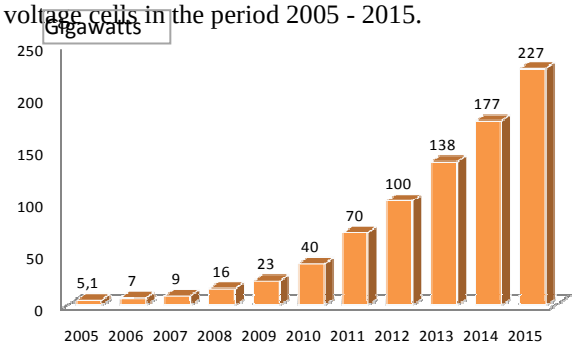

Fig. 5: Energy production (using solar cells PV) in the world from 2005 – 2015 [6-13]

As shown in Figure 5, energy production using solar cells (PV) in the world is increasing each year, i. e. has a growing trend, so that it reached 227 GW in 2015. It is expected that the growing trend will continue in the future, as it comes to the development of new technologies allowing ever greater use of energy generation with solar cells PV.

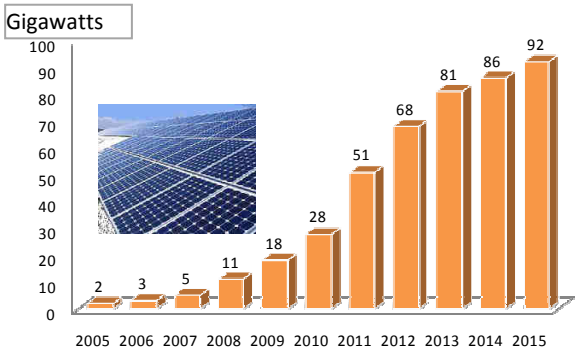

Fig. 6: Energy production (using solar cells PV) in the EU from 2005 – 2015

When it comes to the European Union, energy production using solar cells (PV) is increasing each year. In 2015, energy production using solar cells in the EU has reached 92 GW, which is 40.52% of the world energy production. The trend of energy production using solar cells will increase in the future.

Fig. 7: Energy production (using solar cells PV) in the world intop five countries from 2005-2015

Figure 7. shows energy production using solar cells (PV) in five countries in the world that produce the most energy of this kind. In the period 2005-2015, we see that energy production in Germany, China, Japan, USA and Italy is increasing each year. Figure 8. is an overview of capacities of energy production in each of the countries.

Fig. 8: Energy production (using solar cells PV) in top ten countries in the world in 2015 [5,6]

As can be inferred from Figure 8, the first country in the world in energy production using solar cells in 2015 was China with about 45 GW, which increased its production by 15.2 GW compared to 2014 (in 2014, Germany was number one). China is followed by Germany with a production of about 41 GW, and then come following countries: Japan, USA, Italy, England, France, Spain, India and Australia with about 5 GW of energy produced using solar cells. Lately, solar power plants for electricity production are being opened in the world, and the capacities of producing electricity using solar power plants are shown in Figure 9.

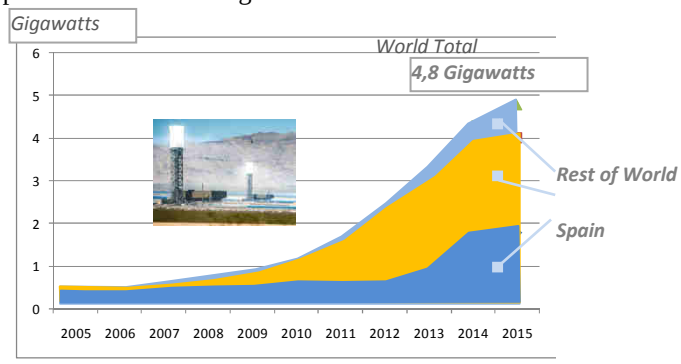

Fig. 9: Production of solar (CSP, known as STE) electrical energy in the world from 2005-2015 [2,6]

Electricity production in solar power plants has suddenly begun to increase from 2008, so that the capacity worldwide reached 4.8 gigawatts in 2015. As it can be seen from Figure 8, it is the most produced in Spain and the USA. The largest solar power plant in the world is to be built in the Mojave Desert in California, which will have a capacity of 1,000 MW and will cost six billion dollars. The largest solar power plants in the world are: Ivanpah 392MW (California), Perovo 100MW (Ukraine), Sarnia 92 MW (Canada), Montalto di Castro 84 MW (Italy), Finsterwalde 83 MW (Germany), Ohotnikovo 80 MW (Ukraine) Senftengerg 78 MW (Germany), Lieberose 71 MW (Germany), Ravingo 70 MW (Italy), Olmedilla de Alarcon 60 MW (Spain) and Boulder City 56 MW (USA). Many energy experts believe that solar energy is the only renewable energy source that has

Gigawatts44,2

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enough potential to replace fossil fuels as the dominant energy source in coming years. Quite a few of the countries is seriously considering solar energy and are investing large amounts of money in various projects, mainly solar plants for electricity generation.

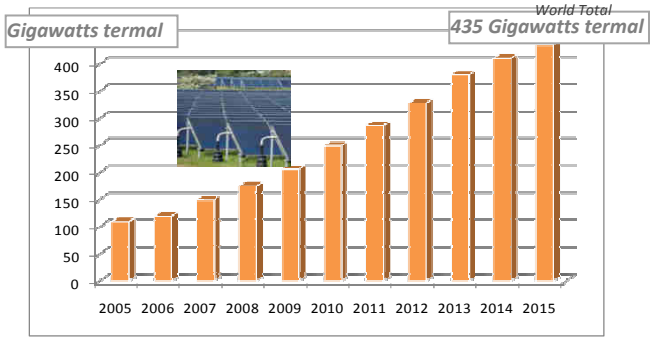

Fig. 10: Solar water heating of global capacities in the worldfrom 2005-2015 [1,7,42]

The capacity of production of solar thermal energy increases each year from 2005-2015, as shown in the diagram 10. In 2015, it reached a record production of 435 Gigawatts-thermal. The development of technology leads to increased production of this type of energy, because the sun is one of the best examples of renewable energy sources.

IV. CONCLUSION

Analysis the application of renewable energy sources in the world, with special emphasis on renewable sources of energy, we can conclude that fossil fuels occupy the first three places in the production of energy in the world in the last fifteen years: coal, oil and natural gas; then renewable energy; and in last place is obtaining energy from nuclear fuel. In the world, energy assessment in the global final energy consumption is as follows: 78.3% of the fossil fuels, 19.2% of renewable energy sources and nuclear energy 2.5% in 2014. In 2015, 785 GW of energy was produced from renewable energy sources: 267 GW in the EU, 262 GW in the countries of BRICS (Brazil, Russia, India and China), and the first in energy production from renewable energy sources is China, which produced 199 GW of energy in 2015. Energy production (using solar cells PV) in the world is continuously increasing every year in the world and the European Union, so that it reached 227 GW in 2015 in the world and 92GW in the European Union. China is number one country in the world in energy production using solar cells and it produced about 45 GW of energy in 2015. Germany is number one country in the EU with 41GW of energy. Electricity production (CSP known as STE) in the world has reached 4.8GWh. In 2015, 8.1 million employees work in the production of energy from renewable energy sources (also including the creation of plants for energy production), of which: 3,725,000 employees work in solar energy; 2,882,000 employees work in energy from biomass; 1,081. 000 work in wind energy; 204,000 employees work in small hydropower; and 160,000 employees work in geothermal energy. We note that solar energy employs most workers. We expect wider use of renewable energy sources in total energy production in the world and the EU in the coming period, and the development of new technologies will speed up the replacement of fossil fuels with renewable energy sources.

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