ADVANTAGES AND DISADVANTAGES OF SOLAR ENERGY PRODUCTION AND USE

Simo Stevanović[1*], Snežana Stevanović[1], Radovan Živković[2]

[1]University of Belgrade, Faculty of agriculture, Belgrade, Serbia
[2] Vehicle Department AMSS Motor Vehicle Centre Ltd, Belgrade, Serbia
[*]email: simo.stevanovic@agrif.bg.ac.rs

ABSTRACT

The energy released through nuclear fusion on the Sun expands into space in the form of electromagnetic radiation. A total of 1.5x109 TWh reaches the surface of the Earth. About 30% of the energy returns into space by reflexion, whereas 70% of the energy is absorbed on the Earth's surface (1,05x109 TWh). This amount is greater than the total coal and oil reserves taken together. Using solar energy has its specificities. First, the energy of the Sun records great fluctuations during the day and year. Second, there is a great daily, seasonal, yearly and meteorological variability of the Sun's radiation accompanied by a very low congruence of the production and consumption of the energy of the Sun. Third, there is a low degree of the conversion of the Sun's energy to electrical energy. The growth of production and an ever-increasing mass use of solar systems, especially so in China, will for sure exert an influence on a reduction in the prices of these systems in the future. Due to its specificity, the surplus of produced solar energy has to immediately be used or stored in the batteries that are still a major cost of the construction of solar systems. It is more frequently the case that the current surplus of produced solar energy is delivered to electrical power enterprises "to be stored", whereas the same is taken from the electrical grid during the time of a deficit.

Key words: RESs, solar energy, energy efficiency, photovoltaic panels, balance energy.

INTRODUCTION

Until the global energy crisis in the 70s of the XX century and due to the attitude of energy inexhaustibility, energy was not considered an important factor in economic development. It was believed that man can use nature's resources in unlimited quantities, and that nature is capable of neutralizing and recycling waste generated by human activity. However, research has shown that reserves of conventional energy sources (CES) are limited and their reserves range from a few tens (oil and gas) to several hundreds of years (coal). Reserves of renewable energy sources (RES) are estimated to last several million years or are permanent, if they are used in compliance with the concept of the rate of renewal (regeneration). At the same time, with the development of technologies for converting energy into useful forms for humanity, human civilization will increasingly use renewable energy in the future, such as solar energy, wind energy, geothermal energy, etc. Available energy on Earth comes from three sources: a) the Sun (biomass-photosynthesis, hydropower-evaporation of water-precipitation, wind-air flow-waves), b) the Earth's crust (geothermal energy) and c) gravity (tides). To this day, solar radiation is the largest known source of energy in space that also reaches planet Earth. The sun's energy is the result of nuclear fusion that takes place in its center under the influence of high temperature and pressure. The energy released in this process spreads into space in the form of electromagnetic radiation. By passing through the atmosphere, $1.5x10^9$ TWh reaches the Earth's surface. Through reflection, about 30% of the energy returns to space, and 70% of the energy

($1.05x10^9$ TWh) is absorbed on the Earth's surface. The amount of energy we are talking about is indicated by the fact that it is greater than the total reserves of coal and oil combined. Despite the unlimited duration and amount of energy, solar energy today only accounts for 2-3% of the total energy production in the world. Greater use of RES in overall energy production is important for several reasons. First, they emit zero or minimal CO_2 into the atmosphere. Second, a higher share of RES in total energy increases the energy stability of a country's electric power system. And thirdly, by lowering the installation costs of systems for energy production from renewable sources, it can be expected that RES (especially solar energy, wind energy and biomass energy) will become economically competitive with conventional energy sources. Using solar energy has its drawbacks. First of all, solar radiation records large oscillations during the day and night. Secondly, there is great daily, seasonal, annual and meteorological variability of solar radiation with a very low coincidence of production and consumption of solar energy. Thirdly, the low degree of conversion of solar energy into electrical energy. It is considered that the environmental pollution with the use of solar systems is negligible compared to other sources of energy. However, the production of solar energy is linked to environmental pollution. It is about indirect pollution that occurs in the process of production, transportation and installation of solar systems, while the exploitation of solar systems itself takes place with zero emission of harmful gases.

Bearing in mind the limited reserves of CES, the aim of the work is to point out the advantages and disadvantages of production and the needs of solar energy as RES. Bearing in mind all that has been said above, the energy of the Sun, as renewable and inexhaustible and without which there is no life, will become an unavoidable subject of research in the coming period. In order to determine the production capacity, advantages and disadvantages of using solar energy for the needs of the population and the economy, various professional and scientific literature related to the researched issues were consulted. Data from other authors, domestic and foreign literature, as well as data from the Internet were used.

Characteristics of solar energy production

Energy, which appears in various forms, is an irreplaceable factor in the economic growth and development of any country, regardless of the level of development. In the world, a large number of researches related to the impact of energy on the national and basically the world economy has been conducted. The connection between energy, economy and ecology (so-called 3E) has been established. It has been shown that the accelerated economic development is based on the increased use of energy from conventional sources, which has led to increased emissions of greenhouse gases and environmental pollution. Due to the lack of knowledge of the nature of resources (inexhaustibility), at that time it was believed that man could use all resources in unlimited quantities. It was even believed that nature itself is capable of neutralizing the disposal of waste generated by human activity (Stern, 2010). In the desire to create a balance between opposing views of economists and ecologists regarding future economic development and environmental protection, the concept of sustainable development was promoted. It implies a compromise between the speed of economic development and the use of available natural resources that will be available to future generations with maximum environmental protection. This means that today's economic development should not be based on the increased exploitation of natural resources for the benefit of current generations, but to promote such economic development that will leave future generations at least as many resources as are available to current generations. On the principle of sustainability, through the concept of green economy, a step has been taken in promoting the link between energy, economy and ecology.

In addition to the problems of energy, economy and ecology, the green economy must solve the new problems of today. Those problems are the shortage of food and drinking water, followed by drastic environmental pollution and the consequences caused by climate change.

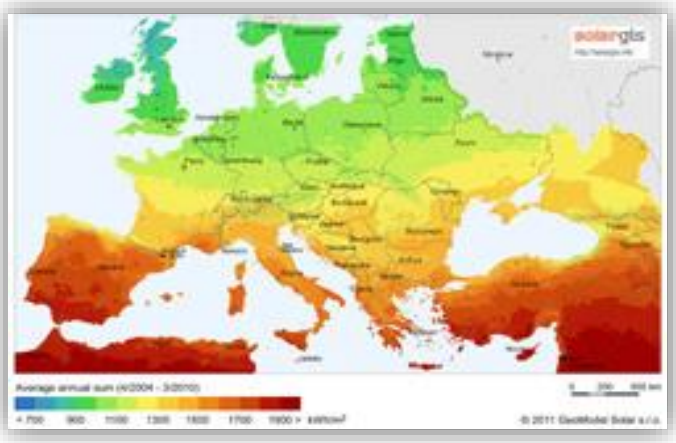
Due to the limitation of conventional energy resources, the need for rational use of energy, i.e. its economically and ecologically efficient production, emerged. So today, instead of 3E, we talk about the fourth component, i.e., energy efficiency, i.e., about the fourth E (4E: energy, efficiency, economy, ecology). Energy efficiency includes all ways to provide the same amount of energy services with as few energy resources as possible. Energy efficiency is one of two ways[1] of fighting for environmental protection, ie. for the lowest possible emission of greenhouse gases. More efficient use of energy would reduce the need for more energy production. According to the IEA[2], improving the energy efficiency of the areas that require the most energy (buildings, industry, transport) by 2050 could reduce global energy needs by a third of the current energy demand (Ilić et al., 2018). The emission of energy from the Sun, as the closest star to the Earth, has been very stable for the last 5 billion years. Despite the fact that solar energy is by far the largest known source of energy in terms of the volume of emissions reaching the Earth, solar energy participates with a very low percentage (2-3%) in the total energy production. Energy production is dominated by transformed forms of energy such as fossil fuels, biomass and hydropower. However, one should not ignore the limitations of certain CES, as well as the high environmental pollution caused by their use in the production of primary energy. The energy of solar radiation on the Earth's surface depends on the amount of radiation that reaches the Earth's surface and the angle at which the sun's rays fall. Climatic conditions and relief affect the amount of solar energy that reaches the earth. The angle of incidence at which the sun's rays fall on the earth is determined by the season and the latitude of the place on Earth. Depending on the pollution of the atmosphere with particles, the Sun's rays passing through the Earth's atmosphere are reflected by the particles and scattered, which reduces the amount of energy that reaches the Earth from the Sun. The smaller the angle of incidence of the sun's rays (closer to the poles), the longer the path of the sun's rays, and the greater the dispersion (Energy Efficiency & Renewable Energy). The sun's energy is the result of nuclear fusion that takes place in its center under the influence of high temperature and pressure. The energy released in this process spreads into space in the form of electromagnetic radiation. By passing through the atmosphere, $1.5x10^9$ TWh reaches the Earth's surface. Through reflection[3], about 30% of the energy is returned to space, and 70% of the energy or $1.05x10^9$ TWh is absorbed on the Earth's surface. This amount is greater than the total reserves of coal and oil combined.

Today, only a small part of the Sun's energy is directly used for energy production through thermal collectors (heat energy) and photovoltaic panels (electricity). A significant part of the Sun's energy is transformed into intermediate forms of energy: biomass energy (photosynthesis process), water energy (evaporation of water and precipitation), wind energy (air flow) and wave energy (sea currents and waves). Since the Earth moves around the Sun in an elliptical path, the distance depends on the season. Therefore, the power of solar radiation that reaches the earth's surface at a right angle during the year ranges[4] from 1307-1399 W/m^2 (Šljivac, Šimić, 2007.). It is often mistakenly concluded that solar energy could be the energy of the future. When using solar energy, there are several problems that are relativized. First, solar energy is a very scattered energy source, with large fluctuations throughout the day and year.

Therefore, for the concentration of this energy and its conversion into electricity, spacious devices that occupy a large area are needed. At the same time, a large amount of conventional energy is used for the construction and maintenance of such devices. Secondly, there is great daily, seasonal, annual and meteorological variability of solar radiation with a very low

[1] Another way of fighting for the preservation of the environment is the greater use of RES.
[2] International Energy Agency (IEA)
[3] Clouds, atmospheric particles, and lighter areas of the Earth's surface, such as areas covered by snow or ice
[4] The mean value of the power of the Sun's radiation at a right angle (90^o) in relation to the Earth's surface is called the solar constant, which is 1367.7 W/m^2.

coincidence of production and consumption of solar energy. Thirdly, the low degree of conversion of solar energy into electrical energy, which results in a low degree of usefulness of the device (Đorđević, 2008). The number of hours of solar radiation on the territory of Serbia is between 1,500 and 2,200 hours per year. he average intensity of solar radiation is from 1.1 kWh/m^2/day in the north to 1.7 kWh/m^2/day in the south - during January, and from 5.9 to 6.6 kWh/m^2/day - during July. The average value of radiation energy is from 1,200 kWh/m^2/year in northwestern Serbia to 1,550 kWh/m^2/year in southeastern Serbia. Serbia has a significantly higher number of hours of solar radiation than most European countries, such as Germany, the Netherlands, Sweden, etc.
(https://www.energetskiportal.rs/obnovljivi-izvori-energije/energija-sunca/).



Map 1. Global horizontal irradiation in Europe
Source: https://www.solarnipaneli.org/

In addition to direct solar radiation reaching the Earth, the indirect effects of solar radiation, i.e. the effects of passive application of solar energy, should not be neglected. It is based on the application of building elements and materials that are aesthetically and functionally connected into a compact whole. In this way, solar energy is collected and used without installing special mechanical or electrical devices.

Benefits of using solar energy

Despite the limitlessness and the possibility of applying the concept of sustainable development in the production of solar energy, its use has its advantages and disadvantages compared to other sources of renewable energy that are available to us. As a basic advantage compared to other sources of energy, it will be available in unlimited quantities as long as the Sun exists, according to scientists' estimates for at least another 5 billion years. The use of solar energy significantly reduces the cost of electricity consumption. Savings can be even greater if excess energy produced is delivered during the day, and energy is withdrawn from the distribution system during the night when the price of electricity is significantly lower. An important segment of the advantages of using solar energy is reflected in the low maintenance costs of solar systems during the exploitation period. Solar panels must be clean in order to absorb as much solar energy as possible. The period of exploitation of solar systems ranges from 20-25 years, and the period of return of capital invested in the construction of solar systems is from 8-10 years, depending on the price and the number of incentives for the supplied energy. Considering that there are no moving parts, the costs of maintenance and possible repairs of solar panels in relation to the initial investment are low during the exploitation period. The cost of producing solar panels has been reduced in the last 15 years by more than 50%. Production technology in the solar industry is constantly evolving, thanks to innovations in quantum

physics and nanotechnology. The new technology will multiply the efficiency and output power of solar panels. Thanks to easy portability and installation on almost all surfaces, solar energy will find application in places where it is not possible to bring or produce electricity from other sources, especially non-renewable ones. The disadvantages of using solar energy should also be mentioned. Until recently, the production of solar panels was characterized by a high production cost. The constant increase in the production of solar systems (especially in China) as well as their increasingly massive use in energy production will certainly affect the price of these systems in the future. The efficiency of solar systems drops drastically during the night, with the change of season and worsening weather conditions. Due to the specifics of production, solar energy must be used immediately or stored in batteries, which still represent a large cost of building solar systems. The batteries are charged with excess solar energy produced during the day in order to use the energy from the batteries during the night when solar energy production is zero or minimal. It is often practiced during the day to deliver surplus solar energy to electrical distribution systems, and at night it is taken from the power grid. This is justified by the higher energy consumption during the day compared to the night energy consumption. Bearing in mind that the amount of solar energy produced is proportionally dependent on the size of the solar panel and the amount of sunlight that reaches the panel, very often the panels occupy large areas and must be in places where the sun's rays reach unhindered, without obstacles and shadows for most of the day. Although environmental pollution during solar energy production is negligible compared to other energy sources, solar energy production can still be linked to environmental pollution. However, it is indirect pollution that occurs during the production, transportation and installation of solar systems (Vierda, 2018). When analyzing the benefits of using solar energy, the condition of the power grid that should take over and deliver the produced energy to the user should also be taken into account. This is especially pronounced in the summer months when the production and surplus of solar energy are maximum. On the contrary, in the winter months when the production of solar energy is the lowest and the energy consumption is the highest, there is a need for its increased withdrawal from the power grid. Based on the currently available capacities of the Serbian power system for providing tertiary reserves, it was adopted that the maximum technically usable capacity of solar power plants is 450MW, i.e. the technically usable potential amounts to 540 GWh per year. The technically usable energy potential for converting solar energy into thermal energy is estimated at 0.194 million tons per year. This is assuming the application of solar thermal collectors on 50% of available facilities in Serbia. The technically usable potential for electricity production is a variable quantity that depends on the dynamics with which the transmission and distribution network of the Serbian power system will be developed (Energy Development Strategy of the Republic of Serbia until 2025 with projections until 2030).

CONCLUSIONS

Despite the fact that the use of renewable energy sources contributes to reducing environmental pollution and stabilizing the climate, it seems that we are underusing cheap and easily available renewable energy. This is especially true for solar energy. It is safe, unlimited, available everywhere and is not harmful to life, and the energy of solar radiation that reaches the surface of the Earth is sufficient to meet all the energy needs of the population and economy in the world. In addition to the importance, they have in preserving the environment and diversifying energy production, the future participation of RES in total energy production will depend on the political will for investments in clean energy production facilities, as well as on increasing the environmental awareness of the population about the importance of energy production from renewable sources for life and health. The number of incentives that energy producers will receive for each kW of delivered energy from RES and the obligations of the requirements from EU Directive 2009/28/EC will affect the future growth dynamics of the

participation of this energy source in the total energy produced. Due to large fluctuations in the production of solar energy (which is affected by the time of day, season, geographical location and not coinciding with peaks in energy consumption), the produced surplus solar energy must be stored in batteries, which is a more expensive option, or handed over to the electricity distribution company for safekeeping businesses, which is the more common option. Energy is withdrawn from the operator in times of deficit, most often at night, when the price per kW is significantly cheaper. The problem is the still not precisely defined procedure and market relations between producers and electricity distribution operators.

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