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Increasing the Energy Efficiency of Solar Radiation in Photoelectric Batteries

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Annotation:

This article analyzes from a scientific point of view the factors that negatively affect the energy efficiency of solar cells in the Republic of Uzbekistan, the shortcomings in the installation of solar panels, and methods for their elimination.

Keywords: renewable energy sources, solar panels, energy transportation, profitability, silicon.

Introduction

According to the UN report, by 2050, the world population will reach 9.8 billion. Demographic growth, of course, will also create new problems for humanity. These include food shortages, drinking water problems, population density, and the need for social protection. And there is another problem, the solution of which can eliminate most of the remaining problems. This is the energy problem. Today, both its presence and absence cause the same problem: while energy shortages complicate socio-economic issues, an abundance of energy production capacity has a negative impact on nature. After all, more than 80 percent of primary energy comes from traditional hydrocarbon sources and nuclear energy. Energy is transported in liquid form - in the form of oil and gas.

The limited availability of fossil energy sources, in addition to affecting the economies of countries, also causes geopolitical problems in regions. Therefore, in the last decades of the 20th century, scientific and practical efforts were launched to introduce renewable energy instead of traditional energy sources.

Much has been said about the prospects for renewable energy sources. For example, the amount of energy from solar radiation reaching our planet is on average 1.3-1.4 kW/m². If we do not take into account the amount of radiation returning from the atmosphere to space, the average energy on the earth's surface is 1 kW/m². This energy is 9,000 times more than the current energy needs of our

planet. Therefore, the newly added energy capacity is not provided by traditional energy, but by renewable sources.

If we look at the evolution of the share of renewable energy sources added by type over the past 10 years, solar energy is the fastest growing renewable energy in the added energy capacity. The main reason for this can be attributed to the fact that solar energy installations can be profitable even on a small scale and the constant introduction of technological innovations into the sector.

It is often observed that installing a solar power plant in a house and obtaining autonomous energy does not yield the expected results. For example, you install a 2 kW plant and cannot obtain more than 1 kW of energy. There are several reasons for this.

Disadvantages of installing solar panels. Since solar panels convert radiation from the sun into electricity, in order to obtain maximum energy, solar radiation must fall as directly as possible on the surface of the panel.

The light that is not absorbed by the surface of the panels does not work in energy generation. Therefore, when installing solar panels on a farm, you should rely on a professional project. After all, the project that suits your neighbor will not suit your house. To do this, the place where the solar panels are installed on your house must have conditions so that they can receive the maximum amount of energy from the sun during the day in an upright position. The angle of installation of the panels and the configuration of the panels play an important role in this. The location of the angle of installation of the panels is taken into account in relation to the sun. If special devices and satellite data are used in these calculations, as well as if the measurements are very accurate, the panels will be as close to the expected result as possible. In addition, it is better to have solar panel specialists perform the installation work. Often, since this work is entrusted to electricians, short circuits are observed on the surface of the panels. This is often observed when the consumer independently purchases and installs panels and other components for autonomous and hybrid operation. We conducted a special survey to study this situation. The survey included 10 consumers who independently installed solar panels. 9 of them complained about the lack of expected efficiency, and 4 people had technical problems. 6 of the respondents carried out the installation work independently, and the remaining four used the services of an electrician. 3 of the 4 consumers who used an electrician reported technical problems in the survey. From this it can be concluded that not all electricians who provide electrical installation services can properly carry out work related to the electrical installation of solar power plants. This requires the experience of specialists and engineers with special education. So, today there is a need for specialists in the field of alternative energy. The curriculum of universities should include topics such as design and operation of alternative energy devices, power supply. This direction has now begun to be taught in technical educational institutions. In the future, as the number of specialists expands, the number of solar panels and the quality of their installation will also increase.

Low efficiency of solar panels. The efficiency of a solar panel is measured by the percentage of solar radiation that falls on it that is converted into electrical energy. When talking about efficiency, the efficiency of the solar cell and the overall efficiency of the panel are given separate evaluations. This is because the efficiency of a solar cell decreases after they are placed on the panel due to the panel configuration and losses in current dissipation. Therefore, the efficiency of the overall panel is lower than that of an individual solar cell. Today, the efficiency of standard solar panels is in the range of 15-20%. In recent years, the increase in efficiency has increased the output power of a standard solar panel from 250 W to 340 W. Depending on the type of solar cells, their efficiency varies. Today, more than 90 percent of solar cells on the market are made of silicon. Depending on the type of crystal (mono, poly, multi), structure and other technical and technological solutions, silicon solar cells are classified and differ in efficiency.

The Uzbek market mainly sells solar panels based on polycrystalline silicon with an efficiency of 16-17%. Some PERC (passivated emitter rear contact) and SHJ (silicon heterojunction solar cells) solar cells have an efficiency higher than 22%. Unfortunately, due to the similarity of the appearance of solar panels, it is difficult to distinguish the quality of the device at first glance. Therefore, the consumer does not always buy a high-quality solar panel. The above survey showed that only 3 out of 10 people who bought solar panels have complete information about the type and characteristics of this device. It is almost impossible to assess the quality of a solar panel without checking it using special devices. The shortcomings of the panels naturally manifest themselves within 5 years. That is, this requires a long time in naturally aggressive (hot, cold) conditions. Over time, panels decrease their output power under the influence of external conditions, that is, they undergo natural degradation. In the first 2 years, the output power degradation is 2-3 percent, but in subsequent years, the degradation rate decreases sharply and amounts to 0.5-0.7 percent per year. Panels that deviate from these indicators and have a high degradation rate are considered poor quality. Therefore, when purchasing solar panels, you should ask the manufacturer and seller for a guarantee of at least 5 years.

The effect of climate on efficiency. The efficiency of solar panels is also affected by the climatic conditions of the location where the panels are located. Before releasing solar cells and panels for sale, the manufacturer tests them in a special laboratory. The indicators must meet the established standards for the characteristics of solar panels. These indicators are also written in the device passport. And we purchase the product based on these characteristics. The problem is that the characteristics indicated in the passport are given values corresponding to the Mediterranean climate. That is, in order for the characteristics indicated in the passport to be fully manifested in practice, winter should be mild (10-16 ° C), and summer should be dry and moderately hot (22-30 ° C). Air humidity should be 50-65% in summer and 65-80% in winter. Solar panels are tested in conditions close to this climate and their characteristics are written. More precisely, the standard test conditions (STC) are 1000 W/m² of radiation, an air mass coefficient for the solar spectrum of 1.5, and a panel temperature of 25°C. Therefore, the characteristic data indicated by the manufacturer will differ from the actual value on the ground, which differs from laboratory conditions. In general, the efficiency of solar panels depends on 5 main factors: the annual distribution of solar radiation intensity, the change in panel efficiency in accordance with this intensity, the annual temperature distribution, the temperature coefficient of the panels, and the rate of degradation over time. The most important factor that directly affects efficiency is the ambient temperature. As the air temperature increases, the efficiency of solar panels decreases. At first glance, it may seem that the more radiation falls on the panel's surface, the more electricity is generated, but in fact, this is not the case. An increase in temperature leads to an increase in internal resistance in the solar cell. Temperature causes an increase in the flow of electrons. This leads to an increase in current and a drop in voltage. However, since the voltage drop is greater than the increase in current, the total power decreases. The temperature coefficient of the panels evaluates how much they differ from the standard characteristics specified under a certain temperature. The temperature coefficient varies depending on the type of solar panels. The most popular monocrystalline silicon panels in our country lose efficiency by 0.5% at temperatures above 25°C - for every degree. For example, let's take the most popular monocrystalline silicon panel on the Uzbek market, which has an efficiency of 17%. Its passport indicates a temperature coefficient of -0.45% of the total efficiency. That is, a panel with an efficiency of 17% loses efficiency by 0.077% at a temperature of 25°C - for every degree. At a temperature of 30°C, the efficiency is 16.6%, and at 35°C, it is 16.2%. If the temperature exceeds 40°C, the efficiency drops below 10%. A similar situation is observed in the summer in our country. During the heat of the day, the efficiency of solar panels drops by half, and the amount of electricity generated decreases by the same amount.

There are two solutions to this problem. First, when installing solar panels, it is necessary to take into account air circulation and, if possible, avoid overlapping the panels. At the installation location, it is necessary to choose a place that is maximally suitable for wind paths. It is necessary to pay attention to the frame materials of the panels. It is necessary to purchase panels made of materials that conduct heat as well as possible and do not allow local heating. The second is to choose panels consisting of solar elements suitable for the climate. The third is the amount of dust. Dusting that occurs as a result of dust particles settling on the surface of the panels is one of the main factors that negatively affect efficiency. Unfortunately, since our geographical location is mainly a flat terrain, there is a lot of dust particles in the climate of our country. The dusting characteristics of the surface of the panels depend on two factors: the nature of the dust and the environment. The nature of the dust refers to the size, shape, weight, particle surface, and chemical and biological properties of the dust particles. All of these factors affect the accumulation of dust particles on a given surface. If the dust particle is heavy and the surface is not smooth, the probability of dust settling and accumulating on the surface is high, or vice versa. A surface covered with dust attracts dust better to subsequent layers. When it comes to dust, the environment must also be taken into account. The location of agricultural activities or highways around the location where the panels are installed determines the level of dust. If there is a light wind in this location, the level of dust will also be high. Strong winds reduce the amount of dust by cleaning the surfaces from dust. Therefore, when installing photovoltaic solar panels, the environment and the characteristics of the dust in that environment must be taken into account. In addition, preventive cleaning work should be carried out on the surface of the panels. Another solution is to protect the surface of the panels with hydrophobic and transparent dust-proof layers.

In conclusion, it should be noted that solar energy has become competitive with traditional energy in terms of the cost of energy produced today. It would be appropriate for the Republic of Uzbekistan to introduce alternative energy, in particular, solar power plants, when updating its infrastructure. There are a number of benefits for individuals installing solar photovoltaic panels, and bureaucratic obstacles have been minimized. However, due to the large initial investment in autonomous solar systems, the opportunities for individuals to introduce this technology are decreasing. The lack of specialists is the reason why these technologies are not sufficiently or correctly implemented, and this, in turn, leads to underutilization or misuse of the full potential of solar photovoltaic systems. The introduction of alternative energy, in particular, solar photovoltaic systems, leads to the formation of a culture of energy saving and the popularization of energy-saving techniques and technologies in everyday life.

Methodology

This study focuses on analyzing the factors affecting the energy efficiency of solar photovoltaic systems in Uzbekistan. A combination of theoretical and empirical research methods was employed. Theoretical analysis involved reviewing existing literature on solar energy, photovoltaic panel efficiency, and the impact of climate and environmental factors on solar power generation. Additionally, comparative analysis was used to examine different types of solar panels available on the market, particularly in terms of their efficiency, materials, and technological advancements.To gather practical insights, a survey was conducted involving 10 consumers who had installed solar panels independently or with the help of electricians. This survey aimed to identify common issues related to solar panel installation, maintenance, and performance. Data from the survey were analyzed to assess the effectiveness of different installation practices and their correlation with panel efficiency. Furthermore, field observations and case studies were carried out to evaluate the impact of local environmental conditions—such as dust accumulation and temperature fluctuations—on solar panel performance. The findings were used to propose methods for

improving the energy efficiency of solar panels in Uzbekistan, focusing on proper installation, maintenance, and climate-specific solutions.

Results and Discussion

The analysis revealed several key factors impacting the energy efficiency of solar panels in Uzbekistan. The survey indicated that improper installation and lack of specialized knowledge were significant causes of low efficiency. Nine out of ten consumers reported not achieving the expected energy output, with many facing technical issues due to unqualified installation. This highlights the need for specialized training in the field of solar energy to ensure correct installation and maximum efficiency. The efficiency of solar panels was found to be heavily influenced by local climate conditions. High temperatures in the summer caused a notable decrease in panel efficiency, with temperature coefficients indicating a reduction in power generation as temperatures rose. Additionally, dust accumulation on the surface of the panels further reduced their performance. This problem is particularly relevant in Uzbekistan, where dust levels are high due to the geographical and climatic conditions. Furthermore, the study found that polycrystalline panels, commonly used in the region, have an efficiency range of 16-17%, while higher-efficiency models like PERC and SHJ cells can exceed 22%. However, many consumers were unaware of the differences in panel quality, leading to the purchase of suboptimal products. To address these issues, the study recommends improving installation practices, selecting panels suitable for local climate conditions, and implementing regular maintenance to reduce dust buildup. Training programs for specialists in solar energy and better consumer education on solar panel quality are essential for increasing energy efficiency and maximizing the potential of solar power in Uzbekistan.

Conclusion

In conclusion, the energy efficiency of solar panels in Uzbekistan can be significantly improved by addressing key issues such as improper installation, lack of specialized knowledge, and local climatic conditions. High temperatures and dust accumulation were identified as major factors reducing panel performance. To optimize solar energy production, it is essential to invest in professional installation services, select appropriate panel types, and ensure regular maintenance. Furthermore, educating consumers and training specialists in solar energy technologies will play a crucial role in maximizing the efficiency and potential of solar power in the country. By addressing these challenges, Uzbekistan can effectively harness solar energy as a sustainable and cost-effective alternative energy source.

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