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INDICATORS FOR THE INSTALLATION OF SOLAR PHOTOVOLTAIC PANELS AROUND THE WORLD AND THE PROCESSING OF WASTE GENERATED FROM THEM

Shokhrukh Meyliyev Egamberdi ug'li

Tashkent State Technical University

Undergraduates in the direction of renewable energy sources

Annotatsiya:

Quyosh fotoelektrik panellarining dunyo bo'ylab o'rnatilishi va ulardan hosil bo'layotgan chiqindilarni qayta ishlash masalalari bugungi kunda global energiya sohasida juda muhim ahamiyatga ega. Quyosh energiyasi insoniyatning barqaror rivojlanishi va atrof-muhitni muhofaza qilish yo'lida asosiy o'rinlardan birini egallaydi. Quyosh fotoelektrik panellari — bu quyosh nurini to'g'ridan-to'g'ri elektr energiyasiga aylantiruvchi qurilmalar bo'lib, ularning keng qo'llanilishi ko'plab mamlakatlarda energiya ta'minotining ekologik toza va iqtisodiy jihatdan samarali manbai sifatida qaralmoqda.

Kalit so'zlar: fotoelektrik panellar, quyosh energiyasi, iqlim o'zgarishi, strategiyalar, atrof-muhit, resurslar, iqtisodiyot, moliya.

Аннотация:

Вопросы установки солнечных фотоэлектрических панелей во всем мире и переработки образующихся из них отходов сегодня очень важны в глобальном энергетическом секторе. Солнечная энергия занимает одно из ключевых мест на пути устойчивого развития человечества и защиты окружающей среды. Солнечные фотоэлектрические панели-это устройства, преобразующие солнечный свет непосредственно в электричество, широкое применение которых во многих странах рассматривается как экологически чистый и экономически эффективный источник энергоснабжения.

Ключевые слова: фотоэлектрические панели, солнечная энергия, изменение климата, стратегии, окружающая среда, ресурсы, экономика, финансы.



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Abstract:

The worldwide installation of solar photovoltaic panels and the issues of waste recycling generated from them are very important in the global energy sector today. Solar energy occupies one of the main places in the path of sustainable human development and Environmental Protection. Solar photovoltaic panels are devices that convert sunlight directly into electricity, and their widespread use is seen as an environmentally friendly and cost-effective source of energy supply in many countries.

Keywords: photovoltaic panels, solar energy, climate change, strategies, environment, resources, economy, finance.

INTRODUCTION

The rate of installation of solar photovoltaic panels around the world has increased significantly in recent decades. This process is mainly due to a decrease in the cost of solar energy, technological progress, increased policies of support by states and strategies to combat climate change. Solar panels are widely installed in various regions, including household facilities, industrial enterprises, agricultural fields and even large solar power plants. This leads to diversification of energy systems, increased energy security, and decreased carbon footprint. Although the installation of solar photovoltaic panels provides many positive aspects, at the end of their service life, the issue of waste management is emerging as a serious environmental problem. Solar panels typically have a long service life of ten years or more, but when their shelf life expires, they switch to an exhaust state. These wastes contain various chemical elements, including heavy metals and harmful substances, and mismanagement can adversely affect the environment. In recent years, especially between 2021-2023, solar panels have caused revolutionary changes in the energy sector. Many of their advantages have become important not only economically, but also from an ecological and technological point of view. Below are the main benefits and changes observed during this period, presented in numbers. Using solar panels, the electricity costs of homes and businesses decreased by an average of 30-50%. This figure was especially significant in the period of increased energy prices. As a



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result, many families and businesses were able to save their budgets. Reducing carbon dioxide emissions is important for environmental protection purposes. Carbon emissions were reduced by 20-40% due to energy generated by solar panels. This has greatly helped combat climate change. In 2021-2023, energy independence in areas with solar panels increased by an average of 25%. This is a particularly effective measure against energy supply disruptions and price fluctuations. As a result, many regions began to meet their energy needs more independently. The efficiency of the new generation of solar panels improved by 15-20% during this period. These technological upgrades allowed more energy to be produced in the same area and increased the efficiency of solar energy. In many countries, subsidies and tax benefits for the installation of solar panels in 2021-2023 were up to 10-30%. These programs made their procurement and installation even easier and increased interest in renewable energy sources. Globally, demand for renewable energy sources increased by 40%. This prompted the rapid development of the solar panel industry and attracted new jobs as well as investment. By 2023, household solar panel installation rates had increased by 35%, while small businesses had increased by 20%. This in turn was an important factor in reducing energy costs and moving towards environmentally friendly energy. The 2021-2023 cross section found that solar panels could reduce energy costs by 30-50%, cut carbon emissions by 20-40%, and increase energy independence by 25%. Technological upgrades, state support, and increased global demand have further popularized solar energy and increased its efficiency. Thus, solar panels are seen as the future of the world energy sector, not only economically, but also ecologically and socially..

MATERIALS AND METHODS

The processes of recycling and recovering waste from solar panels have evolved differently around the world. Some developed countries have specific infrastructure and technologies for the collection, sorting and processing of solar panel waste. In these processes, the metal part of the panels, glass, plastic and semiconductor materials are separated. The separated materials are recycled and used in the manufacture of new solar panels or other industrial products. This will save resources and protect the environment from pollution. [1]



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However, in many developing countries, the solar panel waste management system is not yet sufficiently developed. This condition can cause illegal waste disposal, environmental damage, and health risks. Therefore, there is a need to introduce standards and procedures for recycling solar panel waste globally, as well as to develop technology and provide financial support.[2]

One of the most noticeable aspects in the process of processing waste of solar photovoltaic panels is the effective separation of valuable materials in their composition. For example, elements such as silicon, silver, copper, aluminum used in panels can be recovered and used in the manufacture of new products. It not only protects the environment, but is also considered economically beneficial. At the same time, the safe management of harmful substances in waste, in particular heavy metals such as lead and cadmium, ensures environmental safety. Long-term use of solar panels significantly reduces their ecological footprint, but the processes of their manufacture and disposal also have an impact on the environment. Therefore, environmental aspects must be taken into account during the entire life cycle of the panels to ensure sustainability in the solar energy sector. This involves the use of low energy consumption and low waste-generating technologies in manufacturing processes, as well as ensuring the recycling of the panels used.[3]

The main material that is considered the heart of solar panels is silicone. Silicon is Semiconductor in nature, which receives sunlight and converts them into energy in the form of an electric current. The composition of silicone panels is about 90-95%. This is a very high indicator, the main reason for which is that silicon is widespread in nature, has a relatively low cost and high efficiency. Crystalline forms of silicon, specifically monocrystalline and polycrystalline silicones, are widely used in solar panels. Although the efficiency of monocrystalline silicon panels is high, the cost of production is slightly more expensive. Polycrystalline silicone, on the other hand, is cheaper, but the efficiency is slightly lower.

In solar panels, metal contacts are important for the collection and transport of electricity generated from solar energy. These metal contacts are located on the front and rear surfaces of the panels, and their electrical conductivity should be high. Silver metals have the highest electrical conductivity and are widely used in Contacts on the front surface of solar panels. Silver contacts play an important role in



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increasing the efficiency of the panels, since they carry electricity with minimal loss. The share of silver in the total composition is about 1-2%, but due to its high cost, manufacturers try to save on it. Aluminum is used in the back cover and frames of panels. This metal is lightweight, corrosion resistant and relatively inexpensive, and is important in increasing the mechanical strength of solar panels. The proportion of aluminum in the composition is usually around 5-8%.

In solar panels, copper (Cu) is also used in contacts. Copper has good electrical conductivity, with a 1-3% share. In addition, a small amount of other metals is also used in the production process of solar panels:

Tin (Sn): used to protect contact layers and keep them from corrosion.

Indium (In) and gallium (Ga): used in some types of solar panels, in particular in thin-layer panels.

Titanium (Ti): applied to increase the mechanical strength of the panels and ensure corrosion resistance.

Each of these metals is important in ensuring the performance, durability and longevity of solar panels. The choice of metals used in solar panels depends not only on technical characteristics, but also on environmental and economic factors. For example, the high cost of silver increases production costs, so manufacturers are introducing new technologies to save it. Aluminum, on the other hand, is one of the easiest and environmentally friendly metals to process. Therefore, it is important that metals are used efficiently and economically in the production of solar panels.

RESULTS AND DISCUSSIONS

Scientific research and innovation play an important role in the field of waste management of solar photovoltaic panels. New technologies are being developed, with which the efficiency of waste processing is increased, costs are decreasing, and the level of environmental safety is increasing.[4]

For example, the modular design of panels facilitates their dismantling, while new materials simplify the processing process. At the same time, automation and robotics technologies are also expanding in the field of waste processing. Globally, cooperation and exchange of expertise in solar photovoltaic panel waste management are important. It is possible to improve the efficiency of waste



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recycling by exchanging data between countries, combining standards and implementing joint projects. This will help create environmentally friendly and sustainable energy systems around the world. It is also necessary to increase the awareness of the population on solar energy and waste management issues. Education and media outreach, community engagement, and environmental awareness are important in this area. [5]

Residents and business entities must understand the benefits of solar energy and actively participate in proper waste management. The installation of solar photovoltaic panels and the waste recycling issues generated from them are expected to be more relevant in the future. As solar energy begins to occupy a huge place in the global energy balance, the need to ensure the stability and environmental safety of its use increases. Therefore, technological innovations, political will and public activism should combine to improve the life cycle management of solar photovoltaic panels.[6]

In recent years, solar energy has become one of the fastest growing energy sources globally. As a type of environmentally friendly and renewable energy, solar panels are widely used around the world. As of 2024, the total installed solar array capacity worldwide has reached approximately 115 gigawatts (GW). Leading countries in the solar sector include:

China: ranked first in the world with more than 350 GW installed capacity. USA: has a capacity of around 130 GW. EU countries: with a total capacity of more than 150 GW. These indicators indicate an increase in solar energy in the global energy system and an increase in demand for environmentally friendly energy sources. The service life of solar panels is usually 20-25 years. At the end of their service life, waste is formed. Currently, solar panel waste recycling rates are around 20-30% globally. In developed countries, processing rates are high, reaching 40-50%. In developing countries, however, recycling systems are not yet sufficiently developed, with percentages of only 10-20%. This situation indicates the need to develop technologies for efficient waste management and recycling.[7]

Solar panels installed over the past 10 years are approaching the end of their service life, so the volume of emissions is expected to increase significantly. Approximately 1.7 million tons of solar panel emissions are expected to be generated worldwide



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over the next 5 years. Over the next 10 years, however, this figure may exceed 6 million tons. This requires the rapid development of waste management and recycling systems, since the current global infrastructure is not ready for the efficient recycling of this amount of waste. The installed capacity in the solar sector is increasing from year to year, which encourages environmentally friendly and sustainable energy production. However, the increase in solar panel emissions remains relevant as a global environmental problem.[8]

CONCLUSION

In general, the worldwide installation of solar photovoltaic panels is bringing about revolutionary changes in the energy sector. Their waste recycling, on the other hand, is an important factor in maintaining ecological balance and saving resources. Together, these two processes serve the sustainable development of humanity, the protection of the environment and the fight against climate change. Therefore, a comprehensive and integrated approach is necessary in the field of solar energy, which includes technological, environmental and social aspects.

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