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ANALYSIS OF SOLAR ENERGY DEVICES

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Abstract: Analytical research on the effective use of solar energy in the conditions of Uzbekistan was conducted in the article. It was mainly analyzed that solar energy devices are more effective in using them according to their goals. The article contains theoretical conclusions based on the results of the research methods used in the literature. The data was analyzed using the "Methodological analysis" and "Meta-analysis" methods.

Keywords. solar air heater, solar water collector, tower solar power plant, parabolic cylindrical solar thermal power plant, solar photovoltaic panel.

Introduction. Currently, in order to meet the demand of energy consumers, nature is being damaged due to the use of organic fuels in the world. As a result, new types of diseases are appearing in the human and animal world (land and water). In addition, the sharp reduction of organic fuel reserves leads to an increase in indicators of the shortage of energy resources in various fields. Therefore, one of the main problems facing humanity is to provide energy consumers with environmentally friendly energy. Environmentally clean energy can be obtained only from energy sources that exist in nature and do not emit harmful gases and waste as a result of their use [1-23].

Methods. The use of solar energy is an unlimited source of energy for the planet earth. At present, scientific research is being conducted to achieve efficient use of solar energy based on the use of new technologies using various methods. In theory, solar energy has the potential to adequately meet the energy needs of the

entire world. An average of four million exa-joules of energy reaches the earth per year (EJ=10^{18}J). Approximate calculations show that 5×10^{4} EJ of the total solar energy can be conveniently used [2].

One of the main reasons for increasing the use of solar energy is related to the efforts aimed at reducing global carbon emissions, which have become an environmental and socio-economic problem in the main world in recent years [3].

Expanding the scope of use of energy devices operating on the basis of renewable energy sources is not only one of the main goals of the Republic of Uzbekistan, but also one of the main issues for the countries of the world. This necessity arises from the need to save primary energy reserves, guarantee the country's energy security, and improve the living and social conditions of the population [4].

The total area of Uzbekistan is 448.9 thousand square kilometers, 70% of its total area is occupied by deserts. It is located in a favorable climate for the use of solar energy (37° to 45° north latitude and 56° to 73° east longitude). Solar energy makes up 98.5% of the total renewable energies and therefore serves as the main factor in planning the share of renewable energy use in the total energy balance of the Republic [5].

The main renewable energy sources in the Republic of Uzbekistan are solar, hydropower, wind, geothermal and biomass. The total technological potential of the Republic in terms of existing renewable energy sources is 179.4 million tons of oil equivalent. This is almost 3 times more than the current energy demand of the country [6].

The amount of solar energy reaching the earth's surface is large, reaching one kilowatt per square meter in the summer season in the middle regions. Solar energy can be used with photovoltaic panels, parabolic solar collectors, heliostat tower solar collectors, solar Sterling engines, solar water heating collectors, and solar air heaters [7].

Scientific researchers conducting scientific research are conducting scientific research on the introduction of energy-efficient, economically efficient, environmentally friendly energy-based modern technology and equipment into heat energy supply networks [8].

Taking into account that the natural fuel and energy reserves used by the economic sectors are rapidly decreasing, the use of renewable energy sources is the basis for saving natural resources and keeping the natural ecological situation unchanged from negative aspects.

One of the main energy problems faced by world scientists in the 21st century is the development of an environmentally friendly and high-potential energy supply system. Because all types of energy reserves of all types of existing primary energy sources are short-lived, it is considered that the level of bringing big problems related to energy reserves in the near future is high [9].

The use of solar energy is effective in the climatic conditions of Uzbekistan. In particular, the gross potential of solar energy is equal to 50973 million tons of oil equivalent [1].

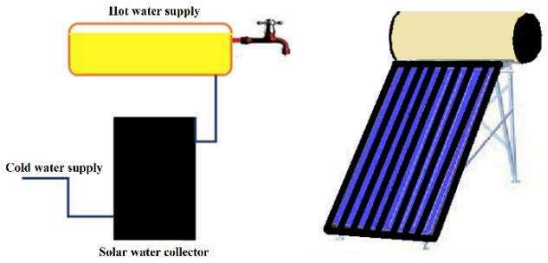
By now, solar energy has reached the level of widespread use in industrial production, household life, small production, processing enterprises, service places, horticulture, fisheries and almost all industries. Technologies for converting solar energy into heat and electricity, necessary for all industries, have been created, and scientific research works are being carried out in the directions of their further development, lowering the cost, extending the service life, simplifying use, and increasing efficiency. The technologies of conversion from solar energy to thermal energy are considered to be one of the fastest developing directions in recent

years. A hot water system using solar energy is called a solar collector.

A solar photovoltaic panel is a system of obtaining electricity based on solar energy. The system for obtaining hot air based on solar energy is called a solar air heater. The hot water system based on solar energy is implemented using solar collectors. The principle scheme of solar collectors is shown in Fig. 1.1. Solar collectors are divided into direct and indirect working groups. Directly working solar collectors (Fig. 1.1a) heat the metal on the working surface based on solar energy, and the temperature of the water increases due to the heat transfer of the metal. Such systems cannot be used in winter seasons, that is, when the air temperature is below 0 C^0. In solar water heaters working with a motor, substances with a low freezing temperature are used as a working substance. For example, it can be used in antifreeze [7].

Vacuum tubes are widely used in modern solar water heaters. Vacuum tubes use solar energy to heat a metal made of high thermal conductivity material in the center of the tube, and the metal uses heat energy to heat water in a thermally insulated water tank. There are various schemes of such solar collectors, from a simple construction to a complex one.

The first generations of solar collectors have been used for a long time. Such methods are related to people putting water in a container in the sunlight and heating it. Solar collectors are still widely used in a simple form, especially in rural areas, where hot water is obtained by painting large water tanks black.



a) b)

Figure 1.1. The principle scheme of the solar collector

Solar collectors are divided into two systems depending on the forced and natural form of movement of the working substance. Active and passive systems. In active systems, the working substance is forced to circulate with the help of a pump. In passive systems, natural circulation is implemented. In addition, mixed systems of solar water heaters are also used. Such systems heat cold water to a certain extent with the help of a solar collector, and heat it by spending additional energy to bring it to the desired temperature [7].

Using solar water heaters in many countries, it is possible to provide about 85% of the demand for domestic hot water. In addition, it is a safe system, it can be used in areas where there is no electricity or during power outages. It is possible to save energy from 40% to 80% by replacing the existing electric and fuel hot water systems with solar water heating systems.

Globally, the main countries that effectively use solar water heaters are Figure 1.2 [10].

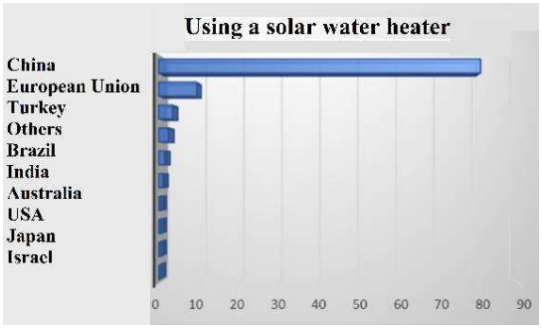


Figure 1.2. Major countries with extensive use of solar water collectors

The conversion of solar energy into electrical energy using photovoltaic panels is carried out using semiconductor elements. The system of obtaining electricity using solar photovoltaic panels is based on the principle of photovoltaic effect. The principle of photovoltaic effect was first observed in 1839 by Alexandre Edmond Becquerel. Currently, scientific research is being carried out to increase the efficiency of solar photovoltaic panels and reduce their cost. Silicon is one of the most common semiconductor materials. Silicon is currently the main material in the production of photocells. The price of pure silicon is expensive because the technology of extracting pure silicon is very complicated and requires a lot of money. In addition to silicon, solar panels are also produced from materials such as copper, indium, selenium, gallium, and cadmium. Figure 1.3 External appearance of a solar photovoltaic panel.

Figure 1.3. Solar photovoltaic panel

The efficiency of standard solar panels produced today is around 20%. And some panels are produced based on two-way energy capture. According to the results of approximate calculations, porobolosindrik solar thermal power plants would meet the demand for electricity of the whole world if one percent of the Sahara Desert was used. The construction of solar thermal power plants in equatorial countries will cause a sharp drop in the price of electricity. The principle of operation of parobolosylindrical solar thermal power plants is not based on the photoeffect phenomenon. Its principle of operation is mainly based on heat processes. Three main types of solar thermal power plants are developed.

-Porobolosylindrical solar thermal power plants;

- Tower solar thermal power plants;

-Solar thermal power plants based on the Stirling engine.

In porobolo-cylindrical solar thermal power plants, the temperature of the working substance is sharply increased in the pipes located in the center of the porobolo-shaped solar concentrator. A solar thermal power plant with this principle of operation was first created in 1906 in the

USA and built and tested near Cairo, Egypt. The first commercial thermal power plant was built in 1984. After the oil crisis, during 1984-1991, a thermal power plant with such a working mode was built in the Mojey desert of the California state of the United States of America. The total area of 6 km2 was needed for the thermal power plant built in the Mojai desert. The installed capacity of the thermal power plant is 354 MW [7].

Porobolosylindrical solar thermal power plants can be used in their pure form in equatorial countries. In other regions, it is appropriate to use it as a mixed system. In pure thermal power plants, energy is obtained only on the basis of solar energy (Fig. 1.4). In mixed systems, along with solar energy, other fuels are used (Fig. 1.5).

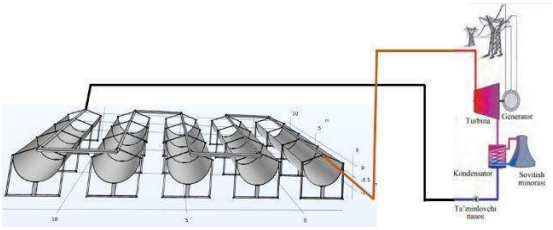


Figure 1.4. Pure porobolosylindrical solar thermal power plant

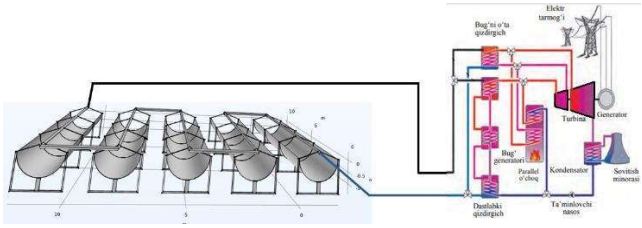


Figure 1.5. Mixed porobolosylindrical solar thermal power plant

The use of solar thermal power plants of this type in the climatic conditions of Uzbekistan has a great effect, taking into account the sharp reduction of fuel reserves and the increase in the cost of fuel. Electricity generation using tower solar thermal power plants is carried out by collecting a large area of sunlight energy in a small area energy receiver located in the tower. Solar thermal power plants of this type are now widely used in Spain, USA, Israel, Germany and other countries [18].

Solar energy is transferred to the receiving device located in the tower using reflective mirrors (heliostats) (Fig. 1.6).

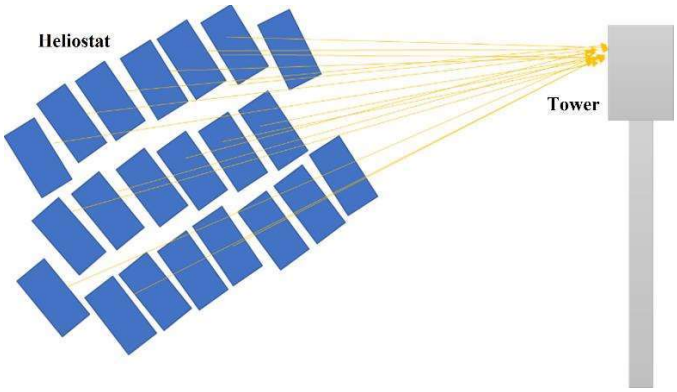


Figure 1.6. Tower solar thermal power plant

The system of converting solar energy into electricity using the Sterling engine is used in developed countries. The conversion of solar energy into electrical energy using the Sterling engine is carried out in the form of a porobolo solar concentrator. The engine moves due to the expansion of the working substance inside the hot piston of the Sterling engine due to the accumulated heat energy. Mechanical energy is extracted from thermal energy and mechanical energy is converted into electrical energy using a generator [11, 13].

Figure 1.7. A system of generating electricity from solar energy using a Sterling engine

The system of obtaining thermal energy using solar air heaters is one of the developing systems. Solar air heaters can be effectively used in homes, greenhouses, industries, manufacturing enterprises, dormitories and many other places. The solar air heater device increases the temperature of the absorber surface on the basis of solar energy, and the solar air heater works by transferring the heat from the high-temperature surface to the consumer. Convection process is natural and forced. For efficient use of solar air collectors, it is necessary to place the device perpendicular to the sunlight. In addition, the efficiency of the device depends on many factors. The use of solar air heaters in the spring and autumn seasons is very beneficial for our country. The efficiency of solar air heaters can be increased depending on the accelerating elements placed on the surface. In this case, it is necessary to select the accelerating elements in the device, depending on the dimensions of the device, such as height, length and width. In addition, it is necessary to pay special attention to the location, height, shape and smooth passage of air. Accelerating elements in the device cause an increase in hydraulic resistance, which in turn causes a drop in pressure. Determining the efficiency of the device is carried out by determining the balance of pressure loss, heat gain and hydraulic resistance [12,21,22,23].

Figure 1.8. External view of the solar air heater

Results. The main common types of solar energy devices were analyzed based on the results presented in the articles. The change in the efficiency of solar energy devices depending on the location and location angles was studied based on the analysis of the literature and the factors affecting the efficiency of the solar energy structures were determined based on the analysis of the literature [12-23].

Discussions. In the analysis of solar energy devices, it is possible to take into account the solar energy potential of the region when using all devices and observe changes in the technical indicators of devices under the influence of external factors.

Conclusion. When using solar energy devices, it is effective to use different devices based on the purpose:

- The use of solar water heaters for hot water supply is appropriate, the use for the purpose of heating buildings leads to a sharp decrease in efficiency;
- Centralized (not individual) use of steam-cylinder solar thermal power plants is appropriate;
- The use of solar photovoltaic panels in a battery-free system is economically efficient;
- The system of obtaining electricity from solar energy using the Sterling engine has a complex construction compared to other systems;
- The use of solar air heater collectors for heating buildings and structures is economically and energetically efficient.

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