STAGES OF DEVELOPMENT OF PHOTOVOLTAIC POWER CONVERTERS

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After the global energy crisis in the 70s of the last century, the development of unconventional and renewable energy began. Currently, the total capacity of operating power plants based on renewable energy sources is about 600 GW, which is almost twice the capacity of all operating nuclear power plants in the world. [1].
On the territory of the Central Asian region, the priority areas of research in the field of solar energy are:
1. Improvement of solar power plants (SPP), allowing to generate electrical and thermal power on an energetically significant scale without negative impact on the ecological environment [2];
2. Experimental research and practical application of solar parabolic cylindrical power plants [3];
3. Developments for the widespread use of heat pipes as a heat sink for solar parabolic cylindrical installations [4];
4. Research to improve the efficiency of photoelectric conversion (solar flux, ambient temperature, wind speed, optimal system load matching) [5];
5. Development and improvement of existing hybrid structures for air, water cooling, heat removal from panels, with forced cooling [6].
In the automated systems for measuring the energy indicators of the above solar systems, certain structures and algorithms are formed, which consist of the following main parts:
– object of research - solar energy system;
– sensor;
– secondary, microprocessor device;
– actuating mechanism;
– experimental data logger.
The measuring system of experimental data consists of functionally combined measures, measuring instruments, measuring transducers, computers, other hardware and software modules installed to measure one or more energy quantities. The main task of measuring systems is to generate measuring information signals in a form most convenient for automatic processing and control, transmission and use in registration systems [7, 8].
Every year, the production of energy, which is generated thanks to photovoltaic converters, is growing. At the moment, the market for photovoltaic solar energy is growing very rapidly around the world, which makes it one of the fastest growing industries.
The efficiency of a solar cell (SC) is one of the most important parameters for the introduction of this technology in the world.
There are already many SC fabrication technologies, which differ in the level of development and complexity. For manufacturing, various materials are used that affect the price and efficiency of solar modules (SM). SC depending on the design, materials and production method are divided into 3 main generations.
SC of the first generation based on c-Si crystalline silicon wafers. The main material for the production of solar cells of this generation is silicon, which is a common element on Earth, as a result of which it is inexpensive. Today, this solar cell is the most widespread in the world.
The share of first-generation SMs is about 90 % in global production due to the fact that the cost of silicon has been falling, making SM production cheaper. The average service life is 25 years. Crystalline silicon modules are divided into two types - monocrystalline and polycrystalline.
Monocrystalline solar cells have an average efficiency of 22 %. For their production, ultra-pure silicon rods are used, which are cut into thin plates.

Polycrystalline solar cells have an average efficiency of 17 %. Unlike monocrystalline cells, silicon is cast into blocks. In the process of solidification, crystalline structures of various sizes are formed, at the boundaries of which defects appear. These defects lead to a decrease in efficiency.

The development of technology is possible by reducing the cost and improving the quality of materials, as well as production processes and economic factors. This is assuming the market continues to evolve, offering a very attractive commercial choice.

Second-generation SCs based on thin films consist of a series of thin layers, with a thickness of only 1 to 4 μm, deposited on a cheap auxiliary layer (glass, metal, polymer film). As a result, less semiconductor material is used in fabrication to absorb the same amount of solar radiation. Also, thin films can be applied to the surface of a car, glass facades of buildings, portable chargers, and even embedded in clothing.

Four main types of photocells:

Amorphous silicon α-Si. A number of well-developed and widely known thin-film SCs are fabricated from amorphous silicon. The efficiency of solar cells based on amorphous silicon averages 8 %. Over time, they reduce their output power by 15-35 % due to degradation under the influence of solar radiation.

Amorphous silicon with microcrystalline silicon α-Si/μc-Si. Consists of SC amorphous silicon with additional layers of microcrystalline silicon attached to the substrate. The advantage of the microcrystalline silicon layer is that it absorbs more radiation from the red and infrared spectrum, thereby increasing the efficiency by up to 10 % on average.

Cadmium telluride CdTe. Cadmium telluride solar cells have lower production costs and high efficiency up to 16.7 % than other thin film technologies. The two main materials are cadmium and tellurium. Cadmium is obtained during the mining and production of zinc, and tellurium during the production of copper.

Copper-indium-gallium selenide CIGS. On average, the efficiency of such SMs ranges from 7 to 16 %. The advantage of these solar cells is that with increasing temperature, the efficiency decreases much less than when using silicon solar cells.

The third generation solar cells are mainly in the commercial stage of development. Some third-generation technologies are beginning to enter the mass market.

There are 3 types of third generation elements:

Cascade solar cells with concentrators. To improve the efficiency of power plants, multilayer (cascade) solar cells are developed and used, as well as concentrators using CPV (concentration photovoltaics) technology. Cascade solar cells have an extended range of spectral sensitivity compared to traditional thin-film solar cells and solar cells based on crystalline silicon. To concentrate solar radiation on solar cells, lenses and mirrors are used.

To increase power generation, concentrating photovoltaic modules must be constantly pointed at the Sun using solar tracking systems. The cost of SM with concentrators is much higher. The cost can be compensated in case of high efficiency. It is recommended to use SM with concentrators at latitude where sunny day prevails, because efficiency directly depends on the incident solar radiation.

Photosensitized by dye. They use photoelectrochemical solar cells based on semiconductor structures. These solar cells use inexpensive materials and have a simple manufacturing technology. The disadvantage is that over time, under the influence of ultraviolet rays, the efficiency decreases. Laboratory efficiency is about 12 %, in real conditions the efficiency is 4-5 %. The reason is that at the moment there are no such dyes that could absorb a wide spectral range.

Organic. They are composed of organic or polymeric materials (such as organic polymers or small organic molecules). They have low efficiency, but also low price. The efficiency reaches an average of 4 % to 5 %. Organic solar cells in some areas can compete with other technologies due to lower production costs.

Organic SCs can be applied to plastic sheets. They are thin and flexible films, making them mobile and able to be installed on uneven surfaces. They can be used in portable devices: chargers for smartphones, laptops, walkie-talkies, flashlights, toys and other compact devices that use batteries. The solar cell can be attached to almost any surface of the device case. When not in use, they can be folded or rolled up for storage.

At the moment, the growth in the use of solar electricity is growing. There are various SMs on the market that differ in manufacturing technology, cost, output characteristics and scope. Increasingly, SM with concentrators are beginning to be used. Technology and production are constantly improved, achieving maximum efficiency from SM. However, there are still many problems to be solved.

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