CONVERTING SOLAR ENERGY INTO ELECTRICITY

M. Hamidova[1], G.I. Sayfullayeva[2]
Master's student of Navoi State University[1]
Supervisor[2]
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Abstract. *This article extensively covers the physical and technological foundations of the process of converting solar energy into electricity. The properties of solar radiation, the mechanism of the photoelectric effect, and the structure and principles of operation of solar panels based on semiconductor materials are analyzed. The efficiency, advantages and disadvantages of monocrystalline, polycrystalline, and thin-film solar panels are also comparatively considered. The article also highlights the importance of integrating solar energy into power grids, inverters, and energy storage systems, and evaluates the future prospects of renewable energy sources on a scientific basis.*

Keywords: *solar energy, photovoltaic effect, solar panels, semiconductors, silicon, electricity, renewable energy sources, inverter, energy storage systems, environmentally friendly energy.*

Introduction: Today, the global energy system is facing serious challenges. The limited availability of traditional fuel sources, environmental pollution, and climate change are sharply increasing the need for alternative energy sources. Among them, solar energy is considered one of the most promising and environmentally friendly energy sources. The process of converting solar energy into electrical energy is a complex technological system based on the achievements of modern physics, materials science, and electrical engineering.

Solar energy is the energy of electromagnetic radiation generated as a result of thermonuclear reactions occurring in the core of the Sun. Sunlight reaching the Earth consists of a stream of photons, and when these photons interact with matter, energy is transferred. It is this phenomenon that forms the basis of the principle of operation of solar cells.

The conversion of solar energy into electrical energy is based on the photoelectric effect. This phenomenon was first discovered in 1839 by A. E. Becquerel and is explained by the formation of electric charge carriers in certain materials under the influence of light. Modern solar panels are mainly made of semiconductor materials, in particular silicon.

In the structure of the silicon atom, p-type and n-type layers are formed. When sunlight falls on it, photons eject electrons from the valence band to the conduction band. As a result, under the influence of an electric field, electrons and holes move in opposite directions, creating an electric current.

Solar panels are technologically divided into several types:

- Monocrystalline solar panels- Have a single crystal structure and are characterized by high efficiency (20–24%). They are complex and expensive to manufacture.
- Polycrystalline solar panels- Consist of several crystals and have a relatively low efficiency (15–18%), but are widely used due to their low cost.
- Thin-film panels- Made on the basis of cadmium telluride or amorphous silicon. Although they are lightweight and flexible, they are less efficient.

Electricity is undoubtedly the most convenient form of energy to use. From high school physics, the concepts of electric charges, electric current and the associated electric field, potential, electromotive force, current strength, current density, thermal, chemical, and magnetic effects of current are known. We assume that the student also has basic knowledge about the structure of the atom and the structure of the atomic nucleus. In practice, people often work with solids, and the issues we are going to describe are directly related to the properties of such bodies. Therefore, let's first briefly get acquainted with the structure of solids.

First, let's recall the structure of the atom. As is known, its planets revolve around the sun in certain orbits. Similarly, around the positively charged nucleus of an atom (which has a very small volume, almost the entire mass of the atom), negatively charged light particles - electrons - revolve in certain orbits, separated from each other. This is a planetary imitation of an atom, in which there are many orbits for its electrons, and they are in equilibrium in states close to the nucleus, but possible states far from the nucleus, where there are no electrons, remain empty. An atom absorbs light energy in the form of certain small fractions, particles called photons (photon - a particle of light).

When a photon is absorbed, an electron in the atom goes to a higher energy state, and vice versa, when an excited electron goes to a lower state, the atom emits a photon of light energy. Depicting the energy states of electrons in an atom on the E energy axis greatly simplifies considerations. It is customary to call the state of the electron in the atom closest to the nucleus the E_1 level, and the subsequent ones the E_2, E_3, . . . En levels. An electron in the E_1 level can move to the E_2, E_3, and En levels due to the photon energy absorbed by the atom. However, for this, the photon energy must be equal to the difference in energy levels.

Let us recall one rule - the Pauli exclusion principle. According to it, at most two electrons with opposite spins (direction of velocities) can be in one energy level, but there can be one electron in the level or the level can be without electrons (empty). This depends on the composition of the atom of the chemical element. An electron cannot have energy values between the levels, these intervals are forbidden energy intervals.

A solid consists of a large number of atoms. In this case, it is natural to ask what the energy states (levels) of electrons will be. According to the above-mentioned Pauli exclusion principle, instead of the energy level of an electron of an atom, there should be states in a solid in which the electrons of all atoms can occupy. The number of these states should be as many as the number of atoms that make up the solid. These states constitute the range (zone) of allowed energies. It is not difficult to notice that the forbidden energy bands are empty among the allowed energies.

The extent to which these allowed bands are filled with electrons depends on the chemical element to which the atoms belong and, consequently, on how many electrons are in the atom, and on some other factors. Depending on this, substances are divided into groups such as metals, semiconductors, dielectrics. In metallic substances that conduct electricity well, only half of the upper allowed band is filled with electrons, they are called free electrons and they can participate in the conduction of current.

In semiconductors, at a temperature of absolute zero (K), the upper allowed energy band is completely occupied by electrons, but there are no electrons in the band above it. The electrons in the fully filled band are bound, unbound electrons, and cannot participate in current conduction. At this temperature, the semiconductor does not conduct current (insulator-dielectric). However, at any temperature above absolute zero, some of the electrons in the filled band can move to the upper band, that is, the bound electrons turn into free electrons (conduction electrons). The

semiconductor conducts current to a certain extent. This phenomenon is similar to the transformation of liquid molecules into vapor molecules.

➢ The zone of electrons in the bond is called the valence band, and the zone of free (conduction) electrons is called the conduction band. When an electron moves from the valence band to the conduction band, the free state behaves as a positively charged mobile particle and is called a hole, which can also participate in the conduction of current. The gap between these two zones is called the forbidden Eq band. We draw attention to two important differences in the electrical properties of metals and semiconductors.

➢ The electrical conductivity of a metal is much greater than that of a semiconductor. For example, the conductivity of the semiconductor pure germanium is billions of times smaller than that of most metals. The electrical resistance of a metal increases slowly with increasing temperature. On the contrary, the resistance of a semiconductor can decrease by a factor of thousands or more with even a small change in temperature. In short: a semiconductor is a substance that is very sensitive to temperature changes. A semiconductor is also incomparably more sensitive than metals to light and other external influences. The above-mentioned properties have led to the increasingly widespread use of semiconductors.

Conclusion: Technologies for converting solar energy into electricity are one of the most important areas of scientific and technological progress today. The development of these technologies not only increases the stability of energy supply, but also plays an important role in solving environmental problems. In the future, the efficiency of solar energy is expected to increase further with the help of new materials and innovative technologies.

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