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TOWER SOLAR POWER PLANTS AND ANALYSIS OF THEIR ENERGY CHARACTERISTICS

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Abstract: This article discusses tower solar power plants, their operating principles, and main energy characteristics. An analysis of the efficiency of converting solar energy into electrical energy was carried out, and the features of thermal processes and energy storage systems were investigated. The advantages and disadvantages of tower solar power plants, their impact on the development of renewable energy, and the prospects for their application in modern energy systems are considered.

Keywords: tower solar power plant, solar energy, heliostats, energy characteristics, renewable energy sources, thermal energy, efficiency, solar power engineering, energy storage, concentrated solar energy.

Introduction. The development of renewable energy sources is currently one of the most important challenges in the global energy sector. Rising electricity consumption, limited traditional fuel resources, and worsening environmental conditions are driving the active implementation of clean energy technologies. One promising area of solar energy is tower solar power plants, which utilize concentrated solar energy.

Solar tower power plants are complex energy systems in which solar radiation is concentrated by a system of heliostats onto a central receiver located at the top of the tower. The resulting thermal energy is used to generate electricity via steam turbines or other power units. This type of solar power plant is characterized by high energy conversion efficiency and the ability to store thermal energy for later use.

The relevance of research into solar tower power plants stems from the need to improve energy efficiency, reduce harmful emissions, and ensure the sustainable development of energy systems. Analyzing the energy characteristics of such plants allows us to determine their performance, operating efficiency, and potential for use in various climatic conditions [1-2].

Methods. This study utilized theoretical and analytical research methods to study tower-type solar power plants and analyze their energy performance. A review of scientific literature, modern concentrated solar power technologies, and the operating principles of tower-type solar power plants was conducted [3].

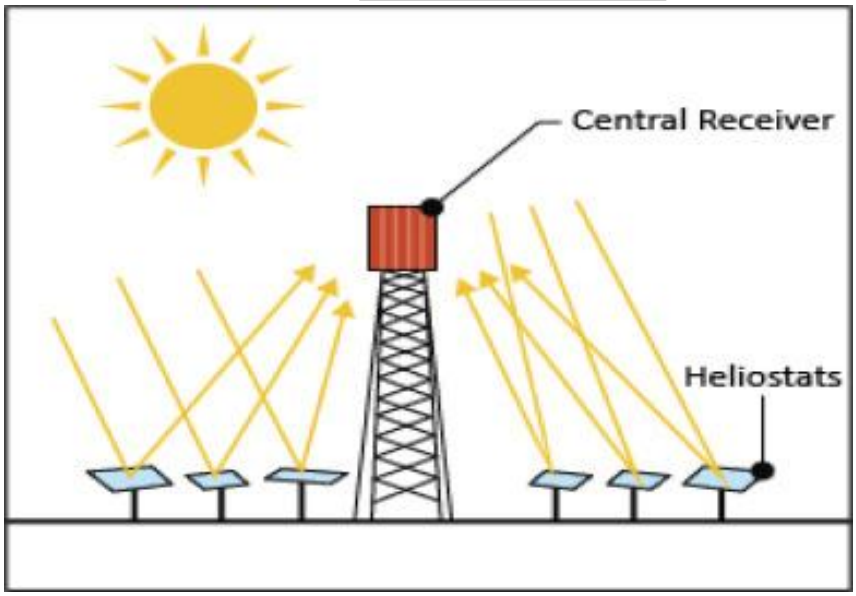


Figure 1. Tower type solar water collectors.

To assess the plant's energy efficiency, methods for converting solar energy into thermal and electrical energy, as well as the operating characteristics of the heliostat system and central solar receiver, were examined. A comparative analysis of the energy performance of tower-type solar power plants with other types of solar energy systems was conducted.

The study utilized mathematical analysis and engineering calculations to determine the efficiency, heat loss, and energy storage efficiency. Factors affecting plant performance, including solar radiation intensity, climatic conditions, and coolant characteristics, were also examined [4].

1-Table. – Main parameters of a tower solar power plant.

Parameter	Value
Power Plant Type:	Solar Tower Power Plant
Energy Source:	Solar Radiation
Receiver Operating Temperature:	500–1000 °C
System Efficiency:	20–35 %
Heat Fluid Type:	Molten Salt / Water / Air
Energy Storage Method:	Thermal Storage
Primary Concentrating Element:	Heliostats
Tower Height:	100–250 m

After analyzing the key parameters of the tower-type solar power plant, a study was conducted on the factors influencing solar energy conversion efficiency. Particular attention was paid to the operation of the heliostat system, which concentrates solar radiation onto a central receiver [5].

The study found that the station's efficiency depends largely on solar radiation intensity, the positioning accuracy of the heliostats, and the characteristics of the coolant. To improve the station's performance, thermal storage systems are used to store excess thermal energy and utilize it during periods of low solar activity.

Furthermore, heat losses during energy transfer and the impact of climatic conditions on the station's operational stability were examined. The analysis showed that using molten salts as a coolant increases the operating cycle temperature and improves the system's efficiency [6].

In addition to the methods used in this study, energy balancing of the solar tower power plant system was applied. This took into account all key energy flows: incoming solar radiation, reflection from the heliostats, heat losses in the receiver, and useful electrical energy output.

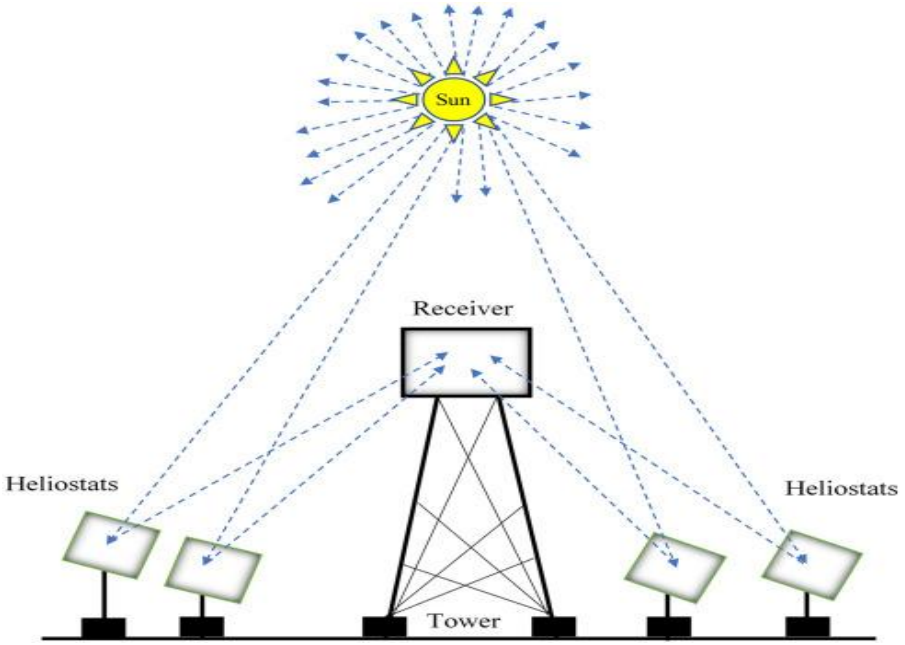


Figure 2. Focusing and heating trajectory of sunlight.

A method for modeling the angle of incidence of solar rays on the heliostat surface depending on the time of day and the geographic location of the plant was also used. This allowed us to assess changes in system efficiency throughout the day and season.

Particular attention was paid to analyzing the solar power concentration factor, which is determined by the ratio of the heliostat mirror area to the receiver area. This indicator has a direct impact on the operating temperature and overall efficiency of the system.

Furthermore, a comparative analysis of various types of concentrated solar power plants (tower, dish, and linear focusing) was used, which allowed us to determine the advantages of tower systems in terms of temperature levels and energy storage capabilities [7].

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