
# FLAT AND VACUUM SUN COLLECTORS TECHNICAL AND ECONOMIC FEATURES COMPARISON

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**Abstract:** This article compares the technical and economic characteristics of flat plate and vacuum tube solar collectors. Article collectors work principles, efficiency , costs , exploitation conditions and Uzbekistan to the climate compatibility point of view from the point of view analysis own inside takes . The study combines practical and theoretical aspects and provides recommendations on energy efficiency and investment efficiency.

**Keywords:** Solar collectors, flat plate collector, vacuum collector, energy efficiency, climate of Uzbekistan, investment cost

**Introduction.** The use of solar collectors plays an important role in the transition to sustainable energy sources. Energy costs can be reduced by reusing solar energy in hot water supply, heating systems , and industrial processes. The aim of the article is to compare the advantages and disadvantages of flat-plate and evacuated tube collectors theoretically and practically, and to determine which type is more efficient in the conditions of Uzbekistan.

**General operating principle of solar collectors.** The general principle of operation of solar collectors is based on receiving solar radiation, converting it into thermal energy , and transferring the resulting heat to the consumer through a heat transfer medium. This process is carried out through several sequential physical stages.

In the first stage, sunlight passes through the collector's transparent coating (usually tempered glass or a special polymer) and hits the absorber surface. Of metal (copper, aluminum, steel) with high thermal conductivity , and its surface is coated with a black or selective coating to maximize solar absorption.

Selective coatings absorb sunlight well and have the property of reflecting less heat back into the external environment .

In the second stage, the heat accumulated in the absorber is transferred to a moving heat transfer medium (usually water, antifreeze, or a water-glycol mixture) through an internal piping system.

This process occurs based on the laws of heat conduction and convection. As a result of heating the heat carrier, its density decreases and natural or forced circulation occurs in the system. In the third stage, the heated heat carrier is directed to the storage tank.

Heat is accumulated in this tank and transferred to consumers when necessary. The storage tanks are covered with a thick layer of thermal insulation to reduce heat loss [1-2].

Solar collector systems are divided into open and closed circuit systems depending on the type of circulation. In open systems, water flows directly through the collector and is heated. In closed systems, water is heated in a heat exchanger with a heat transfer fluid through a separate circuit.

Closed systems are widely used in cold climates because there is no risk of freezing . Solar collector systems can also be natural circulation (thermosiphon) or forced circulation (pumped). In natural circulation systems, the movement of water occurs due to density differences, while in forced systems, constant circulation is ensured using electric pumps.

Forced circulation systems are more efficient in large-capacity and multi-consumer facilities. In general, the principle of operation of solar collectors is based on direct heat extraction from solar energy, which is an environmentally friendly, renewable energy source , and significantly reduces the need for traditional fuels.

Description of flat plate collectors — flat panel devices with a glass coating and an absorber layer made of metal or other material. They have a simple design, easy to manufacture and install on a large scale. Description of vacuum collectors — each collector element is in the form of a vacuumed glass tube. The vacuum minimizes heat loss and helps maintain high efficiency even in cold conditions [3-4].

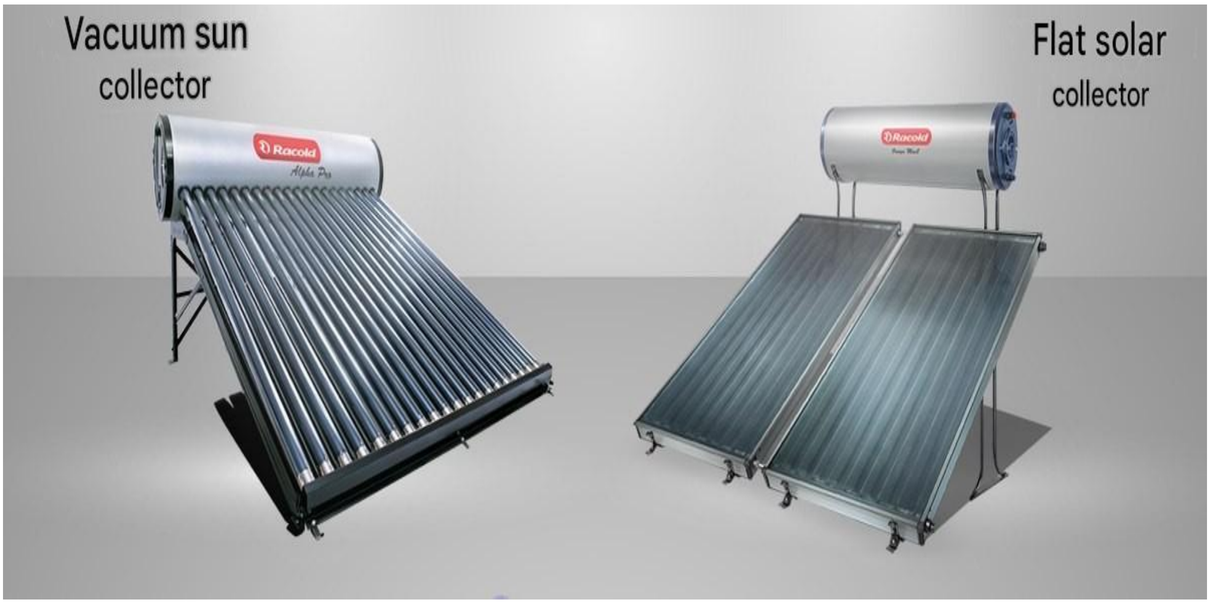


**Figure 1.** Modern collectors

**Table 1:** Technical parameters of collectors.

| Criteria | Flat collector | Vacuum collector |
|---|---|---|
| Working principle | Flat absorber + glass coating | Vacuum boroscopic tube |
| F.I.C. | Medium (40-70%) | High (50-85%) |
| Heating capacity in the cold season | Lower | High (due to vacuum insulation) |
| Price | Lower initial cost | High initial cost |
| Installation and maintenance | Simple and affordable service | More complex requires specialized skills |
| Mechanical strength | Good (glass coating may break) | Separate protection for each pipe, longer service life |
| Operating time | 15-25 years (depending on collector material) | 20-30 years (if well maintained) |
| Placement adaptation | Can adapt to even the most curved surfaces | Usually requires a large area |
| Technical complexity | Low | High |

**Which one is suitable for the climate of Uzbekistan - analysis.** The climate in Uzbekistan is predominantly continental , with hot summers and cold winters. The following features are important: Low winter temperatures , especially in mountainous areas, High number of sunny days - high annual radiation, Variability of wind and dust exposure [5-7].

**Analytical conclusions:** Oasis and lowland regions (e.g. Kashkadarya, Khorezm): flat-plate collectors can be cheap and effective in these regions, as there are fewer extreme winter colds and more sunny days: Mountainous and cold regions (e.g. some areas of Tashkent region, partially the Fergana Valley): vacuum collectors are more effective, as they maintain high efficiency even at low temperatures; General recommendation for all regions: if the budget is limited and the main goal is hot water for the summer months — flat-plate collector; if the goal is to achieve high efficiency and energy independence throughout the year (including in winter) — vacuum collector investment is justified.

**Energy efficiency and investment assessment.** Energy efficiency. Flat plate collectors: in well-optimized systems, annual thermal energy savings are significant, and the initial investment can usually be recovered within 4–8 years (depending on energy prices and system size). Evacuated tube collectors: higher annual energy savings due to higher efficiency ; payback period can be 5–10+ years due to higher initial cost , but is advantageous in winter and periods of low radiation [8-11].

**Table 2:** Investment analysis.

| | For a flat system | For vacuum system |
|---|---|---|
| Initial cost | 1000 USD | 1700 USD |
| Annual savings | 300USD | 420USD |
| Investment payback period | 1000/300=tahini 3.5 years | 1700/420=approximately 4 years |

**CONCLUSION:** This study comprehensively analyzed the technical, economic and operational characteristics of flat plate and vacuum solar collectors. Studies have shown that flat plate collectors are structurally simple, have relatively low initial costs and are highly efficient in warm climates, but in cold and windy conditions, heat losses increase and efficiency decreases.

have high thermal insulation and are characterized by stable operation even at low temperatures and low sunlight, but their initial cost and maintenance costs are higher. Taking into account the continental climate of Uzbekistan, high solar radiation potential and temperature differences across regions, it was found that flat-plate collectors are economically feasible for low-lying and warm regions, while vacuum tube collectors are superior in terms of energy efficiency for cold and mountainous regions.

Investment analyses show that both types of collectors pay for themselves in the medium term and significantly reduce energy costs in the long term. In general, the use of solar collectors in a comprehensive and regionally appropriate manner is of great importance in Uzbekistan in increasing energy efficiency, reducing dependence on traditional fuels, and ensuring environmental sustainability.

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