



ANALYSIS OF THE PERFORMANCE EFFICIENCY OF SOLAR COLLECTORS

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Abstract

This paper presents a comprehensive analysis of the performance efficiency of solar collectors, focusing on flat plate collectors (FPC) and evacuated tube collectors (ETC). Thermal efficiency, outlet temperatures, and daily output were evaluated using recent experimental and literature data. The results show ETCs achieve higher efficiency and heat output, making them more suitable for colder and variable climates.

Keywords

solar collectors, thermal efficiency, evacuated tube, flat plate, solar energy, performance analysis

1. Introduction

Solar thermal collectors are vital components of renewable energy systems, converting sunlight into usable heat for domestic, industrial, and agricultural applications. Flat plate collectors and evacuated tube collectors are the two most widely adopted types, each offering different levels of efficiency depending on design and climate [1], [2], [3].

2. Materials and Methods

Performance comparison was conducted based on data from experimental setups and literature review. Metrics such as maximum outlet temperature, daily thermal output, and thermal efficiency were collected. Thermal efficiency η was calculated using:

$$\eta = Q_u / (A_c \times G_t)$$

where Q_u is the useful heat gain, A_c is the collector area, and G_t is the incident solar radiation.

3. Results

Figure 1 compares thermal efficiency of both collectors. ETC shows notably higher efficiency across variable solar conditions.

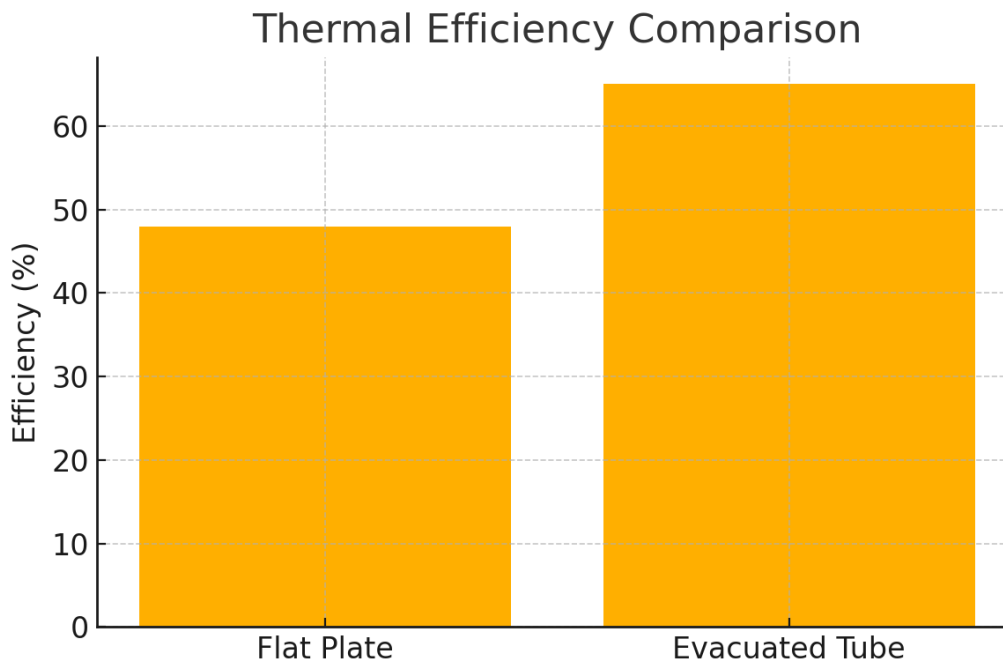


Figure 1. Thermal Efficiency Comparison

Figure 2 presents the maximum outlet temperatures achieved by each system. ETC reaches higher temperatures than FPC.

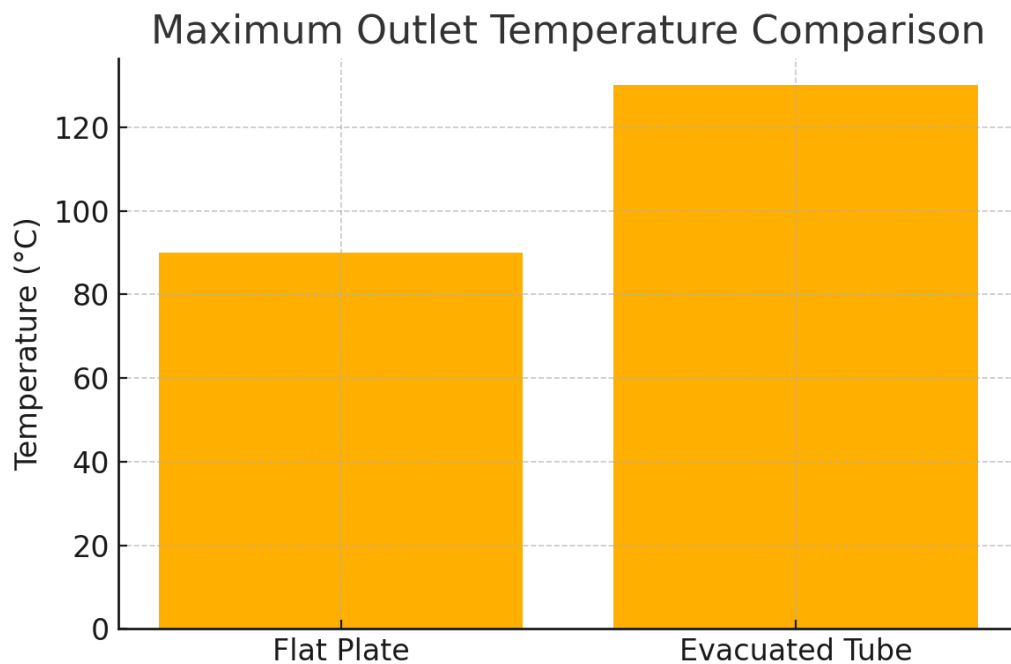


Figure 2. Maximum Outlet Temperature Comparison

Table 1 summarizes comparative performance data including daily output and useful heat gain.

Table 1

Parameter	Flat Plate Collector	Evacuated Tube Collector
Max Temperature (°C)	90	130
Thermal Efficiency (%)	48	65

Daily Output (MJ/day)	13.5	18.2
Useful Heat Gain (kWh)	3.75	5.04

4. Discussion

ETCs demonstrate superior performance due to vacuum insulation, which reduces heat loss through convection. This leads to consistent operation in colder environments. FPCs, though simpler and cheaper, underperform when ambient temperature drops or wind speeds increase [6], [7].

5. Conclusion

The analysis confirms that evacuated tube collectors outperform flat plate types in thermal performance, particularly under varying environmental conditions. These findings support the deployment of ETCs in regions requiring high and stable thermal outputs throughout the year

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