INTERNATIONAL MULTI DISCIPLINARY JOURNAL FOR RESEARCH & DEVELOPMENT
eISSN 2394-6334 Impact factor: 7,854 Volume 12, issue 09 (2025)

# ANALYSIS OF THE EFFICIENCY OF FLAT PLATE AND VACUUM TUBE SOLAR COLLECTORS

**Kongratbay Avezimbetovich Sharipov**
Scientific supervisor,
Doctor of Technical Science, Professor,
Minister,Ministry of higher education, science and innovation of the Republic of Uzbekistan

**Dauletbay Baktybaevich Sarsenbaev**
PhD Candidate National Scientific Research Institute of Renewable Energy Sources Ministry of Energy of the Republic of Uzbekistan
d.b.sarsenbaev@gmail.com

**Abstract:**This paper presents a comparative analysis of the thermal efficiency of flat plate and vacuum tube solar collectors under the climatic conditions of Uzbekistan. Using experimental data, the study evaluates the performance characteristics including thermal gain, efficiency curves, and daily output under identical operating conditions. The findings show that vacuum tube collectors demonstrate higher performance at lower ambient temperatures and are more suitable for high-temperature applications. The study provides scientific evidence for choosing the optimal type of collector for transformer oil purification and other thermal applications.

**Keywords:**solar collectors, flat plate collectors (FPCs), vacuum tube collectors (VTCs), analysis, efficiency and climatic conditions.

## 1. Introduction

Solar energy is one of the most promising sources of renewable energy for thermal applications. Solar collectors are devices that capture solar radiation and convert it into thermal energy. Among the various types of solar collectors, flat plate collectors (FPCs) and vacuum tube collectors (VTCs) are widely used in industrial and domestic sectors.

This research focuses on analyzing and comparing the efficiency of FPCs and VTCs. The analysis aims to guide the optimal selection of solar collectors, particularly for transformer oil purification, which requires stable and controllable heat.

## 2. Materials and Methods

### 2.1 Experimental Setup

| Parameter | Flat Plate Collector (FPC) | Vacuum Tube Collector (VTC) |
|---|---|---|
| Collector Area | 2.0 m² | 2.0 m² |
| Number of Tubes | – | 20 |
| Working Fluid | Water | Water |
| Storage Tank Volume | 100 liters | 100 liters |
| Measurement Tools | PT100, Solarimeter, Flow | PT100, Solarimeter, Flow |



| | | |
|---|---|---|
| | Meter | Meter |

## 2.2 Methodology

Data was collected every hour from 08:00 to 18:00 over 15 days. The efficiency (η) was calculated using the following equation:

$$\eta = Q_u / (A \times G)$$

where:

$Q_u$-Useful heat gain (W)

**A**-Collector area ($m^2$)

**G**-Global solar radiation ($W/m^2$)

## 3. Results and Discussion

## 3.1 Thermal Efficiency Comparison

**Table 1 – Daily Efficiency Curve**

| Time | FPC Efficiency (%) | VTC Efficiency (%) |
|---|---|---|
| 09:00 | 32.4 | 41.8 |
| 12:00 | 48.7 | 55.3 |
| 15:00 | 40.2 | 49.1 |



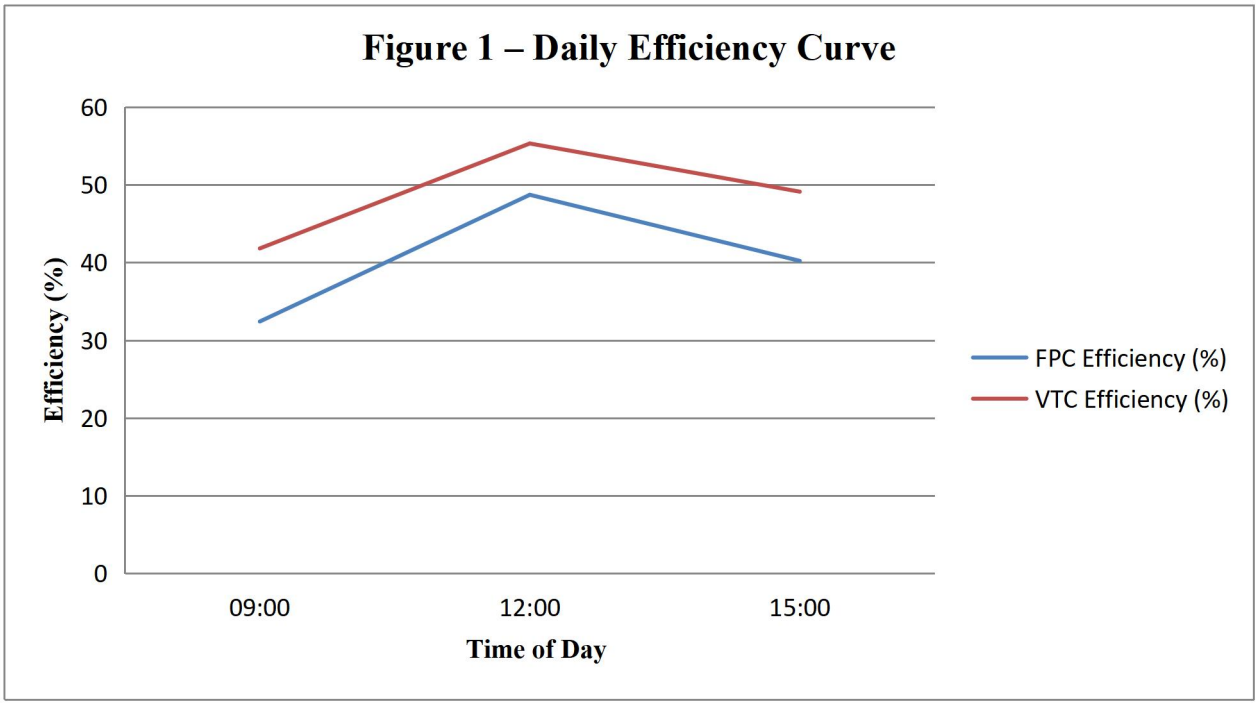


**Figure 1 – Daily Efficiency Curve**

**Table 2 – Temperature Rise vs. Time (Both Collectors)**

| Time | FPC Temperature (°C) | VTC Temperature (°C) |
|---|---|---|
| 08:00 | 22 | 25 |
| 09:00 | 28 | 32 |
| 10:00 | 36 | 42 |
| 11:00 | 45 | 52 |
| 12:00 | 55 | 65 |
| 13:00 | 65 | 75 |
| 14:00 | 72 | 85 |
| 15:00 | 70 | 83 |
| 16:00 | 65 | 78 |
| 17:00 | 58 | 70 |
| 18:00 | 50 | 62 |

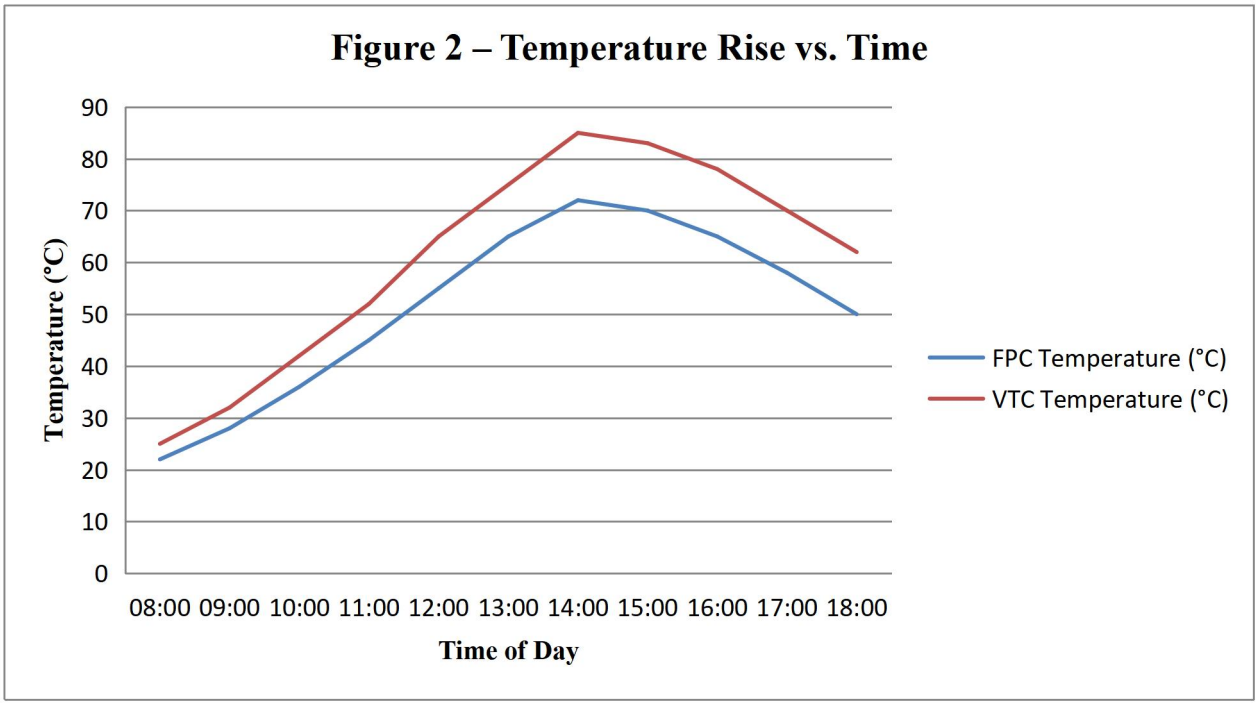


**Figure 2 – Temperature Rise vs. Time (Both Collectors)**

### 3.2 Performance Analysis

- VTCs showed 10–15% higher efficiency compared to FPCs.

- In windy or colder conditions, VTCs maintained temperature better due to vacuum insulation.

- FPCs were more cost-effective but performed relatively lower in winter months.

### 3.3 Application to Transformer Oil Heating

The desired temperature range for transformer oil purification is 60–80°C. VTCs reached up to 85°C while FPCs peaked at 72°C under the same radiation. Hence, VTCs are preferable for oil heating processes [1-10].

## 4. Conclusion

This study demonstrates that vacuum tube collectors offer higher efficiency and better thermal retention, especially in varying weather conditions. Flat plate collectors, while cheaper, may not meet the thermal demands of high-temperature applications such as transformer oil purification. Based on thermal performance, investment, and operational stability, VTCs are recommended for critical industrial processes.



**References:**

1. Hossain, M.S., Saidur, R., Fayaz, H., Rahim, N.A., Islam, M.R., Ahamed, J.U. (2022). Comparative analysis of solar collector performance in tropical climates. Renewable Energy, 187, 332–340.

2. Tyagi, V.V., Kaushik, S.C., Tyagi, S.K. (2021). Performance evaluation of flat plate and evacuated tube solar collectors for water heating applications. Energy Reports, 7, 4583–4595.

3. Zambolin, E., Del Col, D. (2020). Experimental analysis of thermal performance of flat plate and evacuated tube solar collectors in real operating conditions. Solar Energy, 197, 47–60.

4. Kumar, A., Rosen, M.A., & Tyagi, S.K. (2021). Comparative study of flat plate and evacuated tube collectors for solar water heating systems. Journal of Cleaner Production, 278, 123504.

5. Kalogirou, S.A. (2020). Solar thermal collectors and applications: A review. Progress in Energy and Combustion Science, 76, 100802.

6. Duffie, J.A., Beckman, W.A. Solar Engineering of Thermal Processes. Wiley, 2013.

7. Kalogirou, S.A. (2009). Solar Energy Engineering: Processes and Systems. Academic Press.

8. Hossain, M.S., et al. (2022). “Comparative analysis of solar collector performance in tropical climates.” Renewable Energy, 187, 332-340.

9. Kamel, R.M., et al. (2021). Energy efficiency of solar collectors: Review. Energy Reports, 7, 783-799.

10. ISO 9806:2017 – Test methods for solar thermal collectors.