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HEATING SWIMMING POOLS WITH SUNLIGHT IN THE CONDITIONS OF UZBEKISTAN

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Abstract. In this thesis, we explore the efficiency of using solar energy to heat swimming pools in Uzbekistan, a country with a hot, sunny climate. We analyze various factors influencing the effectiveness of solar pool heating systems, including climate conditions, material choices, design configurations, and cost-benefit analysis. We aim to provide a comprehensive evaluation of the viability of solar heating systems for pools in Uzbekistan, discussing both technical and economic implications.

Keywords: *solar energy, pool heating, climate, solar irradiance, swimming pools, flat-plate collectors, evacuated tube collectors, unglazed collectors, system efficiency, energy modeling, thermal performance, insulation.*

I. Introduction

Uzbekistan, located in Central Asia, experiences a continental climate with hot summers and cold winters. These conditions make it an ideal location for implementing solar energy systems. This thesis focuses on the efficiency of using solar energy to heat swimming pools in Uzbekistan. With increasing energy prices and a growing interest in sustainable solutions, solar energy systems are an attractive option. We explore the potential savings, system performance, and long-term benefits of solar pool heating, considering the specific environmental and economic context of Uzbekistan.

II. Background and Literature Review

Solar Energy in Swimming Pool Heating. Solar energy has become a widely accepted source of power for various applications, including pool heating. Studies such as those conducted by [1] have explored the general principles of solar thermal energy systems, highlighting the suitability of solar energy for pool heating due to the relatively low-temperature requirements. Research by [2] further elaborates on the efficiency of solar collectors, noting that even in non-tropical climates, solar heaters can significantly reduce energy costs for swimming pools.

Climate Conditions of Uzbekistan. Uzbekistan experiences over 3,000 hours of sunlight annually, with high solar irradiance during the summer months. According to a report by the [3], the country's geographic location and climate make it one of the sunniest places in Central Asia. However, winter temperatures can drop significantly, which poses a challenge for year-round pool heating. Therefore, the analysis of solar heating systems must consider the seasonal variations in solar energy availability.

Existing Technologies for Solar Pool Heating. Solar pool heaters typically consist of flat plate collectors, evacuated tube collectors, and unglazed collectors. Studies by [4] have shown that unglazed collectors are most effective for heating pools due to their simplicity and cost-effectiveness. These systems use the sun's heat to directly warm pool water, which is then circulated back into the pool. The efficiency of these systems depends on factors such as insulation, water flow rate, and the collector's angle to the sun.

III. Methodology

Data Collection and System Design. To assess the efficiency of solar pool heating systems, we collected data on climate conditions, pool usage patterns, and system specifications. We conducted energy modeling based on real solar irradiance data in Uzbekistan. Our

methodology follows a hybrid approach, combining field experiments with theoretical modeling to calculate thermal energy output and system efficiency.

Energy Modeling and Efficiency Calculations. We used established formulas for calculating solar collector efficiency, focusing on parameters such as collector surface area, water temperature increase, and ambient air conditions. The energy equation for heat gain in the pool water can be expressed as:

$$Q = A \cdot G \cdot \eta \cdot t \qquad (1)$$

Where: Q- is the total heat energy gained (kWh), A- is the collector area (m²), G- is the solar irradiance (kWh/m²), η- is the system efficiency, t- is the time period of operation (hours).

IV. Case Study of Uzbekistan

Pool Heating Needs Based on Climate. Swimming pools in Uzbekistan are typically used from April to October. During these months, the pool water naturally warms due to high ambient temperatures. However, during the shoulder months (April-May and September-October), solar heating is necessary to extend the swimming season. Our study examines the amount of energy required to maintain comfortable swimming temperatures (26-28°C) during these periods.

Application of Solar Heating Systems. Based on real-world data, we analyzed a 50 m³ residential pool in Tashkent. The solar pool heater system designed for this pool consists of flat-plate collectors with an area of 20 m². The collectors are installed at an angle of 30 degrees to optimize energy absorption during the summer months.

V. Efficiency Analysis

Thermal Performance of Solar Heaters. The efficiency of the solar pool heating system was found to be between 60-80% under optimal conditions. During the summer months, the system could raise the pool temperature by 4-5°C over a period of 6 hours. However, during the cooler months, the efficiency dropped due to lower solar irradiance.

Factors Affecting System Efficiency. Several factors were identified that impact the efficiency of the solar pool heating system:

Collector Orientation and Tilt: In Uzbekistan, the ideal tilt angle for solar collectors is approximately 30-35 degrees.

Insulation of the Pool: Heat loss due to evaporation and inadequate insulation significantly reduces efficiency.

Pump Flow Rate: A higher flow rate ensures better heat transfer, though it may increase energy consumption for pumping.

VI. Cost-Benefit Analysis

The cost of installing a solar pool heating system in Uzbekistan is estimated to be between $3,000 and $5,000, depending on the size of the pool and the system's complexity. Based on energy savings, the payback period is approximately 3-5 years, making it a financially viable option for residential and commercial pools. In the long term, solar pool heating systems offer significant cost savings compared to conventional gas or electric heating systems.

VII. Conclusion

In conclusion, solar energy is a highly efficient and cost-effective method for heating swimming pools in Uzbekistan, particularly during the warmer months. The country's high solar irradiance provides an excellent opportunity for utilizing solar pool heating systems. While there are challenges during the colder months, proper system design and insulation can mitigate efficiency losses. The financial benefits, combined with environmental advantages, make solar pool heating a promising solution for Uzbekistan's swimming pool owners.

VIII. References

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