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Economic Viability and Cost Analysis of Thermal Energy Storage in Concentrated Solar Power Systems

[1,2]*Collins Chike Kwasi-Effah*

[1]Department of Mechanical Engineering, University of Alberta, Edmonton Canada
[2]Department of Mechanical Engineering, University of Benin, Edo State, Nigeria

Abstract
This short communication examines the economic viability and cost considerations of Thermal Energy Storage (TES) in Concentrated Solar Power (CSP) systems. We analyze the capital and operational costs associated with various TES technologies, focusing on molten salt systems. The study highlights the impact of TES on Levelized Cost of Electricity (LCOE) and discusses potential pathways for cost reduction to enhance the competitiveness of CSP with TES.

Keywords: Concentrated Solar Power (CSP), Heat Transfer Fluids, Cost Analysis of Thermal Energy Storage, Levelized Cost of Electricity (LCOE)

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Introduction

Thermal Energy Storage (TES) is a critical component in Concentrated Solar Power (CSP) systems, enabling dispatchable renewable energy generation. However, the economic viability of TES in CSP remains a significant challenge for widespread adoption[1- 4]. This communication assesses the current economic landscape of TES in CSP and explores strategies for improving cost-effectiveness.

Cost Structure of TES in CSP:

The cost of TES in CSP systems can be broadly categorized into capital expenditure (CAPEX) and operational expenditure (OPEX). CAPEX includes the costs of storage materials, tanks, heat exchangers, and associated equipment. OPEX encompasses maintenance, replacement of components, and any additional operational costs related to the TES system [1-13]. Table 1 and Figure shows the cost break down of the system.

Table 1: Cost Breakdown for TES in CSP Systems

Cost Component	Percentage of Total TES Cost
Storage Material (e.g., Molten Salt)	35-45%
Storage Tanks	25-35%
Heat Exchangers	15-20%
Balance of System	10-15%

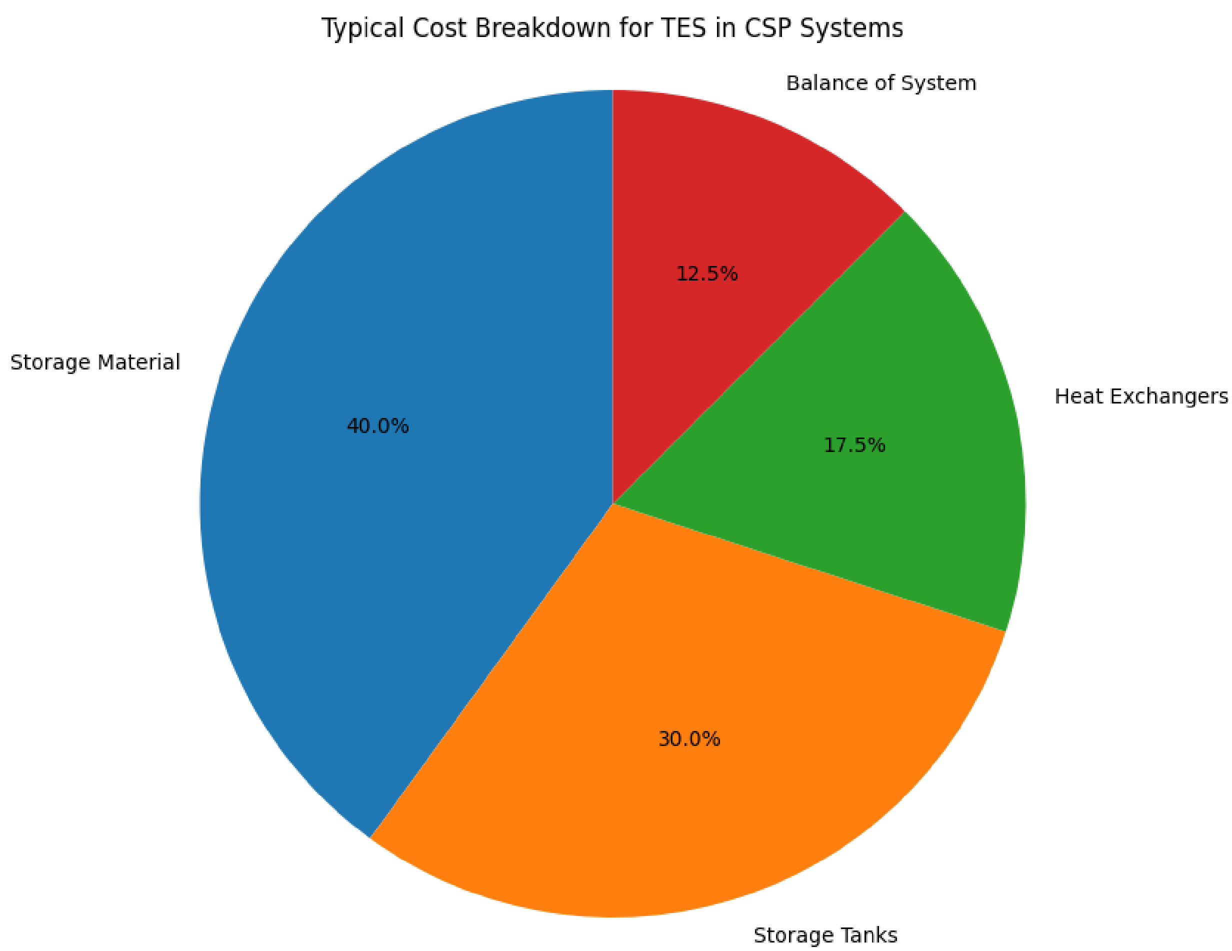

Figure 1: Cost breakdown

Impact on LCOE:

While TES increases the initial capital cost of CSP plants, it significantly improves capacity factor and dispatchability, potentially reducing the Levelized Cost of Electricity (LCOE). Studies have shown that CSP plants with TES can achieve capacity factors of up to 40-50%, compared to 20-25% for plants without storage.

Economic Challenges:

1. High upfront costs: The initial investment for TES systems remains a significant barrier, particularly for molten salt storage.
2. Material costs: The cost of storage materials, especially high-purity salts, contributes substantially to overall TES expenses.
3. Scalability: Economies of scale are crucial for cost reduction, but limited deployment hinders rapid cost decreases.

Pathways for Cost Reduction:

1. Advanced materials: Developing lower-cost, high-performance storage materials could significantly reduce TES expenses.
2. Improved system design: Optimizing tank design and heat exchanger efficiency can lower both CAPEX and OPEX.
3. Manufacturing scale-up: Increased production volumes of key components can drive down costs through economies of scale.
4. Policy support: Incentives and supportive policies can accelerate deployment and indirectly contribute to cost reductions.

Conclusion:

While TES enhances the value proposition of CSP by providing dispatchable renewable energy, its economic viability remains challenging. Focused efforts on material innovation, system optimization, and supportive policies are essential to reduce costs and improve the competitiveness of CSP with TES. Future research should prioritize cost-effective storage solutions and innovative system designs to accelerate the adoption of this promising technology.

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