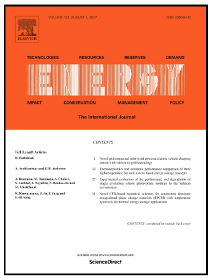

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Thermodynamic analysis and comparison for different direct-heated supercritical CO_2 Brayton cycles integrated into a solar thermal power tower system

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Abstract: In this paper, a complete mathematical model is developed to carry out the thermodynamic analysis and comparison for different direct-heated S-CO_2 Brayton cycles (simple, pre-compression, recompression, partial-cooling, and intercooling) integrated into a solar power tower (SPT) system. Based on the model, the effect of turbine inlet temperature (TIT) on the thermodynamic performances of the receiver, the thermal energy storage unit, the S-CO_2 power cycle blocks and the integrated SPT systems is investigated respectively for these cycles. Additionally, a comparison of cycle efficiencies and overall integrated SPT system efficiencies is performed for five S-CO_2 cycles at a series of total recuperator conductance (UA_{total}) values. The results reveal that the TIT exhibits a parabolic effect on the overall efficiencies for each S-CO_2 cycle, and the intercooling S-CO_2 cycle achieves the highest overall efficiencies followed by the recompression, the partial-cooling, the pre-compression, and the simple cycles at different TIT values. Furthermore, the partial-cooling cycle possesses the highest overall specific work at each TIT and offers higher overall efficiencies than the recompression cycle at a constant TIT (650 °C) as the UA_{total} is rather low, having the potential to reduce the costs of integrated SPT systems with limited UA_{total} values.

Keywords: Direct-heated S-CO_2 Brayton cycles; Solar power tower; Complete mathematical model; Thermodynamic analysis; Performance comparison

1. Introduction

The global environmental crisis resulted from the excessive fossil fuel combustion has become an urgent issue for years [1-3]. Solar energy is a clean and bountiful renewable energy resource which offers a solution to the serious