Keywords: CSP-Fossil hybrid power plant; Organic rankine cycle (ORC); Thermal analysis; Dynamic characteristics; Energy efficiency; Renewable energy integration

Introduction

In the quest for sustainable energy solutions, hybrid power generation systems have emerged as promising alternatives to conventional fossil fuel plants [1-5]. This study explores the integration of Concentrated Solar Power (CSP) with fossil fuel technologies, enhanced by Organic Rankine Cycles (ORC), to achieve synergistic benefits in energy efficiency and operational flexibility. The combination of CSP and ORC allows for harnessing solar thermal energy alongside conventional fossil fuels, mitigating intermittency issues associated with renewable sources and optimizing overall plant performance. This paper conducts a comprehensive thermal analysis to investigate heat transfer dynamics and energy conversion processes within the hybrid system. Additionally, dynamic characteristics are evaluated to assess the system's responsiveness to varying operational conditions and its potential for seamless grid integration. The findings highlight the potential of CSP-fossil hybrid plants with ORC to contribute significantly to sustainable energy generation, offering insights into their technological advancements and environmental benefits. This introduction sets the stage by outlining the significance of hybrid power plants integrating CSP and ORC [6], along with the objectives and focus of the study on thermal analysis and dynamic characteristics.

fossil fuel modes, optimizing operational flexibility and grid stability. Performance metrics and environmental impact quantitative analysis shows a substantial increase in net power output and efficiency gains achieved through the hybridization of CSP and ORC technologies. The reduction in CO2 emissions per unit of electricity generated underscores the environmental benefits of integrating renewable solar energy with conventional fossil fuel resources.

The results underscore the feasibility and advantages of CSP-fossil hybrid power plants with ORC in enhancing energy security, reducing greenhouse gas emissions, and promoting sustainable development. The synergistic integration of renewable solar energy with fossil fuels not only improves overall plant efficiency but also mitigates the intermittency issues associated with solar power. Future research directions may focus on further optimizing system designs, exploring advanced heat transfer materials, and integrating energy storage solutions to enhance the economic viability and scalability of hybrid power generation systems. This section synthesizes the findings from the study on the CSP-fossil hybrid power plant with ORC, discussing the implications of thermal analysis, dynamic characteristics, performance metrics, and environmental impact [10]. It provides a comprehensive overview of the benefits and challenges associated with integrating renewable and conventional energy technologies in hybrid power generation.

Conclusion

The integration of Concentrated Solar Power (CSP) with fossil fuel technologies, complemented by Organic Rankine Cycles (ORC), represents a promising approach to enhancing the efficiency, flexibility, and sustainability of power generation systems. This study has demonstrated through comprehensive thermal analysis and dynamic simulations that the CSP-fossil hybrid power plant with ORC offers significant advantages over traditional fossil fuel plants: The hybrid system capitalizes on solar thermal energy to augment fossil fuel combustion, resulting in higher overall efficiency and reduced fuel consumption per unit of electricity generated. Dynamic simulations have shown that the ORC turbines and thermal storage systems enable rapid response to changing solar irradiance and demand fluctuations, ensuring stable power delivery and grid integration. By reducing CO2 emissions and other pollutants associated with fossil fuel combustion, the hybrid plant contributes to environmental sustainability and supports global climate goals.

The optimized heat exchanger designs and control strategies developed in this study pave the way for further advancements in hybrid power plant technologies, facilitating scalability and cost-effectiveness. Continued research and development efforts should focus on refining system components, exploring advanced materials for heat transfer and storage, and integrating renewable energy sources to enhance the resilience and reliability of hybrid power generation. In conclusion, the CSP-fossil hybrid power plant with ORC represents a viable pathway towards achieving a sustainable energy future. By leveraging the synergies between renewable and conventional energy sources, this hybrid approach not only addresses energy security and environmental concerns but also fosters innovation in clean energy technologies. As global energy demands continue to grow, investments in hybrid power generation systems will play a pivotal role in meeting these challenges while ensuring a low-carbon transition.

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Con ict of Interest

None

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