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Thermodynamic and Cost Analysis of a Solar Dish Power Plant in Spain Hybridized with a Micro-Gas Turbine

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Abstract: Small-scale hybrid parabolic dish concentrated solar power systems are a promising option to obtain distributed electricity. During the day, solar energy is used to produce electricity, and the absence of sunlight can be overwhelmed with fuel combustion. This study presents a thermo-economic survey for a hybridized power plant in different regions of Spain, considering the local climatic conditions. The developed model considers the instant solar irradiance and ambient temperature dynamically, providing an estimation of the power output, the associated fuel consumption, and the most relevant pollutant emissions linked to combustion. Hybrid and combustion-only operating modes at selected geographical locations in Spain (with different latitudes, mean solar irradiances, and meteorological conditions) are analyzed. The levelized cost of electricity indicator is estimated as a function of investment, interest rate, maintenance, and fuel consumption actual costs in Spain. Values of about 124 €/MWhe are feasible. Fuel consumption and emissions in hybrid operation can be reduced above 30% with respect to those of the same turbine working in a pure combustion mode. This model shows the potential of hybrid solar dishes to become cost-competitive against non-renewable technologies from the point of view of costs and reduction in gas emission levels in regions with high solar radiation and low water resources.

Keywords: concentrated solar power; parabolic dish; distributed energy production; Brayton cycles; thermo-economic analysis

1. Introduction

Currently, with respect to the production and consumption of electrical energy, the unavoidable future change from the traditional supply-demand model to a new scheme based on smart grids or the micro-grid concept is recognized. The traditional scheme is defined on a centralized remote power generation and long transmission lines. The producer and consumer are well differentiated. On the contrary, new tendencies are characterized by distributed generation close to the consumption location, bidirectional power flows, and the integration of traditional and renewable energy sources [1,2].

Thermosolar power generation has been established as a viable and promising source of renewable energy [3]. In the last few years, it has emerged as a potential solution to supply dispatchable electricity, since it can rely on hybridization or thermal energy storage [4]. The hybridization of a solar thermal power system with combustion provides a continuous supply of electricity throughout the year, with much lower investment and maintenance costs than thermal storage [5].