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Thermo-Economic Analysis of a Single-Flash Geothermal Power System

Yeh-Tung Chen [1], Jui-Ching Hsieh [1], Nadya Sefira Salsabilla [1]
[1] National Chin-Yi University of technology, Department of Mechanical Engineering
No. 57, Sec. 2, Zhongshan Rd., Taiping Dist., Taichung City 411030, Taiwan (R.O.C.)
chen42682@gmail.com; jchsieh@ncut.edu.tw; nadyasefirasalsabilla@gmail.com

Extended Abstract

With the rapid growth of the global population, energy demand has increased significantly. However, the world still relies heavily on fossil fuels, which are expected to be depleted within the next few decades. The use of fossil fuels not only causes environmental pollution but also contradicts the global trend toward net-zero carbon emissions. A transition to renewable energy sources, such as wind, solar, and deep geothermal energy, is therefore essential. Among these, geothermal energy offers notable advantages, including a stable power supply and independence from weather conditions [1]. It is also suitable for base-load electricity generation and has a relatively small land footprint. In recent years, geothermal energy has gained increasing attention, with global installed capacity exceeding 19 GW as of 2020 [2], led by countries such as the United States, Indonesia, and the Philippines. Despite its high potential, especially in regions with untapped deep geothermal resources, geothermal power remains underutilized compared to other renewables. Nonetheless, the global geothermal power capacity is expected to grow steadily, driven by technological advances and supportive energy policies.

While offering numerous benefits, geothermal power systems are not without challenges, particularly in terms of efficiency, cost, and resource sustainability. One critical issue is the decline in production temperature over time [3]. This directly impacts the long-term economic feasibility of geothermal systems, which has been relatively overlooked in the literature. To understand this, the present study develops a coupled model integrating a geothermal reservoir heat extraction model, a single-flash thermodynamic model, and a turboexpander numerical model to evaluate system performance. This work provides a detailed analysis of the economic implications of long-term operation for geothermal power systems. Results show that the system reaches a maximum net present value (NPV) of $25.17 million in the 10th year. As the production temperature declines over time, the resulting reduction in output power causes the NPV to decrease gradually, reaching $3.87 million by the 30th year.

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