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Performance assessment of a novel hybrid district energy system

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HIGHLIGHTS

► A new hybrid system is proposed for improving the efficiency of geothermal district heating systems (GDHSs).
► The average overall system efficiencies are increased by 7.5% for energy and 13% for exergy, respectively.
► Various energetic and exergetic parameters are studied.

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ABSTRACT

In this paper, a new hybrid system for improving the efficiency of geothermal district heating systems (GDHSs) is proposed. This hybrid system consists of biogas based electricity production and a water-to-water geothermal heat pump unit (GHPU), which uses the waste heat for both heating and domestic hot water purposes. Electricity generated by the biogas plant (BP) is utilized to drive the GDHS's pumps, BP systems and the heat pump units. Both the biogas reactor heating unit and the heat pump unit utilize the waste heat from the GDHS and use the system as a heat source. The feasibility of utilizing a hybrid system in order to increase the overall system (GDHS + BP + GHPU) efficiency is then investigated for possible efficiency improvements. The Edremit GDHS in Turkey, which is selected for investigation in this case study, reinjects 16.8 MW of thermal power into the river at a low temperature; namely at 40 °C. Such a temperature is ideal for mesophilic bacterial growth in the digestion process during biogas production. 1.45 MW of biogas based electricity production potential is obtainable from the waste heat output of the Edremit GDHS. The average overall system efficiencies through the utilization of this kind of hybridized system approach are increased by 7.5% energetically and 13% for exergetically.

1. Introduction

Geothermal energy is a renewable energy source and may in large be used for electricity generation, heating, cooling, industrial drying, fermentation, balneological purposes, as well as for distillation and desalination applications, depending on the temperature of the resource. Additionally, various combinations of these options may practically be employed [1].

District heating and power production are two common utilization forms of geothermal energy in practice. District heating is one of the most common and widespread direct uses of geothermal sources, and such systems are employed in order to provide space heating and/or cooling to multiple consumers from a single well or multiple wells/fields. When geothermal energy is used for residence heating, considerable fuel cost savings are achieved in comparison to the use of a conventional fossil-fuel district heating system. The environmental benefits of using geothermal sources in district heating may be quantified by calculating the reduction in greenhouse gas and air pollutant emissions compared to those emissions emitted from fossil fuels based systems. Protection of the environment is one of our most important obligations and goals serving this purpose were defined in a number of key UN Summits in Rio (1991), Kyoto (1997) and Johannesburg (2001). Any type of energy production, transportation, transformation, conversion and consumption has some impact on the environment and the magnitude of such an impact will depend closely on the technologies and the methods that were used. In addition, the budget savings that would be achieved through the utilization of geothermal sources for heating rather than diesel fuel, LPG, fuel-oil, electricity, domestic lignite coal, LNG, imported coal and natural gas may reach up to 50–90%.

There are numerous research studies available in the literature regarding geothermal energy utilization for district heating and

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