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Economic optimization of a combined heat and power plant: heat vs electricity

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Abstract

This contribution presents the economical optimization of the parallel repartition between electric and heat production for geothermal application. The 350 m^3/h flow of geothermal fluid, assimilated to liquid water at 185°*C*, is then separated in two streams. Its reinjection temperature is fixed at 70°*C*. An Organic Rankine Cycle (ORC) system is used to convert a part of geothermal energy into electricity. The refrigerant chosen is the R245fa. The different components of the ORC are sized in order to calculate the installation cost that depends on one characteristic dimension of each item (exchange surface for heat exchangers and power for the turbine and pumps). The operating cost is proportional to the installation cost. In this contribution, since we do not consider the detailed structural optimization of the District Heating Network (DHN), its investment cost is proportional to the supplied heat. The selling price of the electrical net power is a function of the recovered heat by the network. A Mixed Integer Non-Linear Programming (MINLP) optimization is performed using the GAMS® software. The problem is solved in order to determine the maximal profit of the global system. Results show that it is preferable to produce electricity alone but this is dependent on the choice of the price of sale of heat by the owner. The sell price from which it is more profitable to produce and to sell the heat is determined for each case. The optimization for each case shows that it is not easy to predict the final results and it justifies the use of optimization.

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Keywords: Combined heat and power; District heating network; Mixed integer non-linear programming; Optimization; Organic rankine cycle

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1. Introduction

A consortium of ten partners, led by "FONROCHE Géothermie", works on the FONGEOSEC project, an "Investissement d'Avenir" organized by the French Agency for Environment and Energy (ADEME). The aim of this project is to design and create an innovative demonstrator of a high-energy geothermal power plant. The geothermal energy will be used to produce electricity and heat. Among other tasks, this project aims to develop a support tool for the optimal design of a District Heating Network (DHN) and an Organic Rankine Cycle (ORC) system, both supplied by the geothermal well.

Within the last ten years, many studies [1–3] have been dedicated to the choice of the organic fluid in the ORC. In the aim to protect the turbine, it is recommended to use a dry fluid (fluid with positive slope for the vapour saturation curve in *T-s* diagram). To help the research of the working fluid, S. Quoilin [4] proposes some options:

- Evaluate the cycle performance (efficiency, electrical production or economic analysis) for selected fluids in working conditions.
- Look the dangerousness of the fluid and its environmental impact.
- Verify that the fluid is easily available for purchase and inexpensive.

Z. Shengjun [2] observes that the best fluid is not necessarily the same according to the criterion chosen for the cycle performance. D. Wang [5] proposes some fluids usable per temperature range. The fluid chosen in this contribution is the R-245fa refrigerant.

For the optimization of the cycle, two approaches are confronted in literature: energetic [6,7] or economic optimization. In case of comparison of the two approaches [8–11], the optimums obtained are different.

Studies for Combined Heat and Power (CHP) systems have been recently carried out for economic optimization and it permits to compare different algorithms [12–14]. H.R. Sadeghian [15] has also studied the environmental emissions and K. Sartor [16] has developed, in addition, the heat losses for the DHN.

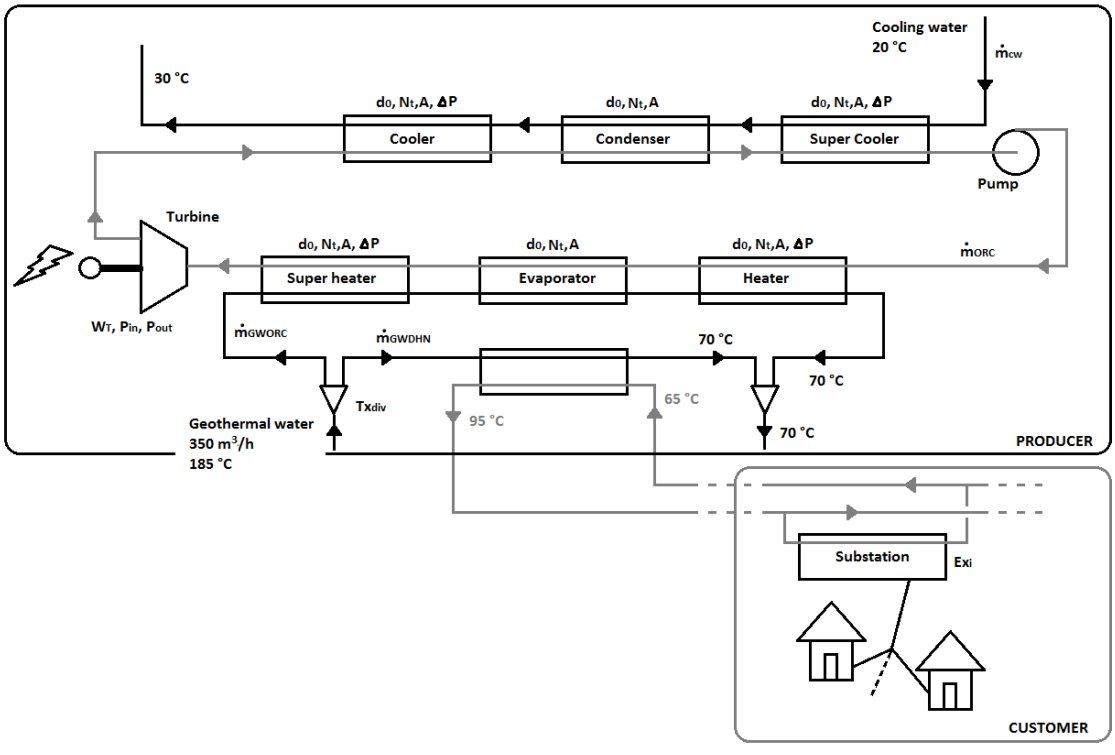

Fig. 1. Schematic representation for variables.