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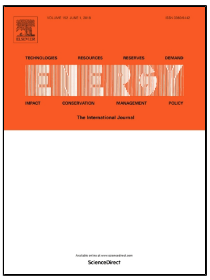

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Simultaneous optimization of the District Heating Network topology and the Organic Rankine Cycle sizing of a geothermal plant

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HIGHLIGHTS

- Combined Heat and Power geothermal plant optimization.
- Parallel distribution of a geothermal fluid between electricity and heat production.
- Detailed modelling of an ORC and a district heating network.
- Strategy for a deterministic MINLP algorithm to initialize and avoid local optima.
- Sensitivity analysis to prove the relevance of using a simultaneous approach.

ABSTRACT

This contribution presents the optimization of parallel distribution between electricity and heat production for a geothermal plant. The geothermal fluid is split into two streams, one used for an Organic Rankine Cycle (ORC) system, and the other for a District Heating Network (DHN). The superstructure to be used for the optimization problem includes the ORC components, one of which is an optional internal heat exchanger which allows exchange between the outlet streams of the turbine and the pump. Each of the components' characteristic dimensions (used in the installation cost) is an optimization variable. The operating cost of the ORC is proportional to the installation cost. The superstructure also includes the DHN topology constituted by a definite consumer and optional consumers. A Mixed Integer Non-Linear Programming (MINLP) optimization problem is formulated and solved using the GAMS software. The strategy used to overcome the critical point of the initialization of the MINLP problem is presented. It consists in dividing the general problem into sub-problems which are solved successively. Three different academic study cases are compared to a reference case. The results validate the stability and the robustness of this optimization tool. A sensitivity analysis is performed in geothermal source conditions. All these results highlight the relevance of the simultaneous approach.

KEYWORDS

Economic Optimization, Geothermal Power Plant, Combined Heat and Power (CHP), District Heating Network (DHN), Organic Rankine Cycle (ORC), Mixed Integer Non-Linear Programming (MINLP).

1. Introduction

To meet the needs of human activities, world energy consumption doubled between 1973 and 2014 [1]. Unfortunately, a large part of this consumption is based on fossil fuels and contributes to GreenHouse Gas (GHG) emissions and global warming. One way to fight against climate change is to reduce the share of fossil fuels in energy production and increase the use of renewable energy sources. More specifically, this means resorting to deep geothermal energy, which does not depend on weather conditions and can be exploited continuously. This geothermal energy can be converted for electricity generation or can be used directly as a heat source. A combination of these two applications is feasible and improves energy efficiency, which is low in the case of electricity production alone (15% with the use of an ORC, for example [2]). This introduces the notion of Combined Heat and Power (CHP) production [3] and integrated usage [4]. In addition, a convenient solution to supply the heat needed for heating buildings, domestic hot water production, industrial applications or other uses (swimming pools, etc.) is the use of a District Heating Network (DHN). A DHN allows great interaction between the different uses which can be cascaded. It also enables