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Energy, economical, environmental evaluation of a CCHP-GSHP system based on carbon tax and electric feed in tariff

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Abstract

In the paper, a new CCHP system is proposed. The proposed system consists of a power generation unit (PGU), an absorption chiller, a storage tank as well as a ground source heat pump (GSHP). Then two basic load following strategies following the electric load(FEL), following the thermal load(FTL) are compared with the strategies following the hybrid load(FHL) and following maximum electric efficiency of PGU load based on primary energy consumption(PEC), operation cost and carbon dioxide emission(CDE). Finally, sensitivity analysis is performed and results are presented when electric and gas price change.

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Keywords: CCHP system, operation strategies; primary energy consumption; operation cost; carbon dioxide emission; sensitivity analysis

1. Introduction

In the face of global warming, there is huge pressure to reduce greenhouse gas emissions in China. Therefore, under the terms of the 1997 Kyoto Protocol, the Chinese government agreed to try their effort to reduce greenhouse gas emissions; the National plan on climate change published in 2014.09 pointed

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out that CO2 emissions per GDP should be reduced by 40%-45% from 2005 to 2020 and up to 2020, 120 low carbon industrial demonstration parks should be built. With increasing energy demand and diversity of energy requirements, CCHP (combined cooling, heating and power) system is an alternative way to mitigate negative environmental impacts and improve energy utilization efficiency simultaneously. A good design of CCHP system results from many factors such as system configuration, and operation strategy etc.. Also, there are many preferential policies such as electric feed in tariff, carbon tax etc. to make CCHP system more economical.

The objective of this paper is to propose a novel CCHP system with a backup GSHP. If the recovery heat of the PGU is insufficient, the GSHP system can be used to supply surplus cooling or heating. In this paper the efficiency of all equipment except heat exchanger is dynamic. Based on above, four different operation strategies are simulated with several optimization criterions such as: operation cost, PEC and CDE considering the feed in tariff and carbon tax. At last, the sensitivity analysis of electric price changing rate and gas price changing rate are given.

2. Analysis Methodology

2.1. System Configuration

In order to provide sufficient energy and improve the flexibility of energy supply, a typical CCHP system consists of a power generation unit (PGU) interacting with thermally-activated components, such as absorption chillers, ground source heat pumps (GSHP), and heating exchanger. Fig. 1 illustrates a schematic of a building CCHP system and separate system.

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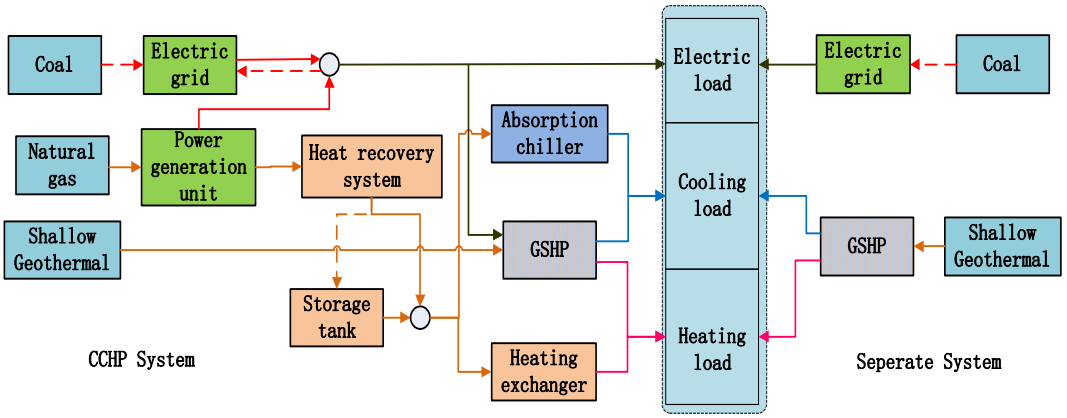

Fig.1 Schematic diagram of a CCHP system and separate system for the reference building