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Optimal Dispatch of a Multiple Energy Carrier System Equipped With a CCHP

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Abstract. With the development of distributed generation (DG) technologies and the implementation of policies to encourage their applications, The Combined Cooling, Heating, and Power (CCHP) systems is expected to play a greater role in the commercial buildings in the future. CCHP is a promising efficiency improvement and carbon mitigation strategy, but careful operation mode is required to achieve a reasonable system performance according to energy consumption characteristics of buildings and technical features of equipments [1].

This paper presents an energy dispatch method which minimizes the cost of energy (e.g., cost of electricity from the grid and cost of natural gas into the gas turbine and boiler) base on the energy hub concept and by regarding carbon market rules. The system includes combined heating power (CHP) module, auxiliary boiler, absorption chiller, utility grid and electrical, thermal, and cooling loads. In fact, by solving this model, optimal energy flow will be determined regarding both the amounts of electric, thermal, and cooling loads in each time interval and prices of electricity and natural gas at the same time, by considering environmental constrains. In the cost function of this model, the total economic benefit of this system is maximized during total daily operation time.

The results of an optimal operation model have been discussed economically and a case study has been investigated.

Key Words

combined cooling heating and power (CCHP), energy hub, optimal operation, CO_2 emission

1. Introduction

Traditional power plants convert about 30% of the fuel's available energy into electric power[2]. The majority of the energy content of the fuel is lost at the power plant through the discharge of waste heat. Further energy losses occur in the transmission and distribution of electric power to the individual user. Inefficiencies and pollution issues associated with conventional power plants provide the motivation for developments in "onsite and near-site" power generation.

To overcome mentioned defects today as a supplement for conventional large-scale power generation system, distributed generation (DG) technologies have got more comprehensive attention. Distributed generation (DG) represents an alternative for generating electricity (and heat) close to the point of demand. One of the keys to the prosperity of fossil-fuelled DG is the ability to use the waste heat from electricity generation, raising total system efficiencies up to 90% (higher heating value) in the best applications. The high efficiencies of such applications, commonly called combined heat and power (CHP), offer both reduced costs and significant reductions of CO_2 emissions. Other factors may also drive increased deployment of DG in the future, including enhanced reliability and security, reduced need for transmission and distribution upgrades, and simpler plant sitting [5-7]. DG also gives prominence to the government's Kyoto Protocol Target Achievement Plan [1].

In addition to recover the waste heat for heating purpose it is also possible to transform the waste heat by-product in a CHP system, such as hot water or steam, into useful cooling by using an absorption chiller. Unlike a conventional electrical chiller that uses mechanical energy, the absorption chiller uses heat in a refrigeration cycle to provide cooling. Combined cooling, heating, and power (CCHP) systems use reciprocating internal combustion engines, turbine engines, and even fuel cells to generate electrical power while recovering waste heat for heating or cooling (through absorption chillers) purposes. CCHP systems produce both electric and useable thermal energy onsite or near site, converting as much as 80% of the fuel into useable energy [8].

Like a traditional power grid that the objective of economic dispatches (ED) is to determine the allocation of electric power for different generating units in order to minimize the total generation cost subject to both technological and physical constraints, ED in CHP or CCHP is assuming an increasingly important role since it provides an economic solution to fulfilling the demands on electric power, district heat and cooling and It is deemed as an effective way of increasing overall energy efficiency[9].

CCHP plants face fluctuating demands for heating cooling and power. Thus, there are more uncertain factors in CCHP than in pure power dispatch [1-2]. Inevitably, more design objectives coupled with tighter constraints need to be incorporated. As a subset of unit commitment, power dispatch is a major function in energy management systems (EMS).

In this paper an optimal dispatch of energy hub [3] equipped with CCHP is considered and the optimum operation of CCHP systems for different climate conditions is exemplified based on energy cost and operational system emissions.

The contents of this paper are organized into six sections. Following this introduction, the energy hub concept and a brief overview of the Energy hub modeling is presented in Section II. To find the optimum operational point, Section III provides detailed formulations on the problem. In section IV, the presented approach is demonstrated in examples. Finally, section V concludes and summarizes this paper.