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An optimal planning method for combined cooling heating and power system

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淮 bstract

In this paper, a combined cooling heating and power micro-grid system framework which considers lots of device types and possible connections is presented. Based on this framework, a mathematical model considering constraints of load demand and operation is built; its optimal objective is to minimize the cost and carbon emission. The Multi-objective Particle Swarm Optimization (MPSO) method with a feedback loop is used to choose the best capacity of the equipment, and the Interior Point (IP) method algorithm is embedded in the MPSO to solve the operational optimization problem .The approach is applied to a mixed commercial and residential area of the Pearl River Delta (PRD) as a case study, verified the effectiveness of the planning method.

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Keywords: Combined cooling heating and power microgrid system; Framework; Multi-objective Particle Swarm Optimization method; Interior Point method;

1. Introduction

In order to cope with the energy crisis and solve the environmental problems, it is necessary to improve the energy efficiency. Based on this consideration, combined cooling, heating and power system (CCHP) is proposed. It is proved that CCHP has higher energy efficiency and lower emission value, compared with traditional divided energy supply system [1]. Thus, CCHP has been widespread concerned by various countries[2].During the CCHP system planning stage, a framework structure is given based on experts' experience normally. In [3-5], a framework contained the original motive equipment and heat exchange

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equipment is given. In [6], six kinds of CCHP framework are given. However, these frameworks contain less device types and less possible connections.

In the optimization of CCHP system, capacities of the devices need to be determined, and the cost and constrains in long-term operation need to be considered as well. Thus, this problem could be split into two stages, the first stage is to choose the best capacity of each device, the second stage is to calculate the long-term operation cost .In [6], NSGA-II-MLIP is designed to solve this problem. However, the capacities generated in the first stage may be surplus; it may not be suitable for the second stage calculation. If the framework is complex, it will take too much time to find the optimal results. The solution is to add a feedback loop between the two stages.

Based on the considerations above, in section 2, a combined cooling, heating and power micro-grid system framework contains lots of device types and possible connections is presented. In section 3，a mathematical model considering constraints of load demand and operation is built. In section 4, the algorithm is introduced. Furthermore, a case from the PRD is studied in section 5.

Nomenclature

NGE	natural gas engine	NGB	natural gas boiler
NGT	natural gas turbine	ERH	electric radiator
ELB	electric boiler	REB	heat recovery steam generator
EBA	battery	EBAC	converter
ABC	absorption chiller	ECC	electric compression chiller
HST	heat storage tank	CST	cold storage tank
FMP	fixed maintenance price	VMP	variable maintenance price
EL	electricity	CW	chilled water
HL	high temperature hot water	HA	hot air
CA	cool air	LHW	low temperature hot water

2. Framework applied to CCHP system planning

This study mainly focuses on natural gas CCHP system connecting to the grid. A framework considers lots of device types and possible connections are proposed in this study, shown as Fig. 1. The equipment whether to be chosen depends on the optimization calculation. Obviously, this framework also contains the divided energy supply system scheme, CCHP system scheme without storage devices. With this framework that contains lots of device types and possible connections, it's more convenient to compare schemes with each other during the optimization calculation.

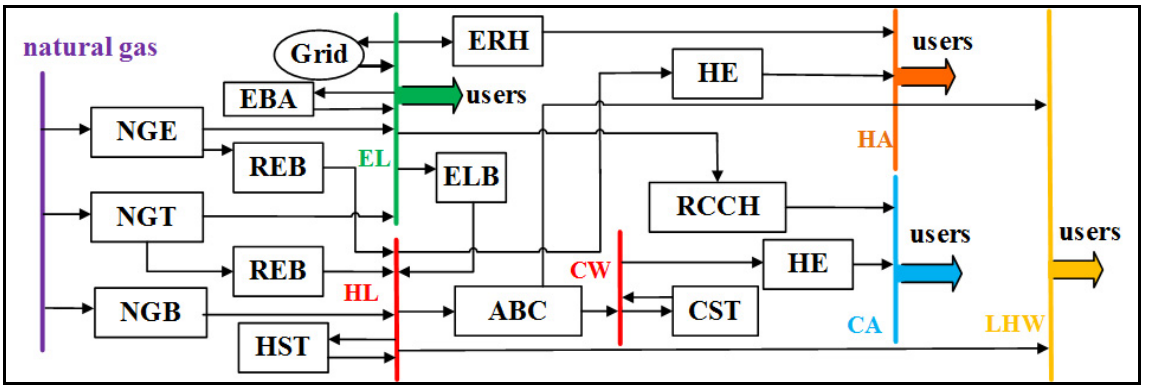

Fig.1 Framework of CCHP system

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