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Application Study of Novel Hybrid Source Heating Mode with Low Energy Consumption for China

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Abstract

Based on the urgent demand of China's emission reduction and air haze control, this study aims to relieve the conventional energy consumption and environmental air pollution problems generated during heating period in China. Combined with the low power supply efficiency and big contradiction between power supply as well as demand status of power supply system, the present paper innovatively combined the renewable shallow geothermal energy with the energy-saving demand side power management concept, and proposed a hybrid source heating mode with the ground coupled heat pump as the main heat source, the valley electricity as the supplemental heat source, and the floor radiation pipes as the terminal form. The life cycle cost of proposed hybrid source heating mode is simulated and compared with traditional heating modes. Results indicate the hybrid source heating mode can make positive contribution to the sustainable development and urbanization construction of north China.

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Keywords: Hybrid source heating mode; Shallow geothermal energy; Demand-side power management; Valley electricity

1. Introduction

With the improvement of people's living standards and conditions, the indoor heating demand of northern region of China in winter grow increasingly, which not only increased the heat stress of centralized heat supply network, but also increase conventional energy consumption of heating season [1]. The combined heat and power generation

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in the northern cities has approached saturation, and coal-fired boiler as the heating source has been forbidden in most cities of China presently. In the situation of high energy consumption and the increasingly serious environmental pollution of China, vigorously develop the green building as well as explore the energy efficient and environmental protection heating mode is very imminently [2]. In recent years, ground coupled heat pump system as the new heating technology utilize the renewable shallow geothermal energy, has received more and more attention and became the popular heating access in winter for buildings far away from municipal heating pipe network [3].

However, when the ground source heat pump system is utilized for heating load dominated buildings located in northern China, heat extracted from the ground in winter will lead to cold accumulation around ground heat exchanger (GHE) gradually and results in temperature decrease of water entering the evaporator of the heat pump. The system heating performance hence experiences degradation even cannot provides heating normally [4]. These features become the bottleneck of the ground source heat pump technology cannot be applied massively in central heating system of northern area of China.

On the other hand, China's power generation installation capacity increasing rapidly to be a large scale in order to meet the requirement of rapid economic development, which also lead to a huge valley electricity power waiting for consumption. Therefore, the application of electric demand side management is promoted in China in last decade for coordinating the orderly development of electric power and national economy [5]. By utilizing the night valley electricity and reducing the peak valley difference of power supply system sufficiently, the electric demand side management can improve the stability of power load, reduce the pressure of power generation as well as supply, and improve the efficiency of local power grid [6]. Therefore, how to utilize the night valley electricity economically and efficiently is the key point of electric demand side management.

Based on the above research background, the present paper innovatively combined the renewable shallow geothermal energy with the energy-saving demand side power management concept, and proposed a novel hybrid source heating mode with the ground coupled heat pump as the main heat source, the heating cable powered by valley electricity as the supplemental heat source, and the floor radiation pipes as the terminal form. This novel mode can prevent the ground coupled heat pump from performance degradation even lose effectiveness during long term heating provision in winter due to the continues decline of soil temperature, and can provide high energy efficiency as well as reliable heating scheme for the northern region. Besides, this novel mode can reduce the peak valley difference of power supply system by using the night valley power as the supplemental heat source. Then the stability of electric load can be improved, the power generation and supply pressure can be reduced, and the efficiency of local power grid can be improved effectively. In addition, part of building cooling load in summer can be afforded by circulating water between ground heat exchanger and floor radiation pipes directly to get "free cooling". The operation performance of novel mode is discussed, and the life cycle cost of proposed mode is simulated and compared with other traditional heating modes in this paper. Results indicate the novel mode can make positive contribution to the sustainable development and urbanization construction of north China.

2. Methods

2.1. Novel hybrid source heating mode design

The novel hybrid source heating mode innovatively combined the shallow geothermal energy with the energy-saving demand side power management concept, and it utilize the ground coupled heat pump as the main heat source, the double conductor heating cable powered by valley electricity as the supplemental heat source, and the floor radiation pipes as the terminal form. As shown in Fig. 1, the novel hybrid source heating mode system mainly consist of the heat pump unit, the ground heat exchanger, the double conductor heating cable, and the floor radiation pipes.