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ScienceDirect

Energy Procedia 143 (2017) 137–143

Energy Procedia

www.elsevier.com/locate/procedia

World Engineers Summit – Applied Energy Symposium & Forum: Low Carbon Cities & Urban Energy Joint Conference, WES-CUE 2017, 19–21 July 2017, Singapore

Research on the Clean Energy Heating Systems in Rural Beijing

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Abstract

Fog and haze weather has seriously affected many important aspects of human life and physical fitness. In order to improve air quality, local government has transformed coal-fired heating into clean energy heating in Beijing rural areas. This paper introduces three typical clean energy heating systems which are low temperature air source heat pump (LTASHP), thermal storage heater (TSH) and wall-mounted gas furnace (WGF), researches and tests the practical operation situation of three heating systems in the field. To compare technical and economic feasibility of three heating systems, the paper takes such residence where energy-saving standard of building palisade structure is approximately 50% as the research object, and establishes technical and economic mathematical analysis models, compares primary energy consumption and carbon dioxide emissions of three heating systems. This paper adopts annual cost approach, comprehensively takes into account power capacity increasing tariff and gas pipe network construction fee, and compares initial investment, operation cost and annual cost of three heating systems respectively from the perspective of users and government. The results show that LTASHP is the most energy-saving and its annual cost is lowest in the three heating systems. LTASHP is the most suitable alternative solutions to coal-fired heating in the three heating systems in rural Beijing.

Peer-review under responsibility of the scientific committee of the World Engineers Summit – Applied Energy Symposium & Forum: Low Carbon Cities & Urban Energy Joint Conference.

Keywords: clean energy; heating system; LTASHP; technical and economic analysis; annual cost approach;

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1876-6102
Peer-review under responsibility of the scientific committee of the World Engineers Summit – Applied Energy Symposium & Forum: Low Carbon Cities & Urban Energy Joint Conference.
10.1016/j.egypro.2017.12.661

1. Introduction

Beijing has established various kinds of policies and measures to clean air, and carried out the regulation of air pollution. The sources of PM2.5 mainly include automobile exhaust, coal-fired power plants, industrial coal boiler, town coal heating boilers, rural coal heating, rural biomass heating and industrial production process (BMBEP,2014). Rural coal consumption is about 4 million tons of standard coal every year, among them 92% coal is used for winter heating (Yongjie Zhang, Jianyun Jiang,et al. 2014). These papers (Ming Shan, Ming Yang,et al.2011, Ming Shan, Pengsu Wang,et al.2012) aimed at the problems which refer to the rapid growth of the rural residential coal consumption, low energy efficiency and serious pollution emissions, put forward the construction of "no coal village" development mode in north China. At present, clean energy heating systems transformation is under way in rural areas and urban-rural fringe of Beijing, the main measures are "coal to electricity", "coal to gas" and high quality coal substitution. It's remarkable to reduce pollution emissions through these measures, there is no local emission with LTASHP and TSH heating systems, also reduction ratio is 100% (Jianyun Jiang, Yongjie Zhang,et al.2014). Using high quality shape-coal, the pollution PM2.5 emission reduces about 55% (Jiandong Ye, Yongjie Zhang,et al.2016).

When scattered coal heating is transformed into clean energy heating system, users mainly consider initial investment, operating cost, indoor comfort, while government focuses on comprehensive annual cost including infrastructure investment. This paper introduces clean energy heating systems in Beijing rural areas, tests running effect on the spot. Assume that energy consumption is nearly equal between the rural residence and the building of envelop enclosure energy-saving standard close to 50%. The paper takes this building as the research object, adopts annual cost approach, compares the technical and economic feasibility of the clean energy heating systems.

2. Research and test in the field

In order to get a more accurate and effective data including initial investment and operation cost of clean energy heating systems, this paper has carried on the on-the-spot investigation aiming at LTASHP, TSH and WGF heating systems, as shown in Table 1.

2.1. General situation of research and test sites

(1) House A is located in Changping district, heating system is LTASHP, the end of heating system is radiator. The total electricity consumption of heating season is about 4282 kWh, and indoor temperature stays around 17~18℃.

(2) House B is located in Miyun district, heating system is unitary air source heat pump, the end of heating system is low temperature radiant floor. The house is single-family small high-rise residential building, where the energy-saving standard of building palisade structure is 65% The total electricity consumption of heating season is about 3052 kWh, and indoor temperature stays around 19~20℃.

(3) House C is located in Shijingshan district, heating system is three TSHs whose capacity are 3.2 kW、3.2 kW and 1.6 kW, respectively. The total electricity consumption of heating season is about 11667 kWh, and indoor temperature stays around 18~20℃.

(4) House D is located in Shijingshan district, heating system is three TSHs whose capacity are 3.2 kW、3.2 kW and 1.6 kW, respectively. The total electricity consumption of heating season is about 13333 kWh, and indoor temperature stays around 17~19℃.

(5)House E is located in Daxing district, heating system is WGF, the end of heating system is low temperature radiant floor. The total gas consumption of heating season is about 1391 m^3, and indoor temperature stays around 18~19℃.

(6)House F is located in Chaoyang district, heating system is WGF, the end of heating system is radiator. The total gas consumption of heating season is about 614 m^3, and indoor temperature stays around 18~20℃.

Table 1 Measured heating costs of different heating systems