Research on the Lhasa city heating engineering project*

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On the basis of the energy planning requirements of China's 13th five-year plan, the ecological environment, building characteristics, and other factors in Lhasa City are thoroughly investigated to identify its decentralized and centralized heating schemes. The performances of these two schemes are compared in terms of management, environmental protection, and energy efficiency. Project analysis results need to be considered in the implementation of energy-efficient buildings with heating, different time periods. Results show that the gas boiler-based household heating method (i.e., decentralized heating scheme) has a short construction period and is inexpensive but has low energy efficiency and produces heavy pollution. By contrast, the regional gas central heating boiler-room-based method (i.e., centralized heating scheme) requires long construction periods, is expensive, but provides high energy efficiency and low pollution. The regional centralized heating gas boiler room is preferable and is in line with the country's energy policy and actual local requirements.

Keywords: Centralized Heating; Decentralized Heating; Solar Energy; Environmental Protection; Energy Efficiency.

1. Introduction

Lhasa is the capital of Tibet, also is the biggest city with most densely populated in Tibet. Public buildings use oil-fired and electric boilers for their heating systems. Residential buildings use household electricity, wood burning, cow dung biogas, and other methods to produce heat. The problem should be solved quickly since it has high energy consumption, and poor comfort. The heating scheme implemented in Lhasa City has recently attracted considerable attention because it marks the beginning of the large-scale urban heating industry in Tibet. Early before 2007, the Tibet autonomous region and the government has attached great importance to Lhasa in Tibet and Lhasa city heating, and organized experts to conduct research on Lhasa City's heating scheme many

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times. But there was not any effective heating scheme come out because of the existing energy problem[1-2].

Heating energy, heating method and other important heating conditions of Lhasa were studied in this paper, and the schemes of Lhasa city heating is put forward, which has great significance for building energy conservation and improving urban heating level.

2. The local Construction Characteristics

2.1. *City layout, distribution, and characteristics*

Lhasa City's urban area measures 75km^2. The city's gross, residential, and public building areas measure approximately 13, 8.08, and 4.92 million m^2, respectively[3]. The city is divided into seven districts, namely, the Central District, North District, West District, Dongcheng District, Hundred-Lake District, Liu Wuxin District, and Donggar District (including Doilungdeqen County).

The Central District is mainly constructed on the basis of the original building plans; therefore, no space can be utilized for development[4-5]. The Xicheng District is adjacent to the Dongcheng District, and its buildings are mainly composed of two to four layers. Similar to the Qianmen Dashilan area in Beijing, the district is adorned with cultural relic companies and narrow streets. Infrastructural development aims to target culture, tourism, and positioning function matching. Urban construction is prioritized over displacement and reconstruction to continuously improve its service function.

However, the heating energy, heating method, and the city's functional division and industry structure should be considered carefully when developing Lhasa's heating scheme.

2.2. *Building structure and heating characteristics*

More than 90% of the buildings in Lhasa City are constructed without sufficient heating facilities. Hence, the Lhasa City heating project covers the construction of heat sources, pipe networks, and indoor terminals.

Lhasa has a large day and night temperature difference. Ultraviolet radiation is strong, and a large temperature difference between sunny and shadier rooms exists. Buildings in Lhasa City are basically constructed without energy-saving measures. Solar energy is easily absorbed in the south side of buildings because of the installation of large windows. However, most of the installed windows are single windows. Therefore, heat is wasted at night despite the large amount of solar energy accumulated during the day. The energy consumption of buildings is 70–120 w/m^2 according to the calculated heating design of companies.

Residential buildings usually require approximately 8–12 h of heating at night, and the basic indoor temperature is above 16 °C. Public buildings in Lhasa are open for 8h a day (i.e., 8 h of heating time). Hence, essential heating is not needed after work. This mode of operation is based on the actual situation in Lhasa City and the energy-saving principle developed in line with Lhasa's climatic characteristics.

3. The whole Urban research Strategy of Heating

3.1. *Urban heating scheme*

Two main schemes are considered to solve the heating problem of Lhasa City. Gas boiler-based household heating is the first scheme, where civil buildings use wall-mounted gas boilers, whereas public buildings simultaneously use small gas-fired boiler room heating, solar energy, electric heating, and ground-source heat pump as supplementary heating methods. The second scheme is a region-based method with a central heating gas boiler. In this scheme, thermal power plants and independent heating gas boiler rooms are mainly used, whereas solar, geothermal, and wall-mounted gas boiler heating are used as complementary methods.

3.1.1. Small public building gas boiler and residential boiler heating scheme

The following situations were considered for the first scheme:

(1) The Jokhang and Ramoche Temples and the surrounding city mainly used electrical heating supplemented by solar energy. The buildings along the streets are 2–3 stories high with walls made of brick-concrete and without heat insulation, whereas others are 1–2 stories high with walls made of tamped clay or stone. The area with single brick-concrete buildings covers approximately 2000–3000 m^2, whereas other local-style dwelling buildings are generally 200–400 m^2. Many roads and buildings do not meet the installation specifications of natural gas pipelines and wall-mounted gas boilers; therefore, electric heating is considered. The buildings contain excessive amounts of wood, and fire prevention equipment is lacking; in case of fire, the old city may be burned totally. Natural gas is not convenient for heating in the central region.

(2) Other residential constructions (i.e., civil constructions) use decentralized heating boilers. To meet the demands of using gas and heating supply simultaneously, the carrying capacity of gas pipelines should be increased. This scheme is inexpensive, requires light workload and short construction period, and no maintenance and operational problems are encountered.

(3) Supplemented by solar heating and ground-source heat pumps, small room-based gas boiler heating is mainly used in public buildings. The construction area of public buildings, which commonly include office, business, tourism, publishing, and transportation constructions, usually covers 1000–20000 m^2. Gas boilers need to be installed and operated by professional workers and managed by the company itself, as recommended by the local government.

The total solar radiation of Lhasa is abundant. Making full use of solar energy for heating does not only save energy and reduce environmental pollution, but also relieves the energy supply pressure in Lhasa. It conforms to China's energy policy. Therefore, solar heating should be fully considered when determining the heating scheme of Lhasa[6].

3.1.2. Central heating based on multi-energy heating solutions

The central heating scheme was preferred according to the overall planning and architectural characteristics of Lhasa City. The decentralized heating scheme was used as a complementary and comprehensive heating method.

Lhasa City has large buildings and densely populated high-rise residential areas. The streets are spacious, and the good thermal conditions have made laying pipelines easy. These conditions suggested the construction of a geothermal power plant in addition to the use of independent gas central heating boiler room supplemented by solar energy.

Lhasa City's center consists of densely populated skyscrapers. Hence, the excavation of cultural relics and installation of comprehensive heating pipes will be difficult. Several construction companies usually employ the central heating gas boiler room method or household-based heating.

Among the city's buildings, 67%, 8%, 10%, 4%, and 11% utilize gas boiler room heating, wall-mounted gas boiler heating, electric heating, heat pump with water source, and solar thermal storage with heat pump, respectively[7].

The following situations were considered in forming the second solution:

(1) The Jokhang and Ramoche Temples and the surrounding old city mainly used household electric heating supplemented by solar energy. This heating method also included the conditional construction of a hanging gas boiler.

(2) The central area of the Xicheng District, which is adjacent to the Dongcheng District, mainly uses household wall-mounted gas boilers constructed in different locations, central heating gas boiler plants supplemented by solar energy, water and source heat pumps, and auxiliary heating.

(3) The central areas of the Dongcheng District, Hundred-Lake District, and Liu Wuxin District mainly utilize the gas boiler room and solar thermal storage with heat pump through the central heating mode.

(4) The North District adjacent to the slopes takes advantage of its geographical characteristics (i.e., hillside). Two to four large-scale central solar heating plants are built and combined with heat storage technology to ensure the district heating.

3.2. *Scheme analysis and comparison*

Both schemes have advantages and disadvantages. The main difference comes from the centralized and decentralized heating using the two schemes[8].

In Scheme 1, household wall-mounted gas heating boiler is relatively easier. First, a single-gas pipeline instead of a heating pipeline needs to be installed. In this way, the road excavated is narrow; and construction, maintenance, and traffic impact is small. Second, gas pipeline installation can solve the problem of heating and gas supply at the same time. With enough constructors, heating engineering construction can be completed in one to two years. At this point, it is incomparable with the central heating scheme.

In Scheme 2, several aspect contents of construction are not considered in Scheme 1, such as gas boiler room and district heating network. The position of the boiler room should be determined first, and the course and routing of heating pipe network should be identified next. In addition, installing the gas pipeline in narrow villages and municipal roads is a serious challenge. Depending on the case, the construction of a gas boiler room would take about one year. The construction of heating pipe networks need to be determined on the basis of specific road conditions. Without initial heating base, 5 to 10 years would be needed to perfect the whole city's central heating construction.

4. Conclusion and Policy Implications

The following conclusions and suggestions are drawn from the study:

(1) The central heating scheme focuses on energy saving and environmental protection, whereas the decentralized heating scheme is more economical and is characterized with a short construction period and low construction investment. I think the second scheme reduces the degree of residents participate in the operation of heating and it is more conducive to local residents.

(2) Heating of city belongs to the municipal infrastructure project with large investment, low profits. It is suggested that the project is mainly invested by the government, and the residents take part in the investment.

(3) Solar energy is the best heating energy in Lhasa. Accordingly, all the references suggest that solar energy should be utilized for heating. Therefore, the implementation of a more effective method for using solar energy for heating should be considered.

(4) The technical project should take into account the social, cultural, and local economy development. The operation management, maintenance, and other technical aspects should be in accordance with local production level and could be appropriately advanced.

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