International Journal of Research in Engineering and Science (IJRES)
ISSN (Online): 2320-9364, ISSN (Print): 2320-9356
www.ijres.org Volume 11 Issue 5 ǁ May 2023 ǁ PP. 659-662

Selection and economic analysis of domestic hot water system of college dormitory

Hui ze
Construction Bureau, University of Shanghai for Science and Technology, Shanghai, China
Corresponding Author: Hui ze

Abstract
College dormitory domestic hot water energy consumption is very large, therefore, choose a reasonable hot water supply to conserve energy is necessary. Air source heat pump system is one of the most economical, environmentally friendly, safe and energy efficient devices at present. This paper introduces the characteristics and principles of air source heat pump system and compares it with traditional domestic hot water system for a renovation project of a student dormitory in University of Shanghai for Science and Technology. Research results show that compared with traditional domestic hot water system, air source heat pump hot water system is more energy efficient, better economical and high security which is worthy promoting.

Keywords: *Air source heat pump hot water system, College dormitory hot water system, Energy conservation and emission reduction*

Date of Submission: 13-05-2023 Date of acceptance: 25-05-2023

I. INTRODUCTION

In recent years, energy consumption continues to increase in the world. The energy consumption of buildings accounts for about 30% of the total energy consumption of the whole society in China, the hot water energy consumption of civil buildings accounts for about 20% and commercial buildings can even reach nearly 40% of the total energy consumption of buildings [1]. Therefore, it is urgent to find a scientific way to supply hot water to buildings to achieve the purpose of energy conservation. Air source heat pump is one of the most economical, environmentally friendly, safe and energy efficient devices which convert low grade heat energy in the air into high grade heat energy by consuming electric energy. Usually, every 1kW of electric energy consumed can produce 4kW of heat, significantly reducing the energy consumption of hot water preparation. In addition, compared with traditional coal or gas fired boilers, the whole process of air source heat pump hot water system has no air pollution, low carbon emission, high security and environmentally friendly which has a broad application prospect [2-5].

Based on a renovation project of a student dormitory building in University of Shanghai for Science and Technology, this paper introduces the characteristics and principles of air source heat pump system, and makes a comparative analysis between air source heat pump domestic hot water system and traditional domestic hot water system in order to provides reliable case experience and ideas for the domestic hot water system renovation of other building projects in colleges and universities, contributes to the subsequent mature development and promotion of air source heat pump hot water system.

II. PRINCIPLE OF AIR SOURCE HEAT PUMP SYSTEM

Air source heat pump contains compressor, condenser, expansion valve and evaporator, as shown in Figure 1. The working medium flows and circulates continuously in the four components, obtains heat from the air through the evaporator, and heats the external water by releasing heat through the condenser. The overall working process keeps circulating until the low temperature water is heated to the set temperature [6].

There are two forms of air source heat pump hot water system, hot water produced immediately (type1) and hot water storage after produced(type2). In the process of type1 which uses the condenser shell as a water storage container directly, low temperature water will be heated in the condenser shell, when the water temperature rises to the set temperature, hot water will flow out and low temperature water will be automatically supplemented from the water inlet. Type1 is mainly suitable for household small water heater. Type2 set up a separate water storage tank, low temperature water flows into the condenser from the water storage tank, heated by the condenser and then flows back to the water storage tank, continuous circulation, to achieve the purpose of heating water. Type2 is mainly suitable for the central hot water supply of industrial or large buildings [3]. The

building in this paper is a dormitory building for college students, adopts type2 air source heat pump hot water system.

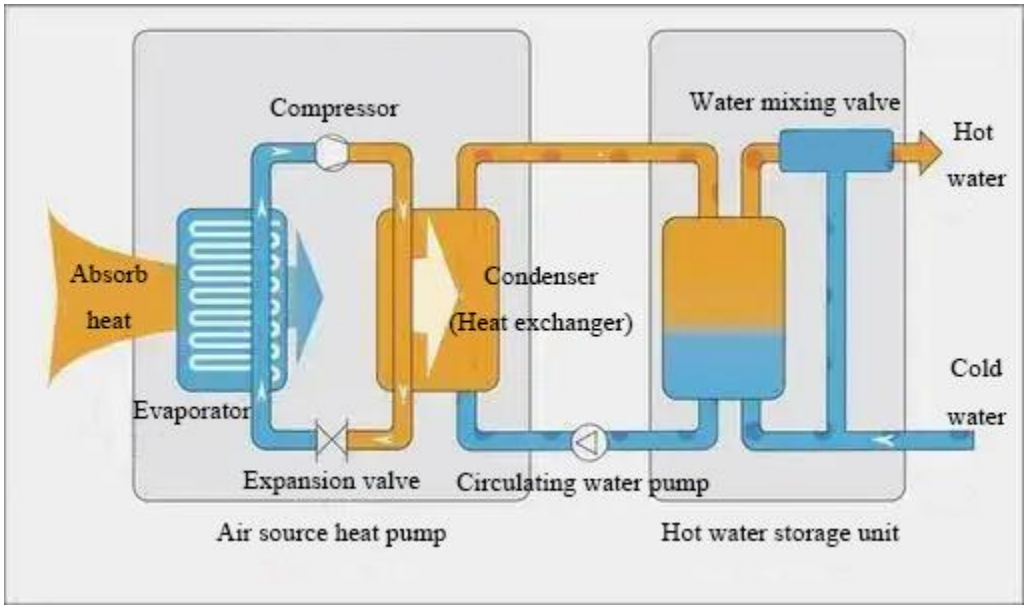

Figure 1: Principle of air source heat pump hot water system

Compared with traditional hot water system, air source heat pump hot water system has great advantages in environmental protection, energy conservation, safety, reliability and so on. In terms of energy conservation, energy efficiency ratio of air source heat pump hot water system is always greater than 1, and can also reach 3~4 under general conditions（Higher energy efficiency ratio, lower energy consumption）. In terms of environmental protection, the air source heat pump hot water system has no direct emissions and no environmental pollution（Lower carbon emissions, more environmentally friendly）. In terms of safety, water and electricity are separated in air source heat pump hot water system which is no leakage and other safety hazards, and because there's no fuel burning happening, is high security. In terms of reliability, air source heat pump hot water system does not need traditional fuel and is not restricted by fuel supply. Except for extreme weather, it is less affected by weather and can realize continuous and safe operation 24 hours a day all year round [7].

III. SELECTION AND ANALYSIS OF HOT WATER SYSTEM OF STUDENT DORMITORY

3.1 Heat supply calculation

The building in this paper has 6 floors which 400 students live in, adopts a centralized hot water supply system. According to relevant literature [8], the water quota for each person is 50 liters per day in dormitory building, the average daily water consumption of hot water in the building is 20m³. Combined with the actual situation of the school, hot water supply system runs for 24h.

$$Q = \rho V c(t_{out} - t_{in})$$

Q-Heat consumption of produce hot water, kJ
ρ-Density of water, $1000kg/m^3$
V-Volume of water, m^3
c-Specific heat capacity of water, $4.19kJ/(kg \cdot ℃)$
t_{in}, t_{out}-System inlet and outlet water temperature, ℃

Assuming that water heated to the set temperature needs rise 50℃, through the above calculation formula, a conclusion can be drawn that hot water supply system needs to provide 4190000KJ heat per day in this building.

3.2 Design and selection of air source heat pump hot water system

Air source heat pump hot water system is composed of the following parts after design: air source heat pump(4sets), 10T water tank(2sets), air source heat pump circulating pump(6sets), hot water variable frequency pressure pump（4sets）. The specific parameters of each part are shown in Table 1.

Table 1: Design and selection of air source heat pump hot water system.

Name	quantity
Air source heat pump(RHPC-19WS, input power 4.6KW, heat production 19.3KW)	4sets
10T water tank	2sets
Air source heat pump circulating pump(Q=4m³ /h, H=15m, N=0.37Kw)	6sets(four for regular run and two for spare)
Hot water variable frequency pressure pump(Q=15m³ /h, H=35m, N=5.5Kw)	4sets(two for regular run and two for spare)

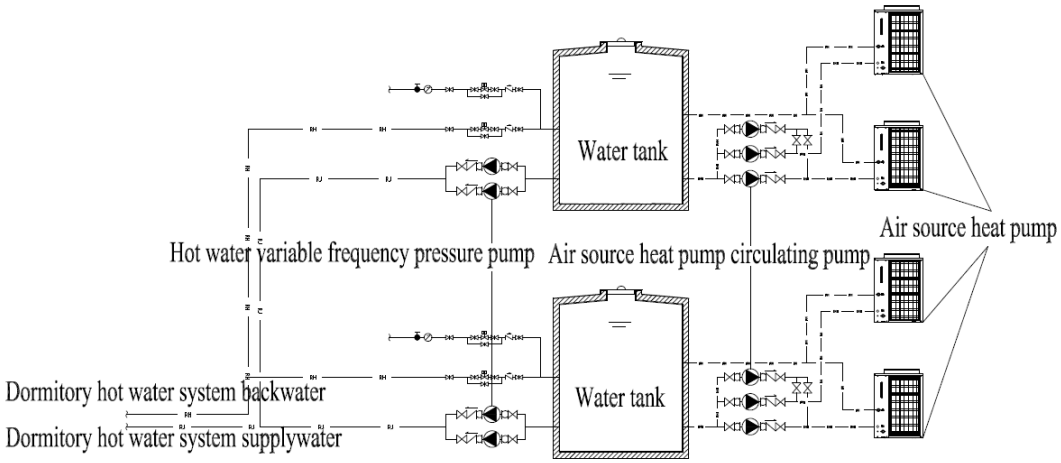

Figure 2: Design and selection of air source heat pump hot water system

3.3 Analysis of energy conservation and economy

Different domestic hot water systems are investigated, analyzed and calculated, the results are shown in Table 2. It can be seen that the air source heat pump hot water system has a great economic advantage and is also significantly ahead in environmental protection and safety factors. Therefore, comprehensive comparison factors, air source heat pump hot water system has a strong leading position in the dormitory and other centralized hot water supply conditions which can achieve the purpose of energy conservation, consumption reduction, security and reliability.

Table 2: Comparative analysis of different forms of hot water systems.

Water heater form	gas boiler	oil boiler	electric boiler	air source heat pump
Type of energy consumed	natural gas	diesel	electricity	electricity
Energy calorific value/(kcal/*)	8651	10996	860	860
Hot water heat /kcal	1000991	1000991	1000991	1000991
Heat conversion efficiency /%	85	85	90	420
Energy consumption /*	136.13	107.1	1293.27	277.13
Energy unit price/RMB	3.05	7.07	0.65	0.65
Cost Expense/RMB	415.2	757.2	840.63	180.13
Whether there are security risks	yes	yes	no	no
Environmental pollution	small	serious	none	none
Use condition restriction	pipeline	Environmental protection	none	Ambient temperature ⩾-30℃

IV. CONCLUSION

Based on a renovation project of a student dormitory building in University of Shanghai for Science and Technology, this paper introduces and selects air source heat pump hot water system, and compared it with several traditional hot water systems. The results show that compared with gas boiler and oil boiler, air source heat pump hot water system has no environmental pollution and safety risks, and in the case of produce same volume of hot water, the cost can be conserved by 76.2% at most, compared with electric boiler, cost can be conserved 78.6%, air source heat pump system can achieve the purpose of energy conservation, consumption reduction, security and reliability which has a long term development prospect in the hot water centralized supply project. At the same time, due to its convenient installation and simple construction, it is especially suitable for the renovation of old buildings. This paper provides reliable case experience and ideas for the renovation of domestic hot water systems of other building projects in colleges and universities, and makes contributions to the subsequent mature development and promotion of air source heat pump hot water system.

REFERENCES

[1]. Jiang Y, Xue Z F. Energy efficiency technology and market analysis of commercial buildings [J]. China Energy, 2000 (4): 35-37.
[2]. Wen X Q, Zheng W H. Research status and prospect of air source heat pump hot water system [J]. Energy Saving, 2018,37 (12): 117-121.
[3]. Yang L M. Research status and prospect of air source heat pump hot water system [J]. Ju She, 2019 (24): 196.
[4]. Wang Y Q, Zhang W Y. Energy conservation operation and maintenance of air source heat pump [J]. Green Building,2022,14(06):40-42.
[5]. Zhang Z G, Liu Y, Yao W X. Analysis of energy efficiency of air source heat pump water heaters in cold regions in winter [J]. Journal of Solar Energy,2023,44(01):543-550. DOI:10.19912/ J.0254-0096.tynxB.2021-0981.
[6]. Yu L W. Principle and application of air source heat pump [J]. Value Engineering, 2018,37 (32):
[7]. Wang Y H, Geng J, Ma S B, Mi L, Zhang X, Ren Y, Yang H Y. LI Y. Selection and economic analysis of domestic hot water system in Tsinghua University [J]. Science & Technology Innovation and Application,2022,12(22):108-113. DOI:10.19981/j.CN23-1581/G3.2022.22.027.
[8]. GB 50015-2003, Code for design of water supply and drainage for buildings (2009 edition) [S]. Beijing: China Planning Press, 2010.