The Construction of Air Energy Hot Water System in Colleges and Universities Students' Dormitories

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Abstract. Hot water entering students' dormitories is the development direction of school hot water system, and air energy hot water system is one of the main forms of heat supply in colleges and universities hot water system. This paper first describes the composition of air energy hot water system and BOT construction mode, then analyses the main equipment selection and operation mode of the system, and finally shows the construction effect diagram of the system. The results show that it is necessary and feasible to construct the air energy hot water system in colleges and universities students' dormitories, which is worth popularizing.

1. Introduction

In recent years, due to the problems of the traditional public bathrooms in colleges and universities, such as fixed opening hours, crowded personnel, poor sanitary conditions, and poor privacy, the students' dormitory urgently needs to build an independent shower room. Students generally hope that hot water can be easily used in the dormitory to shower, wash their faces, wash their feet, etc. hot water entering students' dormitories is the development direction of school hot water system.

At present, air energy hot water system is one of the main forms of heating in the hot water system of colleges and universities. Air energy water heater is the fourth generation of water heater (the first three generations are electric water heater, gas water heater and solar water heater respectively). It can obtain heat about 4 degrees of electricity generated by 1 degree of electricity, so it is a new product with high efficiency, energy saving and environmental protection.

2. Composition of air energy hot water system

Air energy hot water system is mainly composed of air energy heat pump unit, heat preservation water tank, hot water circulating pump, hot water supply pump, pipeline, water flowmeter, valve and other parts, as shown in Figure 1. Air energy heat pump unit is mainly composed of compressor, heat exchanger, expansion valve, evaporator and other parts.
Figure 1. Composition of hot water system

According to the principle of inverse Carnot cycle, the air energy heat pump unit inputs a small amount of electric energy as the driving force, takes the refrigerant as the working medium, continuously absorbs the low-grade heat energy in the external air through the evaporator, transforms from the compressor to the high-grade heat energy, and then releases the high-grade heat energy from the heat exchanger to the cold water entering the heat exchanger. The cold water is heated to about 60°C and stored directly in the heat preservation water tank, and then transported to the student dormitory through the hot water supply pipeline (hot water supply pump, pipeline, water flowmeter, valve) for the use of students.

3. Construction mode of hot water system

At present, according to the different ways of investment, air energy hot water system in colleges and universities students' dormitories can be divided into two modes: self-investment and BOT investment. Due to the problems of investment and management, most colleges and universities adopt BOT investment mode to construct the hot water system (market operation).

3.1. BOT investment mode

The whole air energy hot water project is invested, constructed, managed and operated by a professional energy-saving company. As the investment and profit return of the contractor, the energy-saving company collects the hot water fee from the user for a certain period of time. After the expiration of the fee period, both parties negotiate the follow-up service matters. The school does not need to pay any cost to install the air energy hot water system. Instead, it pays the hot water system provider with the amount of hot water used in daily life. It is a new model that uses more, pays more, and uses less, pays less. This "zero cost campus hot water supply mode" has entered many colleges and universities, solving the problem of campus bathing caused by insufficient funds.

3.2. Hot water charge price

Hot water is charged at the rate of 0.055 yuan/L (each student dormitory is equipped with an IC card Water Flowmeter, and most schools charge by flow, which is fair to students). It can be managed by the energy-saving company by issuing IC card alone, or by using the campus one-card.

3.3. Cooperation time

The contract period of the project is 15 years, in which the first stage is 8 years for enterprise investment recovery, the second stage is 7 years for enterprise profit, and the third stage is 10 years for school profit (the service life of air energy hot water system is 25 years). 15 years later, the property right of air energy hot water system equipment belongs to the school, which enables the school to obtain greater benefits.

4. Main equipment selection of hot water system
Taking a student dormitory building as an example, we choose the main equipment of the hot water system reasonably.

4.1. Calculation of hot water consumption and selection of heat preservation water tank
There are 600 students in the dormitory building. The quota of hot water is 40 liters per person per day. The daily hot water consumption in the dormitory building is:

\[ M = 600 \times 40 = 24000 \text{ (L)} \]  \hspace{1cm} (1)

According to the calculation data, a stainless steel heat preservation water tank with 24000L (24m³) volume is configured.

4.2. Calculation of heat consumption of hot water
According to the coldest working condition in winter, the temperature of tap-water is 10 °C. If the temperature of 24000 liters of water is to rise to 55 °C, the required heat is:

\[ Q = C \times M \times \Delta T \div 860 = 1 \times 24000 \times (55 - 10) \div 860 \approx 1255.8 \text{ (KW)} \]  \hspace{1cm} (2)

C--- Specific heat capacity of water (1Kcal/kg·°C)
M--- Quality of water (kg)
\( \Delta T \)--- Value of temperature rise (°C)

4.3. Selection of air source heat pump unit
The hot water heat load is 1255.8 KW, and the model of NERS-G12B air energy heat pump unit is selected as the heat source of the system. Under the standard working condition, the rated heat capacity of the unit is 44.7 KW, and under the winter ambient temperature of 8 °C, the heat capacity of the unit is about 36.6 KW. If the heating time is calculated as 18 hours / day, the number of units required is:

\[ N = 1255.8 \div 18 \div 36.6 = 1.9 \approx 2 \]  \hspace{1cm} (3)

4.4. Selection of other equipment
According to the installation position of air energy heat pump unit and heat preservation water tank, combined with the floor height of student dormitory, other equipment is selected as follows:

① hot water circulating pump: 2 sets, flow 20m³/h, lift 15m, power 1.5 KW
② hot water supply pump: 2 sets, flow 20m³/h, lift 25m, power 3 KW
③ water flowmeter: 150, solenoid valve, LCD, billing by flow, Bluetooth + NB dual channel data transmission, waterproof level IP68
④ hot water pipe, cold water pipe, cable, shower nozzle, etc.

5. Operation mode of hot water system
Through the operation of the control panel of the air energy heat pump unit, the water temperature of the heat preservation water tank can be set directly. When the temperature in the water tank is lower than the specified temperature, the unit automatically starts to heat it; when the temperature reaches the specified temperature, the unit automatically stops heating, and the hot water in the water tank is in the heat preservation state, ready for standby, so as to provide constant temperature hot water for 24 hours.

When the air energy heat pump unit has problems such as machine fault, maintenance, abnormal startup caused by extremely low ambient temperature, the auxiliary electric heating switch can be opened manually and put into use in an emergency to ensure the use of hot water in schools.

6. Construction effect of hot water system
The construction effect of hot water system is shown in Figure 2-7.

**Figure 2.** Air energy heat pump unit  
**Figure 3.** Hot water supply pump  
**Figure 4.** Heat preservation water tank  
**Figure 5.** Water supply pipeline  
**Figure 6.** Hot water pipeline installation  
**Figure 7.** Water flowmeter

7. **Conclusion**  
Hot water into students' dormitories avoids all kinds of problems in school public bathrooms, which is the development direction of school hot water system. Air hot water system is one of the main forms of
heat supply in University hot water system at present. This paper describes the composition of air energy hot water system and BOT construction mode, analyses the main equipment selection and operation mode of the system, and shows the construction effect diagram of the system. The results show that the construction of air energy hot water system in colleges and universities students' dormitories is the general trend, with strong operability and low construction difficulty, which is worth promoting.

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