ECONOMIC ANALYSIS OF WATER SOURCE HEAT PUMP SYSTEM

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ABSTRACT

On the base of analyzing operation of the air conditioner system with water source heat pump, the effect of energy saving in the system is illustrated in the paper.

Keyword: water source heat pump, operating cost, economic analysis, energy saving

1. INTRODUCTION

Water source heat pump system is a kind of optimized centralized air-conditioner. It has characteristics of energy saving and environmental conservation. Water source heat pump system has been applied widely at present. Water source heat pump makes use of shallow geothermal renewable energy, such as ground water, geothermal water, soil, and even surface water and industrial waste water. It is one of efficient air-conditioning technique for refrigerating and heating.

The operation of water source heat pump is analyzed in the paper for its effect of energy saving.

2. PROJECT SUMMARY

Buildings of the project are located in Changping district of Beijing, which consist of multiple–use building, office building and accessorial building. To solve the requirement of total 10000m^2 area heating in winter and refrigerating in summer, the air conditioner system of water source heat pump was installed in November, 2003. The system has been operating through 2 heating and 2 refrigerate seasons.

2.1 System Configuration

The system is designed with total refrigerating power 490 kW and total heating power 399 kW. The water source heat pump unit with double-screw compressor (LWP1800) made in France by CIAT is equipped in this air-conditioning system .The rated refrigerating power of the water source heat pump unit is 559kW, and electricity supply is 110kW. The rated heating power of the unit is 726kW, and electricity supply is 170kW. The system also has been equipped with two circulating pumps with electricity supply 18.5kW /per unit.

2.2 Heat Source Well

Two designed wells were drilled, one for production and the one for reinjection. The well No.1 has a yield of 1,440m^3/d, and the well No.2 has a yield of 1,144m^3/d. Two pumps were installed in the two wells respectively. The power of pump is 30kW each.

2.3 Room Terminal System Design

To achieve the air temperature needed in every room, air terminal system in room was designed with fan-coil system.

3. CONTRAST OF INITIAL INVESTMENT

According to actual conditions, contrast of initial investment between water source heat pump and other heating/cooling systems is listed in the Table1.

It can be seen from the table that the initial investment of the system with water source heat pump is only a little higher than other air-conditioning systems without considering other costs, and the cost difference is very small.

Table 1 Initial investment comparison with common air-conditioning systems

Unit: 1,000 *Yuan*

Electrothermal boiler + Electro-cool air conditioner		Oil boiler + Electro-cool air conditioner		Gas boiler + Direct-fired air conditioner		Ground-source heat pump system	
Electrothermal boiler	152	Oil boiler	200	Gas boiler	200		
Boiler house	20	Boiler house	20				
Accessorial equipment	288	Accessorial equipment	285	Gas boiler	270		
Refrigerating Station	20	Refrigerating Station	20	Refrigerating Station	80	Refrigerating Station	80
Center air-conditioner	850	Center air-conditioner	850	Center air-conditioner	1,280	Main unit of air conditioner	900
Accessorial equipment	270	Accessorial equipment	270	Accessorial equipment	60	Accessorial equipment	330
Terminal installation	850	Terminal installation	850	Terminal installation	850	Terminal installation	850
						well	380
Total investment	2,450	Total investment	2,495	Total investment	2,740	Total investment	2,540

4. OPERATING COST OF WATER SOURCE HEAT PUMP AIR-CONDITIONING SYSTEM

4.1 Theoretical Operating Cost

4.1.1 Theoretical Operating Cost in Summer

Air conditioner operates 3 months in summer, working 12 hours every day, and the coefficient of operation in different time is 0.8.

Main unit of air conditioner and deep well pumps operation:
(110+30)kW×10（h/ day）×30 days×3 months×0.8 =120,960 kWh

Circulating pump operation:
18.5kW×10（h/day）×30days×3 months =39,960 kWh

Total operating power in summer is 161 MWh. The designed cooling area is 10,000m^2. So it is 16.1 kWh/ m^2·season, or 0.18 kWh/m^2·day.

4.1.2 Theoretical Operating Cost in Winter

The heating period in winter is 4 months, working 24h every day, and the coefficient of operation in different time is 0.6.

Main unit of air conditioner and deep well pumps operation:
(140+30)kW×24h/day×30 days×4 months×0.6 = 293,760kWh

Circulating pump operation:
18.5kW×24h/day×30days×4 months=53,280 kWh

Total operation power in winter is 347 MWh. It is 34.7 kWh/m^2·season, or 0.29 kWh/m^2·day.

4.1.3 Theoretical Operating Cost in a Year (Electricity Fee is 0.6 *Yuan*/kWh)

Operating period	Power	Operating cost
Summer	161 MWh	9.66×10^4 Yuan
Winter	347 MWh	20.82×10^4 Yuan
Total	508 MWh	30.48×10^4 Yuan
Average	508 MWh/m^2·Year	30.48 yuan/m^2·Year

4.1.4 Theoretical Operating Cost of WSHP and Other Air-Conditioning Systems

Form above theoretical analysis it can be concluded that ground source heat pump system and electro-thermal boiler + refrigerating system have the same initial investment, but the former has lower annual operating cost about 90,000-190,000 Yuan less than the others.

Table 2 Comparison of operating cost between WSHP and common air-conditioning systems

(Unit: 10^3 *yuan*)

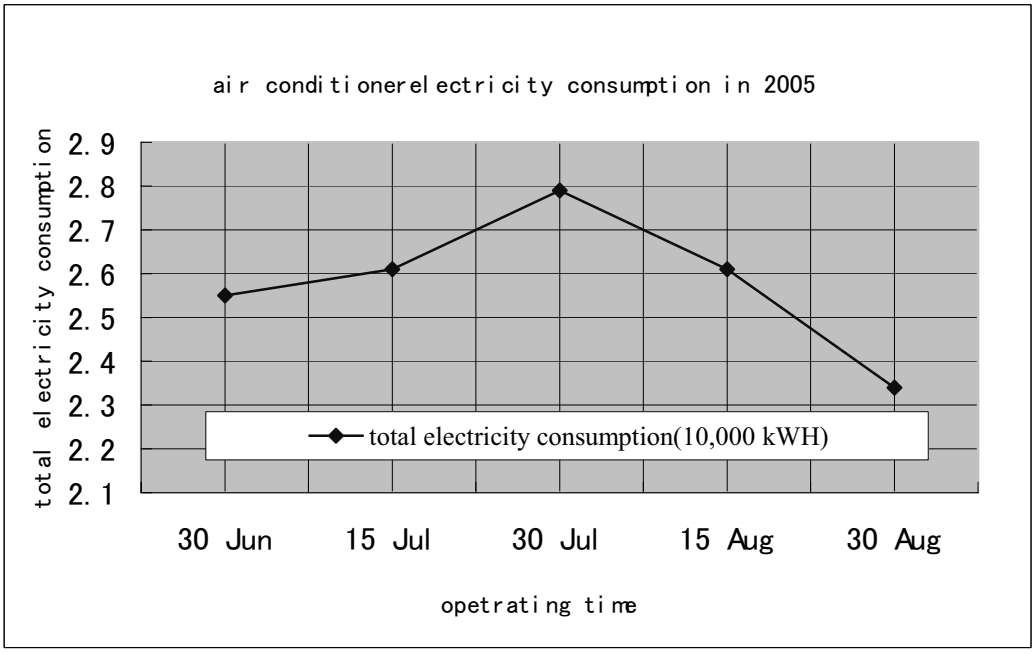
project / item	Electrothermal boiler + Electro-cool air conditioner		Oil boiler+ Electro-cool air conditioner		Gas boiler+ Direct-fired air conditioner		Ground-source heat pump system	
summer100d	electricity fee	163	electricity fee	163	electricity fee	5.5	electricity fee	96.6
					Gas fee	190		
	cost of labor	4	cost of labor	4	cost of labor	4	cost of labor	4
Winter 120d	electricity fee	233	diesel oil	315	electricity fee	4.3	electricity fee	208.2
			electricity fee	4.3	Gas fee	193		
	cost of labor	4.8	cost of labor	4.8	cost of labor	4.8	cost of labor	4.8
Maintenance cost	8.8		16.5		14.3		8.8	
depreciation	156.7		163.7		176		157.3	
Operating cost per year	570.3		671.3		591.9		479.7	

（electricity fee as 0.6*Yuan*/kWh, oil cost:4.0 *Yuan* /L , gas cost:1.9 *Yuan* /m^3, labor cost:20 *Yuan* /person·day）

4.2 Actual Operating Cost in Summer

Water-source heat pump system has normally worked for multiple–use building in cooling season in 2005, so only the operating data in summer in 2005 are analyzed in the paper.

The water source heat pump system worked for multiple–use building (5,000m^2), office building (2,630m^2) and a hall (900m^2) in this cooling season. The total cooling area is 8,530m^2. This water source heat pump system operated full day (24hours) from 15 June to 30 August for total up to 77 days. The electricity consumption is 128.4 MW/h. So it is 15.06kWh/m^2 or 0.20 kWh /m^2·day.



The actual operating cost is 0.20 kWh /m^2·day, which is quite similar with theoretical data 0.18 kWh /m^2·day. The actual cost is a little higher than theoretical analyzing cost, because heat pump works 24h per day and the actual work period is more than designed date. So, on the base of economic analysis, the energy conservation effect of water source heat pump system is obvious. Because the system has characteristics of energy saving and environmental protection, there is a promising future for the market of ground source heat pump system in China.

5. CONCLUSIONS

It is concluded that water source heat pump air conditioning system has the following advantages:

1) When water source heat pump system works in summer, underground temperature is lower than ambient temperature, condensing temperature also is low. So refrigerating coefficient rises and it is higher than that of common air-conditioners.
2) For the same cool and heat load, water source heat pump system consume less energy than common air-conditioner systems. In this project, the water source heat pump system reduces operating cost by 11%.
3) Water source heat pump system does not burn fuel. Its operation is convenient. Moreover, the system could improve local environment and promote environmental protection.