Discussion of an Optimization Scheme for the Ground Source Heat Pump System of HVAC

Wei Mu Suilin Wang Shuyuan Pan Yongzheng Shi
Master Student Professor Lecturer Lecture
Key Laboratory of Heating, Gas Supply, Ventilating & Conditioning Engineering
Beijing Institute of Civil Engineering and Architecture, 100044
Beijing & China
E-mail: m_wei111@sohu.com

Abstract: With the implementation of the global sustainable development strategy, people pay more attention to renewable energy resources such as ground source heat pumps. The technology of ground source heat pump is widely applied to heat and cold. It is critical and important to know how to choose the terminal and make it workable.

This paper makes a technical and economic comparison of various heating terminals (with the example of a north residential district which adopts ground source heat pump as the cold and heat source) and gets the optimum scheme.

Key words: ground source heat pump, the optimum sheme, technical, economic

1. INTRODUCTION

With the implementation of the global sustainable development strategy, The technology of ground source heat pump is widely applied to heating and colding.[1]The ground source heat pump were divided into three kinds base on the different source of geothermal energy;the underground water source heat pump system,the soil source heat pump system and the surficial water source heat pump system. It is a key and important technology that how to select the terminal to match ground source heat pump system and make it to meet the demand of colding and heating economically. The article takes a high-rise residential district as a object which adopt ground water source heat pump system as heat and cold source to supply heat and cold to buildings through network and terminal. This paper makes technical and economic comparisons of different terminals and gets the optimum scheme.

2. GENERALIZATION OF ENGINEERING AND SCHEME

This project is a high-rise residential district in Beijing,which is 18-storey high. The area of one building is 18879 ㎡,this zone include five buildings,the total area is 94396 ㎡.The outdoor design dry-temperature calculated for air conditioning is -12℃ in winter .The outdoor heating design temperature calculated is -9℃ in winter. The outdoor dry-temperature calculated is 33.2℃ and outdoor wet-bulb temperature calculated is 26.4℃ in summer. The heating thermal loads is 28w/m^2,the air-conditioning thermal loads is 31w/ ㎡,the air-conditioning colding loads is 60w/m^2.The total loads will incease 20% due to the loss in pipe and the efficiency of pump unit. This residential district adopt ground heat souce as cold and heat source to supply heat and cool through network.This residential district select four HVAC terminal schemes as sample and make a comparison.

Scheme one: The low temperature water hot water floor radiant heating provide both heat and cold. This scheme has some features such as energy saving, relatively high thermal stability. The thermal comfort is relatively better than other schemes in winter, but is not in summer and condenses easily.

Scheme two: The system chooses Fan-coil units as terminal which provides heat and cold. It can meet both the demand of cold load and heat load. Thermal comfort is worse than scheme one.Forthermore, the fan-coil will consume electric power.

Scheme three: Fan-coil units provide cold in summer and the low temperature water hot water floor radiant heating provide heat in winter.The two terminals share the same pipe system.The thermal comfort of the scheme is same as scheme one and two,but it need two terminal system,therefore its early investment is higher and it consume electric power too.

Scheme four:The common electric Air condition provide cold and low temperature water hot water floor radiant heating provide heat,the thermal comfort is similar to scheme three.But,the system can not utilize heat pump system in summer.

3. THE EARLY INVESTMENT OF PROJECT

The early investment mainly include the investment of well construction and heat/cold source,the investment of outdoor pipe system, and the investment of hvac system for buildings.

3.1 The early investment of well construction and heat and cold source

The main issue of early investment include heat pump units, circulating water pump, electronic water processor, deep-well pump and filter.The total investment is about 7.48 million yuan,79yuan/m^2.

The early investment of well construction is related with quantity of underground water and quantity of diffrent pipe. The temperature of underground water is 18℃ in Beijing,the temperature difference is 7℃ between pump water and recharge water.[4]The water flow is mainly dominated by heat load.When we choose scheme one and two, the water flow is 400t/h and need four wells, two is draw well, others is irrigation wells. When we choose scheme four, the water flow is 200t/h and need two wells, one is draw well, and another is irrigation well. The well depth is 140m.It need steel pipe stainless steel filter and electro-processor to prevent well from blocking and corroding. The price is about 800 Yuan/m.

3.2 The early investment of outdoor network

The residential district include five buildings and the total area is 94396 ㎡.The outdoor network include two main pipe network. The system adopt double pipe system, the system share the same pipe in winter and in summer. The early investment of network is 46 Yuan/㎡.The total is 4.34 million Yuan.

3.3 The investment of hv&ac system for buildings.

The investment of hv&ac system for buildings include pipe and terminal.[2]The pipe system in pipe well adopt upside feed and underside return flow vertical double riser pipe system.The resident adopt household heat-metering.The house install thermal meter and thermovalve.The totall investiment of these equipment is 1.152 million yuan. The main differente investment of different scheme is due to the investment of terminal.

Scheme one:If the system adopt low temperature water hot water floor radiant heating, the investment of terminal mainly include three issue: heating pipe, structural layer and construction cost.Structural layer: Heat insulating layer is polystyrene plate which is 20mm thick,mortal layer is 40 mm thick., ground layer is 20mm thick.The total investment of structural layer is 30 yuan/㎡.The construction cost is about 12 yuan/㎡.There are mainly four kinds of heating pipe used in project:PE-X,PB,PP-R,PE-RT.Therefore,the investment of low temperature water hot water floor radiant heating are fluctuating greatly due to different pipe.The difference is shown as Tab.1.

Scheme two:The system choose fan-coil unit as terminal.The investment of domestic fan-coil is about 3.9 million yuan and the import is about 5.65 million yuan.

Tab.1 The investment of floor heating

Item	Heating pipe	Constructing layer cost	Constructing cost	Average cost	Total cost
	yuan/㎡	yuan/㎡	yuan/㎡	yuan/㎡	Million yuan
PE-X	10-29	25	10	45－64	4.24－6.04
PB	35-45			70－80	6.60－7.55
PP-R	9-21			44－56	4.15－5.28
PE-RT	9-18			44－53	4.15－5.00
XPAP	12-27			47－62	4.43－5.85

Scheme three:The terminal equipment include fan-coil units and low temperature water hot water floor radiant heating system.Fan-coil units spent same money as scheme two.The investment of floor heating is similar to scheme one.

Scheme four:The floor heating need same investment as scheme one. The investment of common electric Air condition is about 5.76 million yuan.

The investment of different scheme is shown as Tab.2.

4. THE ENERGY CONSUMPTION AND RUNNING COST

The energy consumption and running cost of the system mainly include electrical charge and reparation & maintenance cost. There was no obvious difference in reparation & maintenance cost between the four schemes. Electrical Fee is 0.48 yuan/kwh in Beijing. The rough estimate of running cost is shown as Tab. 3.

5. CONCLUSION

(1) The early investment of floor heating is fluctuating from 174 yuan/m^2 to 210 yuan/m^2 relate to different pipe.The investment of fan-coil unit is about from 171 yuan/m^2 to 189 yuan/m^2.The investment of association scheme that be consisted of fan-coil unit and floor heating is 35% lower than the scheme of fan-coil unt system and is 10% higher than the scheme of floor heating and common electric Air condition system.

(2) The running cost of floor heating is the lowest. The running cost of the association scheme that be consisted of fan-coil unit and floor heating is lower. The running cost of the association scheme that be consisted of floor heating and common electric Air condition system is the highest compared with other schemes.

(3)The low temperature water hot water floor radiant heating system has the following advantages: lower investment, energy saving and better thermal comfort in winter.[3]However, the thermal comfort is relatively lower when the system supply cold;The fan-coil unit can supply both heat and cold.The thermal comfort in winter is relatively lower and the running cost is higher compared with floor heating system.Therefore,the scheme of hv&ac shoud be decided according to actual situation of local project

Tab.2 The early investment of project

	terminal equipments			Well construction&heat source		Outdoor netwok		Total	Average
		million yuan	yuan/㎡	million yuan	yuan/㎡	million yuan	yuan/㎡	million yuan	yuan/㎡
1	Floor heating	415-755	44-80	793	84	434	46	1642－1982	174－210
2	Fan-coil unit（import）	565	59	793	84			1617－1792	171－189
	Fan-coil unit（homemade）	390	41						
3	Floor heating	415-755	44-80	793	84			2032－2547	215－269
	Fan-coil unit（import）	565	59						
	Fan-coil unit（homemade）	390	41						
4	Floor heating	415-755	44-80	483	51			1908－2248	202－238
	Common electric Air condition	576	61						

Tab.3 The running cost of project

	Facilities		Total fee	Average fee	Total average fee
			thousand Yuan	Yuan/㎡	Yuan/㎡
1	Heat pump unit		121.8	12.8	13.9
	Water pump		10.5	1.1	
2	Heat pump unit		121.8	12.8	15.5-15.7
	Water pump		13.3	1.3	
	Fan-coil unit	import	14.9	1.4	
		homemade	16.7	1.6	
3	Heat pump unit		121.8	12.8	14.9-15.0
	Water pump		14.4	1.4	
	Fan-coil	import	6.4	0.7	

	unit	homemade	7.2	0.8	
4	Heat pump unit		25.2	2.6	18.8
	Water pump		2.1	0.2	
	electric Air condition		151.2	16.0	

ACKNOWLEDGEMENT

The work of this paper is supported by Funding Project for Academic Human Resources Development in Institutions of Higher Learning under the Jurisdiction of Beijing Municipality (BJE10016200511).

REFERENCES

[1]Rongguang Wang,Yufeng Zhang,Yang,Xiaotong Zheng. Study on Direct Use Of Geothermal Energy For Heating And Its Energy Efficency Effects [J]. ACTA ENERGIAE SOLARIS SINICA, 2002, 23(4):455-458.(In Chinese)

[2]Yanfeng Li,Yingxia Yang,Hui Gao,Bin Zhu,Gaowan Zou. Comparison and Economic and technical Analysis of Some Heating Scheme in China [J]BuildingEnergy&Environment, 2004, 23(4):84-89.(In Chinese)

[3]Xia Tian. The Study on the Floor Construction and Thermal Process of Low-Temperature Hot Water Floor Radiant Heating System[D]. Beijing: Beijing Institute of Technology, 2005.(In Chinese)

[4]Suilin Wang,Junfeng Zhang,Quanying Yan,Xiumin Zhao.Analysis on Distributed Deep Well Water Heat Pump With Central Heat Exchangers.7th Internal Energy Agency Conference on Heat Pumping Technologies [C].Beijing:CHINA ARCHITECTURE&BUILDING PRESS, 2002.