Municipal District Heating and Cooling Co-generation System Feasibility Research

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Abstract: In summer absorption refrigerating machines provide cold water using excess heat from municipal thermoelectric power plant through district heating pipelines, which reduces peak electric load from electricity networks in summer. The paper simulates annual dynamic load of a real project to calculate the first investments, annual operation cost and LCC (life cycle cost) of the four schemes, which are electric chillers, electric chillers with ice-storage system, absorption refrigerating machines using excess heat from power plant and absorption refrigerating machines using excess heat from power plant along with ice-storage system. On the basis of the results, the paper analyzes the prospect of the absorption refrigeration using municipal excess heat, as well as the reasonable heat price, which provides a theoretical basis for municipal heating and cooling co-generation development.

Key words: Municipal District Heating and Cooling Co-generation System;annual operation cost ;LCC

1. INTRODUCTION

Eergy demand rises along with the continuing development of China economy. But the energy utilization ratio is still very low, energy efficiency is an important research subject for continuingdevelopment. Thermoelectric power plant provides dependable and high quality thermal power for district heating, which promotes the reasonable development of urban energy utilization. However, in summer heat load is insufficient so that part of heat supply units cannot be operated or fully operated, which leads to rising coal consumption. Meanwhile, the rapid increase of power consumption for air-conditioning makes the shortage of power supply more severe. If the low-pressure steam or high temperature hot water for power plant could drive lithium-bromide absorption-type refrigerating machines to provide cooling, the heat load rises and peak load for power demand decreases so as to improve power plant economic interest of a whole year.

2. COMBINED DISTRICT HEATING AND COOLING SYSTEM

Combined district heating and cooling system provide low-pressure steam or high temperature hot water from power plant to lithium-bromide absorption-type refigerating machines to generate cold water in summer; in winter heating hot water is generated from primary hot water by heat exchangers. The paper discusses combined district heating and cooling system by high temperature hot water (120~70) from power plant.

3. RESEARCH METHOD

3.1 Research based on 5 real projects

（1）National stadium, total floor area is 258,000 m^2, 10 floors. National stadium is the

main stadium for the 29th Olympic Games in 2008, and operated commercially after Olympics.

（2）Electric Power Department Electric Network Scheduling Control Center, total floor area is 48341 m^2, 23 floors above ground and 3 floors below grounds, office complex building.

（3）Air Force the 4th research institute research complex building, total floor area is 32000m^2, 20 floors above ground and 2 floors below grounds, research and office building.

（4）Financial Street F10 office building, total floor area is 46223m^2, 70.2 meters high, 16 floors above ground and 5 floors below grounds. Office building from the ground floor to the 16th floor, blow ground is dining rooms, garages and machines rooms.

（5）Xizhimen integrate trafic junction and supporting building, total floor area is 264139.6m^2, 23 floors above ground and 3 floors below grounds, office and commercial complex.

3.2 Refrigeration Options

Option I: Electric chillers refrigeration;

Option II: hot water (from thermal electric co-generated system) lithium-bromide absorption refrigeration;

Option III: Electric chillers with ice storage system;

Option IV: hot water lithium-bromide absorption refrigeration with ice storage system.

3.3 Back-to-back scheme design

3.4 Budgetary estimate according the design drawings, and calculate the first cost of the refrigeration system.

3.5 Calculate the annual operation cost for each options based on annual energy consumption analysis.

3.6 Calculate LCC (Life Cycle Cost) for each options

3.7 Calculate district heating cost based on first cost, operation cost and LCC.

4. ECONOMIC AND TECHNICAL ANALYSIS OF COMBINED DISTRICT HEATING AND COOLING SYSTEM

4.1 Reference building---National Stadium

The estimate total cooling load of the National Stadium in summer during Olympics is 11660kW (20000kW for commercial operation after Olympics); the estimate heating load is 7759kW in winter (10900kW for commercial operation after Olympics).

The annual hourly cooling load is showed in figure 1, annual hourly heating load is showed in figure 2, and cooling load distribute time frequency is showed in figure 3.

（1）First cost comparison of the 4 options

The first cost comparison of the 4 options is showed in the chart below.

Electric refrigeration < Absorbed refrigeration < Absorbed refrigeration with ice storage < Ice storage

（2）Annual operation cost comparison of the 4 options

Based on peak and valley time price for electricity, the annual operation cost of the 4 options comparisons is showed in the chart below. The result is:

Absorbed refrigeration with ice storage < Ice storage < Absorbed refrigeration < Electric refrigeration.

（3）LCC comparison of the 4 options

LCC of the 4 options comparisons is showed in the chart below. The result is:

Absorbed refrigeration with ice storage < Ice storage < Absorbed refrigeration < Electric refrigeration

（4）Computed heat price for hot water absorbed refrigeration

Single electricity price

When the single electricity price is 0.6397 yuan/kWh and the LCC of hot water absorbed refrigeration and electric refrigeration is same, the price of heat from hot water is 21.927yuan/GJ. When the annual operation cost of hot water absorbed refrigeration and electric refrigeration is same, the price of heat from hot water is 22.785yuan/GJ.

Mean day-time electricity price

Mean day-time electricity price is 0.80yuan/GJ. When LCC of hot water absorbed refrigeration and electric refrigeration is same, the price of heat from hot water is 27.636yuan/GJ. When the annual

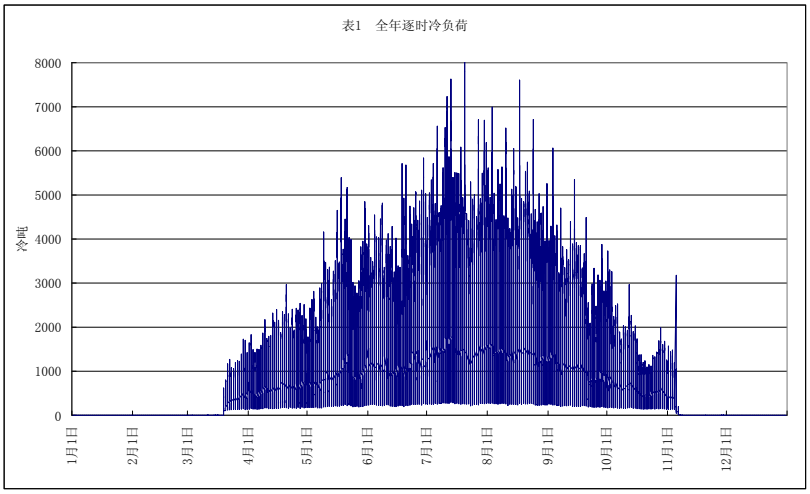

Fig. 1 annual hourly cooling load

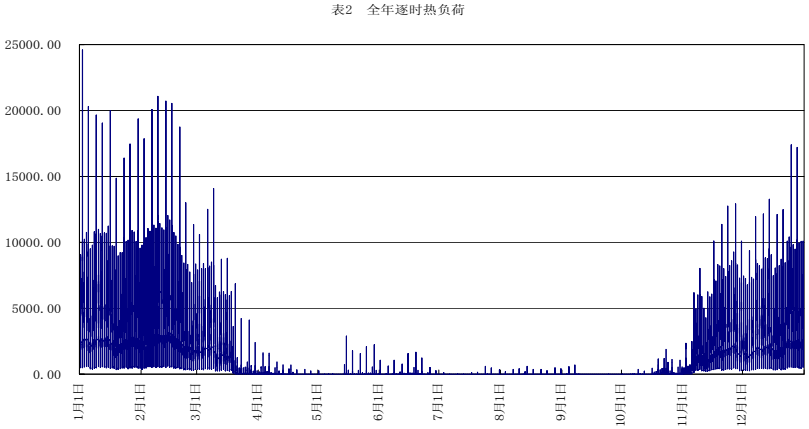

Fig. 2 Anual hourly heating load

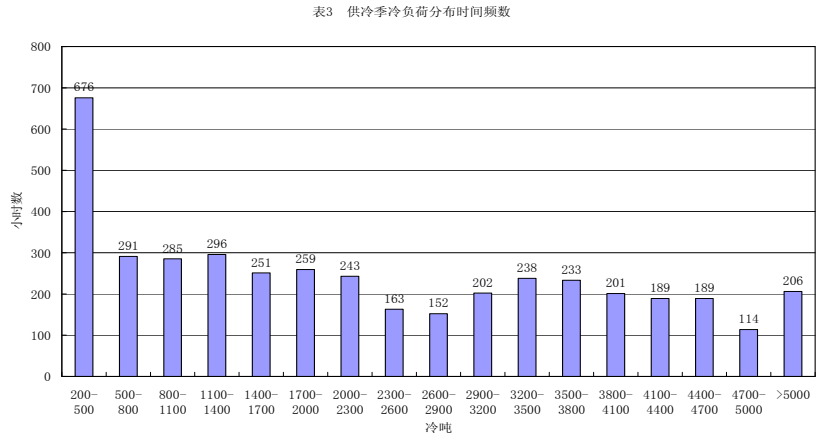

Fig.3 Coling load distribute time frequency

Tab.1 First cost comparison of the 4 options

	Electric refrigeration	Absorbed refrigeration	Ice storage	Absorbed refrigeration with ice storage
First cost (10000yuan RMB)	2312.57	2374.97	2768.52	2743.32

Tab.2 Annual operation cost comparison of the 4 options

	Electric refrigeration	Absorbed refrigeration	Ice storage	Absorbed refrigeration with ice storage
Annual operation cost (10000yuan RMB)	709.29	672.70	598.27	513.76

Note: The heat cost of absorbed refrigeration is calculated by 0.09yuan/kWh.

Tab.3 LCC comparison of the 4 options

	Electric refrigeration	Absorbed refrigeration	Ice storage	Absorbed refrigeration with ice storage
LCC (10000yuan RMB)	831.03	808.28	737.70	657.03

Tab.4 Computed heat price chart

	Computed heat price (yuan /GJ)			
	options		Electric refrigeration	Ice storage
options	Absorbed refrigeration	Equal LCC	26.410	20.562
		Equal annual operation cost	27.268	20.386
	Absorbed refrigeration with ice storage	Equal LCC	51.347	37.064
		Equal annual operation cost	54.607	37.797

Tab.5 Building function and floor area

Building name	function	Floor area (m^2)	Cooling load (kW)	Annual cooling capacity (GJ)
Electric Power Department Electric Network Scheduling Control Center	Office	48341	6215.3	30023.7
Air Force the 4^{th} reseach institute research complex building	Office	32000	3450	14457.6
Financial Street F10 east office building	Office	46223	4075	19015.1
Xizhimen integrate trafic junction and supporting building	Complex	264140	37363	206554.4
Load index per m^2(W/ m^2)	/	/	130.80	/
Annual cooling load index per m^2 (GJ/ m^2•y)	/	/	/	0.69

Tab.6 First cost comparison

Building name	Cooling source first cost (10,000yuan)			
	Electric refrigeration	Absorbed refrigeration	Ice storage	Absorbed refrigeration with ice storage
Electric Power Department Electric Network Scheduling Control Center	895.42	946.20	1067.07	/
Air Force the 4^{th} research institute research complex building	567.85	586.28	744.34	/

Financial Street F10 east office building	575.92	598.15	780.85	/
Xizhimen integrate traffic junction and supporting building	4785.13	4954.26	5678.12	4944.81
First cost per m^2(W/ m^2)	174.67	181.34	211.68	187.20

Tab.7 Annual operation cost comparison

Building name	Cooling source annual operation cost (10,000yuan)			
	Electric refrigeration	Absorbed refrigeration	Ice storage	Absorbed refrigeration with ice storage
Electric Power Department Electric Network Scheduling Control Center	192.7859	170.74	165.41	/
Air Force the 4th research institute research complex building	91.4044	92.66	71.95	/
Financial Street F10 east office building	130.3226	132.64	110.28	/
Xizhimen integrate traffic junction and supporting building	1038.3255	926.59	775.57	855.09
Annual operation cost per m^2 (yuan/ m^2•y)	37.19	33.88	28.75	32.37

Note: The heat cost of absorbed refrigeration is calculated by 0.09yuan/kWh.

Tab.8 LCC comparison

Building name	Cooling source LCC (10,000 yuan)			
	Electric refrigeration	Absorbed refrigeration	Ice storage	Absorbed refrigeration with ice storage
Electric Power Department Electric Network Scheduling Control Center	237.5299	224.02	218.76	/
Air Force the 4th research institute research complex building	119.7969	126.31	109.17	/
Financial Street F10 east office building	159.1186	166.38	149.32	/
Xizhimen integrate traffic junction and supporting building	1277.5820	1206.21	1059.48	1113.23
LCC per m^2 (yuan/ m^2•y)	45.92	44.10	39.33	42.15

Tab.9 Computed heat price comparison

Building name	Comparison options for Absorbed refrigeration	Electric refrigeration (yuan/GJ)	Ice storage (yuan/GJ)
Electric Power Department Electric Network Scheduling Control Center	Equal annual operation cost	30.58	23.65
	Equal LCC	28.42	23.67
Air Force the 4th research institute research complex building	Equal annual operation cost	23.84	13.62
	Equal LCC	21.08	15.49

Financial Street F10 east office building	Equal annual operation cost	24.07	16.06
	Equal LCC	22.10	18.18
Xizhimen integrate traffic junction and supporting building	Equal annual operation cost	30.41	17.69
	Equal LCC	28.46	17.90
Integrated mean value	Equal annual operation cost	29.46	18.09
	Equal LCC	27.42	18.55
Heat price per m^2 (yuan/ m^2•y)	Equal annual operation cost	20.36	12.51
	Equal LCC	18.95	12.82

operation cost of hot water absorbed refrigeration and electric refrigeration is same, the price of heat from hot water is 28.495yuan/GJ.

Peak and valley time price for electricity

When LCC of hot water absorbed refrigeration and electric refrigeration is same, the price of heat from hot water is 26.410yuan/GJ. When the annual operation cost of hot water absorbed refrigeration and electric refrigeration is same, the price of heat from hot water is 27.268yuan/GJ.Computed heat price for different options

4.2 Refrigeration comparison of 4 different type of buildings

In order to fully and accurately analysis the marked price of combined district heating and cooling system, the paper chooses 4 real projects as research object, compares the first cost, annual operation cost and LCC of the 4 projects and calculates the computed heat price in different comparison conditions.

5. CONCLUSION

Based on the National Stadium and 4 real projects, the paper calculate the first cost, annual operation cost and LCC (life cycle cost) of the four schemes, which are electric refrigeration, electric refrigeration with ice-storage system, absorption refrigerating machines using excess heat from power plant and absorption refrigerating machines using excess heat from power plant along with ice-storage system. What's more, the paper calculated the heat price in different conditions, which provides the theoretical basis of combined district heating and cooling development.