

The Economical Analysis of the Air-Conditioning System Using Gas in Beijing

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Abstract: It will be, in this paper, indicated that the fast development of air condition that is powered by electricity is one of the major reason that causes the power shortage in our whole country. Therefore, it is reasonable and effective way to encourage domestic people to use the air-conditioners that are powered by gas rather than electricity. In the paper, a resident tower-building with 22 floor was chosen as analyzing target, which has the room of each area 80 - 120 square meter and 2.9 meter tall. Comparing the design model of the electrical air condition to supply the cooling load in summer plus the central heating in winter with the model of LiBr absorption refrigerating unit that afford the cooling capacity in summer and the heating load in winter based on calculating the original investment (Chilling-set, air condition components, wind coils) and the running cost (according to heating 120days and providing cooling 120 days annually). The predicted results discuss the disadvantages and advantages of refrigerating units powered by gas, analyze the economical feasibility of using the refrigeration unit into air-conditioning system in Beijing region, and point out the developing direction.

Keywords: electricity shortage, air-condition powered by gas, economical analysis

1. INTRODUCTION

"Electricity shortage" has already been known in China. It has already fazed a lot of large and medium cities; Beijing is the most serious one among them. In 2004, the electricity shortage became more serious in Beijing, supreme load in summer is up to 9,436, 000kW, the short of power in Beijing is very outstanding in 2005 all the same, peak load of electric reached 10,700,000 kilowatts, 1,264,000 kilowatts more than the peak load of last summer, so the electricity supply is 1 million kilowatts in short. The government attitude of using electricity has changed from encouraging to restricting. The main reason to form the situation of electricity shortage is the development of air conditioner industry, which has already occupied 40% of the power-consuming load in Beijing. Just the opposite, the natural gas consumption comes into a low valley in summer. According to the report from Beijing Gas Group, the daily consumption of natural gas at the end of May is about 3 million cubic meters, which is only 10% of the average daily consumption in winter, that is 32 million. Therefore, it is necessary to develop a way of utilizing nature gas as energy to compensate some of electricity shortage, especially, for the air-conditioning using nature gas. As the main pattern of the gas air conditioning, the Lithium Bromide absorption chiller using nature gas (LBACNG) has been already widely used. It can use the nature gas in rush hour of electricity used. In summer to release the pressure of power, and make an effect of "moving peak into valley". In addition, it makes the best

use of slack period gas, and plays a positive role to balance energy utilization. In the paper, the feasibility of using nature gas as the energy of air conditioning unit is analyzed based on a resident house in Beijing that is installed this kind of air-condition facility.

2. THE ECONOMIC ANALYSIS OF LBACNG USED IN AIR CONDITIONING SYSTEM

The LBACNG is a new model developed from the Lithium Bromide absorption-refrigerating unit using steam. It uses heat of high temperature fume that comes from the burning of nature gas, fuel or LNG. The LBACNG works on the principle of absorption refrigeration circulation to produce the cooling or hot water, and affords the cooling load in summer and heating load in winter. The characteristics of the machine are as follows^{[1] [2]}

2.1 Technique and environmental protection advantages: The LBACNG is operating at minus pressure and high vacuum, having no dangerous of explosion; have no yawp parts besides canned motor pump. The noise of the machine is very low, maintenance work is simple, and the refrigerating capability of the unit is steady. It can operate steadily at the condition : calefaction steam pressure of 0.2-0.8 MPas, the temperature 5-15℃ of cooling water ; The adjustable range of the cooling ability for the machine is from 20% to 100%^{[3] [4]}. The air-conditioning using LBACNG could protect the environment because the refrigerant in the unit is water that has no poison, can

not be burned, has no irritating, and avoiding the bane to the environment by using CFC, and the supplier of heat to the machine comes from burning nature gas, which almost produces any pollution to environment. (see Table 1^[1])

Table 1. The pollutant exhale of several eldings

Fuel	Sox	NOx	COx
Coal	100%	100%	100%
Oil	70%	80%	80%
Natural gas	0	20~40%	60%

2.2 Economic advantages: Comparing with the air conditioning facilities driven by electric power, the air-condition using LBACNG have some specifically economic advantages in basic construction, investment and consumer: the basic establishment investment of natural gas just accounts for 10% compared with the electric power investment at the same burthen, developing and using gas air conditioning can debate the cost significantly. The air-condition system employing LBACNG can supply cooling water in summer and hot water in winter, thus a boiler will be saved and reduce the capital of original cost. The adjustment of LBACNG is better than the electric air conditioning unit, especially, the former displays higher operation efficiency than latter when the actually load of building varies from 30% to 70%. As a result, it saves the energy consumed and reduces the running cost. Usually, the electric air conditioning system is just used for refrigerating in summer. It needs to add boiler or city heating network for heating in winter. But the air-condition system employing LBACNG can afford the cooling load, heating load and supply hygienic hot water. Furthermore, it has a few movement parts of gas air conditioning, which leads to low maintenance cost and enhances the reliability of the machine^[3].

3 THE FEASIBILITY OF DEVELOPING AND USING THE AIR-CONDITIONING SYSTEM WITH LBACNG

3.1 The feasibility of energy sources reserves^[5]:

The natural gas reserve that has already been found from 1990 to 1995 is 630.8 billion cubic meters. In 1999, the natural gas reserves verified in Talimu area was 567.9 billion cubic meters, the Daqing oil field also found a great deal of natural gas, which could supply Beijing and Tianjin area for 50 years. China is coming to being a natural gas bevy that contains Sichuan, Shanxi-Gansu-Ningxia, Xingjiang, nanhai, natural gas output of which is between 10 to 20 billion cubic meters, and 2 producing areas in east, natural gas output of which are more than 5 billion. Furthermore, Chinese native who has accomplished to build up natural gas conduit between Northeast and annulus of Bohai, and base oil conduit from north of Shanxi to Beijing, all of which establish foundation for using natural gas. The actualizing of these important projects will make a big change in energy sources

configuration of China, which is not only good for circumstance but also provides credibility energy sources ensure for using the gas air conditioning.

3.2 The national policy ensuring:

The key of popularizing the air conditioning unit using nature gas is the policy of gas price establishment. The principal of Beijing Gas Company has denoted that from June to July this summer, the gas price, based on the 1.70 yuan each cubic meter will cut down from 0.05 to 0.1 for the consumers who use the air conditioning unit with nature gas to afford cooling load in summer.

3.3 The technique feasibility of the air conditioning unit using nature gas:^[5]

In recent years, instead of import equipment, many cities in China began to use domestic central air conditioning units. It is shown from reports that the technologies of LBACNG that includes the design principle, manufacturing process, operating criterion and maintaining code have approached mature stage in China, some fields have come into international advanced level.

4 DISCUSSING ON AN EXAMPLE OF LBACNG IN PRACTICE

An example of using LBACNG is analyzed for discussing the feasibility of the air conditioning units using gas.

4.1 The basic information:

4.1.1 Survey of project: It is a high residential building with 22000 m² constructing area, 27 floors and 2.93 meters highness for each floor in Beijing. The area of each apartment is 80~120 m².

4.1.2 Outdoor condition for designing: the outdoor dry-bulb temperature is 33.2℃ in summer, the outdoor wet-bulb temperature is 26.4℃ in summer, and the outdoor dry-bulb temperature is -12℃ in winter.

4.1.3 Indoor condition for designing: the indoor design temperature is 25~27℃ in summer, the indoor design temperature is 18~20℃ in winter.

4.1.4 Load calculating: the maximum hourly cooling load in summer is 1700 kW, and the maximum heating load in winter is 1342 kW. The results computed by Hongye software.

4.1.5 Choosing schemes: Scheme one: cooling load in summer supplied by conventional central air conditioning mode, and central heating in winter.

Scheme two: cooling load in summer and heating load in winter is supplied by the LBACNG^[6].

4.1.6 Choosing main equipments for the schemes (see Table 2):

4.1.7 Choosing assistant facilities for the schemes (see Table 3):

Table2. Main equipments list chosen for comparison of two schemes

Scheme one			Scheme two		
Screw refrigerating units (Carrier)	30HXC400A	30HXY110	LBACNG units (Carrier)	16DF-036	16DF-013
refrigerating capacity (kW)	1392	464	refrigerating capacity (kW)	1266	475
			heating output (kW)	1020	385
chilled water flux (m^3/h)	241	80	chilled water flux (m^3/h)	217.7	81.6
cooling water flux (m^3/h)	284	95	cooling water flux (m^3/h)	329	123
			natural gas (NM^3/h)	88	33
electric power consumed(kW)	279	93	electric power consumed (kW)	7.75	3.25

Table3. Assistant facilities list chosen for the main equipments

Scheme one			Scheme two		
items	technique parameters	Amount (set)	items	technique parameters	Amount (set)
screw refrigerating units (Carrier)	30HXC400A	1	LBACNG units (Carrier)	16DF-036	1
	30HXY110	1		16DF-013	1
chiller water pump	flux: 330 (m^3/h), pressure head: 45(m), power: 55(kW)	3 (2 for using, 1 for spare)	chiller water pump	flux: 330 (m^3/h), pressure head : 45(m), power: 55(kW)	3 (2 for using, 1 for spare)
cooling water pump	flux: 400 (m^3/h), pressure head: 45(m), power: 70(kW)	3 (2 for using, 1 for spare)	cooling water pump	flux: 450 (m^3/h), pressure head: 45(m), power: 80(kW)	3 (2 for using, and 1 for spare)
cooling tower	standard water amount 115 (m^3/h), power: 3.75(kW)	1	cooling tower	standard water amount 115 (m^3/h), power: 3.75(kW)	1
	water amount: 333(m^3/h), power: 11(kW)	1		water amount 385 (m^3/h) power: 11(kW)	1

Table 4. electric price in Beijing and cooling load / heating load coefficient of air conditioning hourly

Time	electricity price (yuan)	cooling load coefficient	heating load coefficient
valley (00: 00~01: 00)	0.2960	0.16	0.4
valley (01: 00~02: 00)	0.2960	0.16	0.4
valley (02: 00~03: 00)	0.2960	0.25	0.4
valley (03: 00~04: 00)	0.2960	0.25	0.4
valley (04: 00~05: 00)	0.2960	0.25	0.4
middle (05: 00~06: 00)	0.6150	0.5	0.6
middle (06: 00~07: 00)	0.6150	0.59	0.8
Peak (07: 00~08: 00)	0.9550	0.67	0.8
Peak (08: 00~09: 00)	0.9550	0.67	0.7
Peak (09: 00~10: 00)	0.9550	0.75	0.7
Peak (10: 00~11: 00)	0.9550	0.84	0.7
middle (11: 00~12: 00)	0.6150	0.9	0.7
middle (12: 00~13: 00)	0.6150	1	0.65
middle (13: 00~14: 00)	0.6150	1	0.65
middle (14: 00~15: 00)	0.6150	0.92	0.65
middle (15: 00~16: 00)	0.6150	0.84	0.7
middle (16: 00~17: 00)	0.6150	0.84	0.8
Peak (17: 00~18: 00)	0.9550	0.74	0.9
Peak (18: 00~19: 00)	0.9550	0.74	0.95
Peak (19: 00~20: 00)	0.9550	0.5	1
Peak (20: 00~21: 00)	0.9550	0.5	1
Peak (21: 00~22: 00)	0.9550	0.33	0.9
Valley (22: 00~23: 00)	0.2960	0.16	0.7
Valley (23: 00~24: 00)	0.2960	0.16	0.5
Total	0.64(average electricity price)	13.72	16.4

- Note: 1. Periodic time of refrigeration in one year are 120 days, which contains 20 days of full load working, 40 days of 80% load working, and 60 days of 60% load working;
 2. Periodic time of heating in one year are 120 days, which contains 20 days of full load working, 50 days of 80% load working, and 50 days of 60% load working;
 3. The price for central heating is 24 yuan each square meter constituted by Beijing Heat Company.

4.2 Computing the running costs for two schemes:

4.2.1 when calculating the running costs for two schemes each day, the different electricity prices and the cooling load or the heating load coefficients in different time were chosen firstly as shown in Table 4:

4.2.2 Comparison of the running costs:

The results of running costs calculated for two schemes are listed Table 5 as follows:

4.2.3 In order to calculate the amount of nature gas consumed based on the results of Table 5 above, the price of nature gas per cubic meter is supposed by x yuan. The some formulas to calculate the economical parameters of using LBACNG are shown in Table 6.

4.2.4 Calculate the prices of nature gas for discussing:

(a) Gas price for cooling load in summer: Assuming the running cost for two schemes annually is equal, below relation could be deduced: The running cost of electricity for cooling load annually[scheme one] = (The running cost of electricity for cooling load annually+The running cost of gas for cooling load annually) [scheme two] , then,

$$x = 1.435 \text{ yuan/m}^3$$

(b) Gas price for heating load in winter: Same as 4.2.4 - (a) above, below relation could be deduced: The running cost of electricity for heating load annually[scheme one] = (The running cost of electricity for heating load annually+The running cost

Table5. Comparison of running costs for two schemes

	items	total cooling load (KW)	running cost of units using electricity (yuan)	running cost of pump using electricity (yuan)	running cost of cooling tower using electricity (yuan)	gas amount (NM ³)
scheme one	results of cooling load daily	2.33×10^4	3388.92	2277.23	121.67	0
	results of running annually	205.3×10^4	29.82×10^4	20.04×10^4	1.07×10^4	0
scheme two	results of cooling load daily	2.33×10^4	104.90	2627.64	141.35	2030.56
	results of cooling load annually	205.25×10^4	9231.2	23.12×10^4	1.24×10^4	17.87×10^4
	result of heating load daily	2.20×10^4	95.63	1230.12	0	2328.80
	result of heating load annually	198.08×10^4	8606.7	11.07×10^4	0	20.96×10^4
	result of running annually	/	1.78×10^4	34.19×10^4	1.24×10^4	38.83×10^4

Table 6. Formulas to calculate the economical parameters of using LBACNG

items	scheme one	scheme two
running cost of electricity for cooling annually (yuan)	50.9×10^4	25.28×10^4
running cost of electricity for heating annually (yuan)	52.8×10^4	11.86×10^4
running cost of electricity annually (yuan)	103.8×10^4	37.14×10^4
running cost of nature gas for cooling annually (yuan)	0	17.87×10^4
running cost of nature gas for heating annually (yuan)	0	20.96×10^4
running cost of nature gas annually (yuan)	0	38.83×10^4

of gas for heating load annually)[scheme two], then,
 $x = 1.95 \text{ yuan/m}^3$

(c) Gas price for the whole year operating: The operating cost of electricity annually[scheme one] = (The operating cost of electricity annually + The operating cost of gas annually) [scheme two], then,
 $x = 1.71 \text{ yuan/m}^3$

4.3 Discussing and analyzing:

(a) When the gas price is, from the results calculated above, lower than 1.435 yuan/m^3 , the

running cost of LBACNG unit for cooling load in summer could be lower than that of the screw refrigerating unit. However, it is impossible to cut down the price of gas to the value according to the current gas policy in Beijing.

(b) When the gas price is lower than 1.95 yuan/m^3 , the running cost of LBACNG unit for heating load in winter could be lower than that of the screw-refrigerating unit. The current price of gas in Beijing now is 1.7 yuan/m^3 temporarily and even it rises up to 1.9 yuan/m^3 , the running cost of the former is still lower than the latter. Therefore, it has economic

predominance for heating load in winter to employ the LBACNG unit.

(c) When the gas price is lower than 1.71yuan/m³, the whole year running cost of LBACNG unit for cooling and heating could be lower than the screw-refrigerating unit. The current price of gas in Beijing is 1.7yuan/m³ temporarily. If the policy, from Beijing Government, that reduce the price of gas about 0.05~0.1 yuan/m³ to encourage people using gas air conditioning units could carry out, from the view of economic predominance, there must be a good prospect for using LBACNG units in whole year in the future.

(d) The results calculated shows that the running cost for electric power consumed annually by the LBACNG unit is 37.2×10^4 yuan, and that by the screw refrigerating unit is 103.8×10^4 yuan. It means that the LBACNG unit could reasonably release the pressure of electricity in rush hour.

5. CONCLUSIONS

Firstly, analyzing the economic feasibility of using the LBACNG unit in Beijing, from the view of energy saving and environment protecting, the air-conditioning facilities that consume nature gas should be recommended to be used in resident buildings. Secondly, based on the gas current price in Beijing (the gas price for air-condition in summer is about 1.6~1.9yuan /m³), comparing the running cost of the LBACNG unit for air-conditioning with the screw-refrigerating unit in summer, the former has no economic predominance. Oppositely, the former is

superior to the latter when heating in winter. Finally, under a reasonable gas price, the air-conditioning facilities using nature gas as energy resource will has conspicuous predominance in technique and good environment conservation.

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