

Economical Analysis of the Air-Conditioning Way of the High-Rise Housing Building with the New Save Energy Design Standard of Housing Building in Beijing District

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Abstract: For carrying out the national policy of energy sources conservation, protecting the environment and keeping the stratagem aim of the sustainable development, by actual condition in Beijing district, the new energy-saving design standard of housing building was established, it would be taken into effect at 1 July 2004. In the paper, the cold and heat loadings were calculated by dynamic simulation according to the new standard. The calculated value was based on several air-conditioning planning ways. The original investment and annual expenditure was compared among the separated air conditioner, the residential central air conditioning system and the central air conditioning system. The preliminary conclusion was educed through discussing its economy. The conclusion gave reference for design.

Keywords: energy-saving; residential central air conditioning; economic analysis

1. INTRODUCTION

With the development of economy and the improvement of living standard for human, the residential air-conditioning has been changed from the luxuriant requirement. At present, the dominating modes of the residential air-conditioning in the cities are the separated air conditioner and window air conditioner. With the swift development of the separated air conditioner and window air conditioner in the residential air-conditioning, many shortages with them are shown, such as the destroy of the building outer surface, noise and waste heat to the contaminate of the city environment. Therefore, the people want to seek the air-conditioning modes that would save more energy than that before. In the big cities, the residential central air conditioning is applied little by little in some commercial residential building. In some well-to-do residential district, the district cooling, district heating and district hot water supply are also used by the land agents. However, the people care not only the effect of air-conditioning but also the economic factor to any air-conditioning modes. In the paper, the economic properties of the separated air conditioner, residential central air conditioning system and central air conditioning system have been discussed and analyzed for searching after the ways of energy-saving.

2. THE LOAD CALCULATION OF THE BUILDING

A high-rise housing building is chosen in Beijing district as the researching target. The building is divided into A, B and C cells, and each cell has 27 floors and is used as dwelling house. The vertical distance is 2.93m every floors. The total building areas are 27125 m². The design parameter is shown in Table 1^[1]. According to literature^[2], the cooling load is calculated by the method of harmonic reaction. The cooling loads that cover the heat conduction through envelope, the heat from solar radiant heat through outer window, the heat from people's body, the heat from lighting and facilities and the heat from fresh air are calculated respectively in per hour and in per item.

The maximal values of loads for the building hour by hour are shown in Table 2. It should note that the heating load, in Table 2, was calculated in steady state in the light of literatures^{[2],[3],[4]}.

Table 1: Design parameters for the building

Indoor design conditions		Envelope overall coefficient of heat transfer(W/ m ² · K)		
Summer	Winter	House top	Outer wall	Outer window
26℃, 65%	18℃	0.6	0.6	2.8

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Table 2: The cooling and heating load of maximal values for the building

A cell	Cooling load (kW)	501
	Heating load (kW)	317
B cell	Cooling load (kW)	521
	Heating load (kW)	341
C cell	Cooling load (kW)	435
	Heating load (kW)	249

3. SELECTING THE AIR CONDITIONING SCHEMES AND COMPARING THE ORIGINAL INVESTMENT

At present, the dominating modes of the residential air-conditioning in Beijing district are the central air conditioning system, the residential central air conditioning system and the separated air conditioner. To the central air conditioning, its original investment consists of main equipments, assisted facilities, pipelines, terminal devices and the construction cost of the building. The assisted facilities consumption is only about 3% of machine in integrated cost. The construction consumption is calculated by 25% of equipment cost. As to residential central air conditioning system, separated air conditioner and equipment prices include construction cost, so their original investment is only comprised by the equipment cost. In the paper, the prices of all products that are utilized come from the Internet. The original investments of three different schemes are shown Table 3, 4, 5. Comparison of the original investment of three different schemes is shown in Table 6

Table 3: Estimating original investment of the central air conditioning system

Items	Central air conditioning system
Main equipment (10^4 ¥)	311.60
Assisted equipment (10^4 ¥)	9.35
Pipelines and terminal devices (10^4 ¥)	100.00
Construction (10^4 ¥)	105.24
Total (10^4 ¥)	526.19

Note: Broad products are chosen in central air conditioning system.

Table 4: Estimating original investment of the residential central air conditioning system

Item	Room conditioning	Outer conditioning	Total
Costs (10^4 ¥)	660.88	669.60	1330.48

Note: Daikin products are chosen in residential central air conditioning system.

Table 5: Estimating original investment of the separated air conditioner

Types		1P	1.5P	2P
Amounts (piece)		783	53	25
Refrigerating (kW)	Cooling capacity	2.6	3.5	5.0
	Consumption of power	0.73	1.05	1.95
Heating (kW)	Heating capacity	2.85	3.8	6.0
	Consumption of power	0.785	1.15	1.9
Unit price (¥)		3548	3948	5636
Total (10^4 ¥)		277.8 1	20.92	14.09

Note: Gree products are chosen in separated air conditioner.

Table 6: Comparison of the original investment of three different schemes

Items	Original investment (10^4 ¥)	Original investment for per square meter (¥)
central air conditioning system	526.19	193.99
residential central air conditioning system	1330.48	490.50
separated air conditioner	312.82	115.33

4. THE CALCULATION OF ANNUAL COSTS

The annual costs of the equipment include two parts. One is fixed charges that cover mainly the equipment depreciation costs. The other is variable cost. It is composed of the system running expenses such as water used, electricity consumed, gas, laborage, and maintaining cost.

● Fixed charges:

Equipment depreciation costs are the proportioned annual expenses within effective life that is a ratio of the total equipment costs to the years of effective life. The effective life of the main equipment for the central air conditioning system and the residential central air conditioning system is chosen by 15 years, and that the effective life of separated air conditioner is chosen as 8 years. The interest rate for per year is fixed by 5%. So the equipment depreciation cost is given by:

$$P = O \times i \times (1+i)^n / [(1+i)^n - 1] \quad (1)$$

Where P depreciation cost
O original cost
i annual interest rate
n effective life

● Variable charges:

a) Running consumptions

In the paper, heating period is calculated by 125 days in winter. The cooling period is calculated by 120 days in summer. The runtimes are calculated by 10 hours per day. So heating hours are 1250 hours. Cooling hours are 1200 hours. The usage factor at same time is chosen as 0.63^[6]. In Beijing district, the civil electric price is 0.48 ¥/kW · h. The price of natural gas is 1.90 ¥/m³ when it is used for refrigeration. Therefore, the results of the cooling and heating annual costs can be calculated in Table 7.

b) Equipment maintenance cost

Maintaining cost for equipment of the system per year is calculated by 10% of equipment depreciation costs.

c) Laborage

The central air conditioning system needs workers to control and manage. Machinery room needs three workers. Their monthly wages are 9 000 ¥ in Beijing district. So laborage for them per year are 10,800 ¥. The residential air conditioning system and the separated air conditioner don't need special workers to control and manage.

Annual costs of the central air conditioning system, residential central air conditioning system and separated air conditioner are shown in Table 7.

Table 7: Comparison of annual costs

Items	central air condition ing system	residential central air conditionin g system	separa ted air conditi oner
Annual fixed charges (10 ⁴ ¥/per year)	50.69	128.18	48.40
Annual running costs (10 ⁴ ¥/ per year)	45.07	61.04	51.86

Annual running consumptions (¥/ per square meter)	16.62	22.50	19.12
Annual costs (10 ⁴ ¥/a)	111.63	202.04	105.10
Annual costs per square meter (¥/m ² · a)	41.15	74.48	38.75

5. CONCLUSIONS

a) Annual running consumptions of the central air conditioning system are least among three schemes. Its annual running consumptions are only 16.62 ¥ per square meter (construction area). Therefore, it shows more attraction to people.

b) The original investments of the residential air conditioning system are the most expensive among three schemes. It doubles original investment of the central air conditioning system. It is three times as many as the original investment of the separated air conditioner. Its annual running consumptions are almost equal to that of the separated air conditioner. However, it gives attention to t more advantages both the central air-conditioning system and the separated air conditioner. It will display more attraction to the team of white-collars.

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