Survey Study on Energy Consumption in Commercial Building of Shanghai

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1 ABSTRACT

The growing demand for energy in China has led to the shortage of energy support and serious environmental prblems. Shanghai is largest economic center, trade harbor, and integrated industrial city in China. Since 1999, natural gas was introduced in Shanghai, and it is the first city to produce electricity and the first city to produce and use pipeline gas in China. In 1882 Shanghai electric company was founded, and in 2002 the total installed capacity is 11366 MW, the single unit above 300 MW is over 60%, coal-fired units over 90%, but electricity shortage and primary energy is more and more serious. Compare to the 1995, enery consumption in 2002 is increased 36% (with 16 million coal equ.), the energy consumption mix of each sector indicates, with industry sector decreased, service sector keeps stable growth. Presently, the energy consumption in the city occupies 26% of the nationwide gross, as for the energy consumption per unit construction area says that there are also 3 times that of advanced nation. Based on these background, the gorvenment summarized Shanghai energy consumption characters as follows; 1. Demand keeps stable but low growth. 2. Energy structure is not reasonable. 3. Pressure on the environment is increasing.

In this paper, according to the investigation data, energy consumptions of 4 years in a commercial building of Shanghai (JM) are elucidated and the consumption condition between Shanghai and the other metropolis are compared. Moreover possibility of the energy conservation of the building in Shanghai is explored.

2 INVESTIGATION OBJECTIVE AND RESEARCH METHOD

JM is an 88-story landmark supertall skyscraper in the Lujiazui area of the Pudong district of Shanghai, it contains offices and hotel. Until 2007 it was the tallest building in the PRC, the fifth tallest in the world by roof height and the seventh tallest by pinnacle height. Offices in this high-rise building occupy floors 3 through 50. A 5-star Grand Hyatt Hotel fills the top 38 floors with 555 rooms. The tower has an observatory (with a floor space of 1,520 square metres) on the 88th floor, at a height of 340.1 metres. Figure 1 shows outline and floor area of JM.

The questionnaires had been handed out and collected from Jan., 2004 to Nov., 2007. The main contents of the questionnaire include: 1. the building's details, including type, floor area; 2. monthly energy consumptions, including electricity, gas and water, etc; 3. the consciusness of energy saving and so on.

3 RECEIVING POWER FACILITY AND AIR-CONDITIONING SYSTEM

Electricity consumption of this building is maintained by the receiving power of systematic electric, and the eceiving voltage is 6.6 kV. Air-conditioning facility is composed of cooling water system, cooling and hot water system and hot water system. Cooling demand is supplied by 8 centrifugal chillers with capacity of 1200 USRT (1 USRT=3.517 kW) and 600 USRT, which are installed 4 units in low-level and high, respectively.

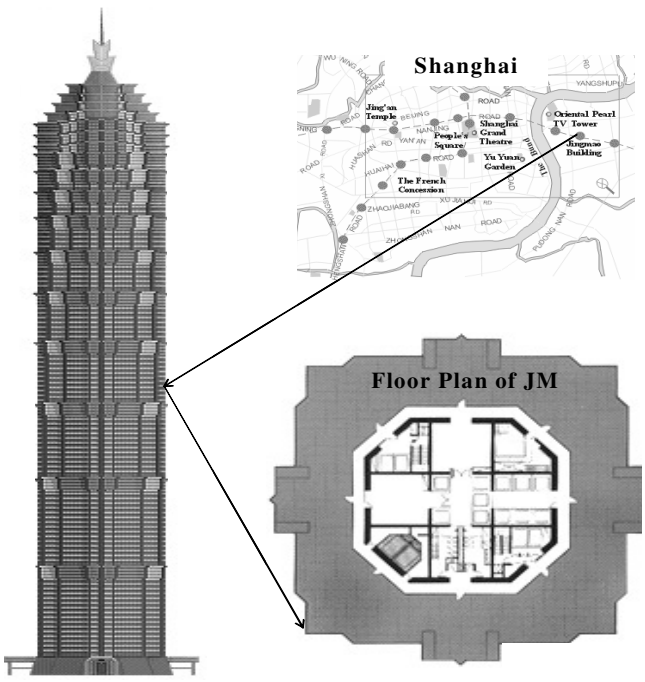

Fig. 1: Floor plan and outline of JM

In addition, to the top of the building there are variety airflow all whole air systems from the 86th floor and below the 57th floor; fan coil is installed from the 58th floor to 85th floor. On the one hand, heating demand is supplied through the heat exchanger, the pump, the air conditioner and the fan coil. Hot water system is maintained through the hot water generator, as shown in Figure 2.

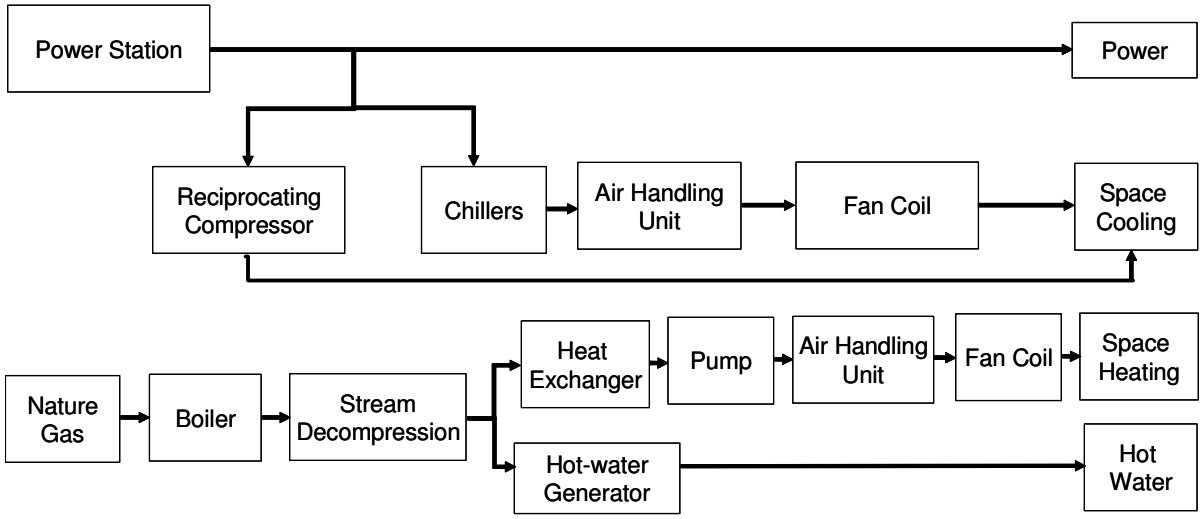

Fig. 2: System Structure of JM

4 ENERGY CONSUMPTIONS

4.1 Annual Consumptions

Annual electricity and gas consumptions (on a primary energy base) is shown in Figure 3. Electricity consumption is growing every year, by contrast, gas consumption change is not obvious. Excluding 2004, the gross of energy consumption in other 3 years exceeded 250,000 GJ. About the ratio, electric power occupies 73%, the natural gas accounts for 27%, it understands that the electricity consumption ratio is extremely high. Concerning details, because monthly data of 2004 could not be collected, the electricity consumption data is classified by using monthly data from 2005 to 2007. Figure 4 and 5 show the amount differences and ratio differences, respectively. As shown in Figure 4, electricity consumption in hotel is most significant, with minimum of 1700 MWh in Feb. 2004, and maximum of 2800 MWh in Jul. 2007, the mean value is 2400 MWh. Follwed by office, varied from 1000 MWh to 2400 MWh and the average is 1780 MWh. The profiles of minimum and maximum are as same as in the hotel's. On the whole, electricity consumption

pattern of 2 facilities is almost same, although power consumption accounts for 30% of the total, and of them, skrit room consumes significantly, with average more than 400 MWh, follwed with observatory, square and car barn.

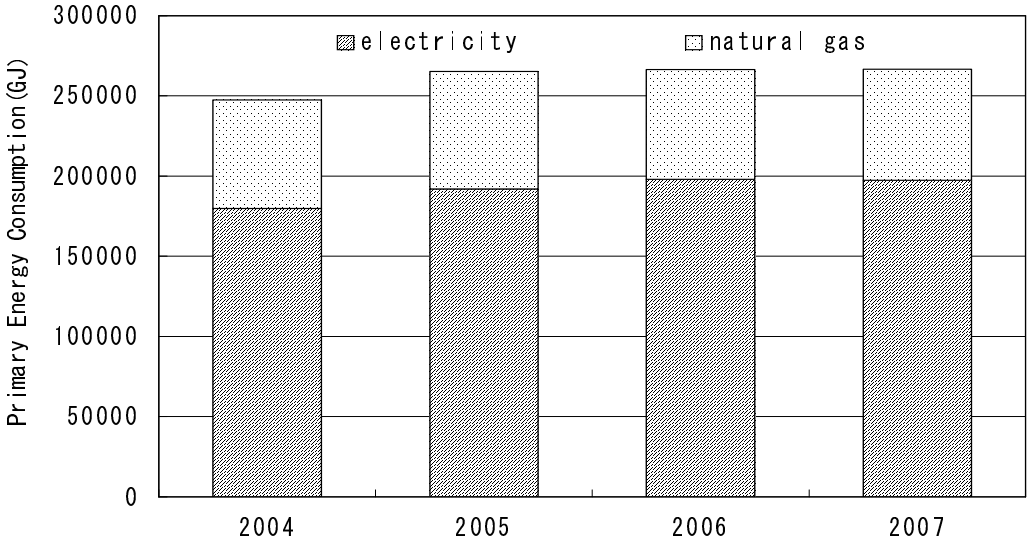

Fig. 3: Annual Consumptions of Electricity and Natural Gas

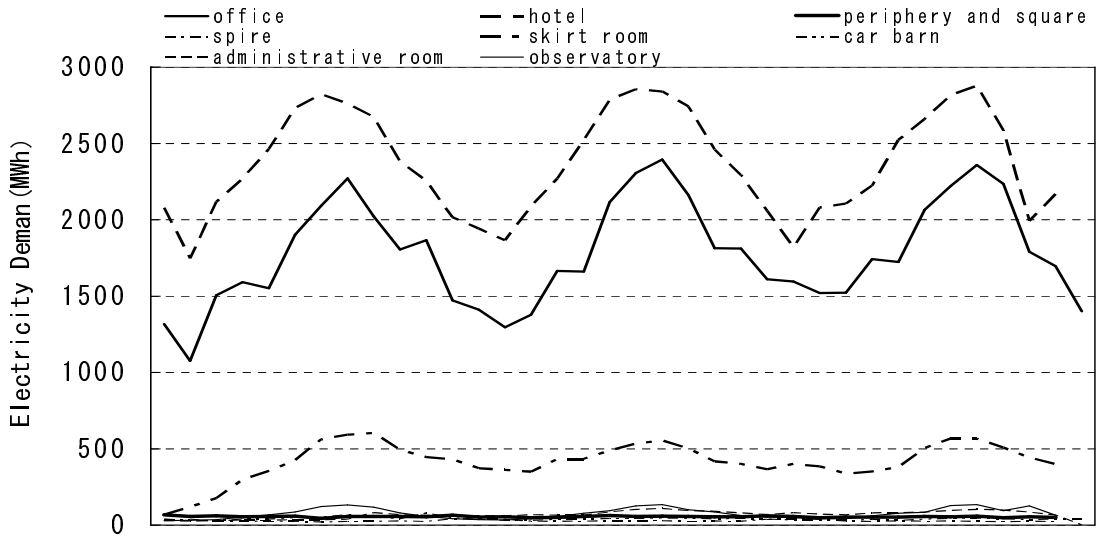

Fig. 4: Annual Electricity Consumptions of 3 Years

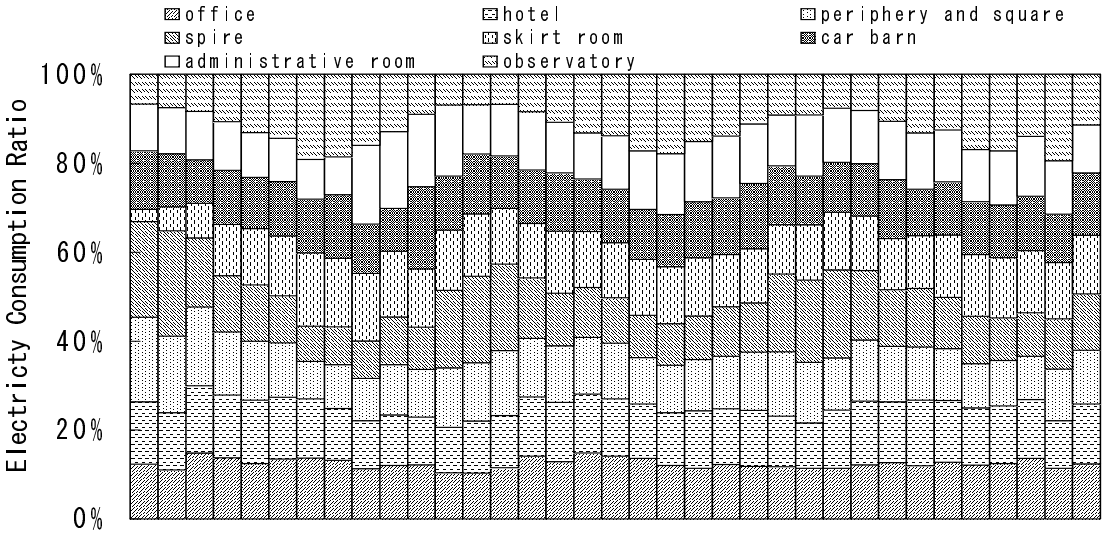

Fig. 5: Annual Electricity Consumption Ratio of 3 Years

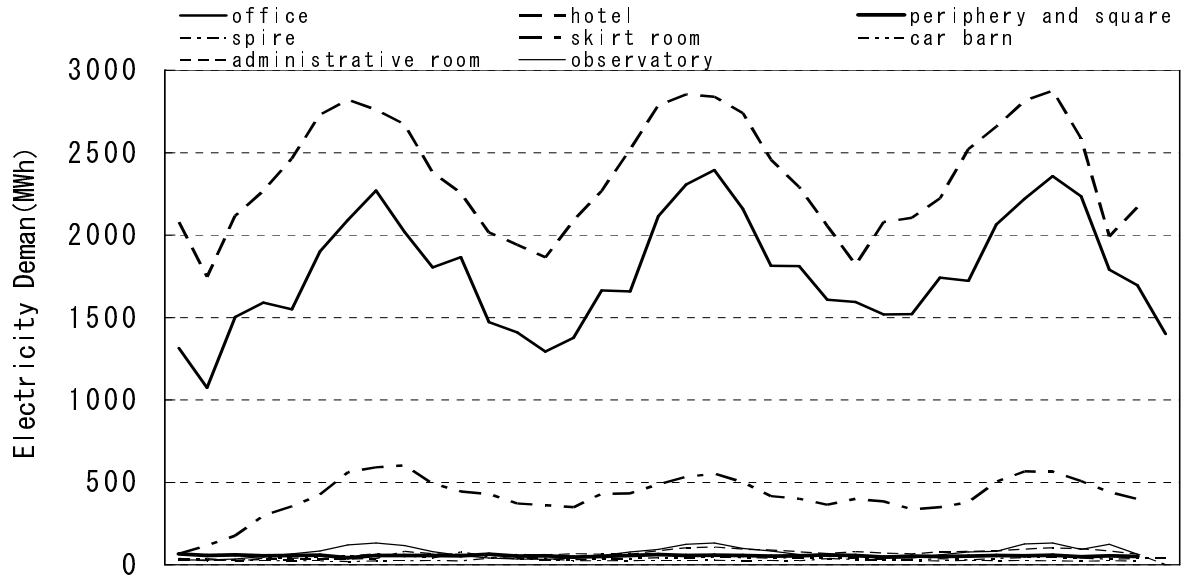

Fig. 4: Annual Electricity Consumptions of 3 Years

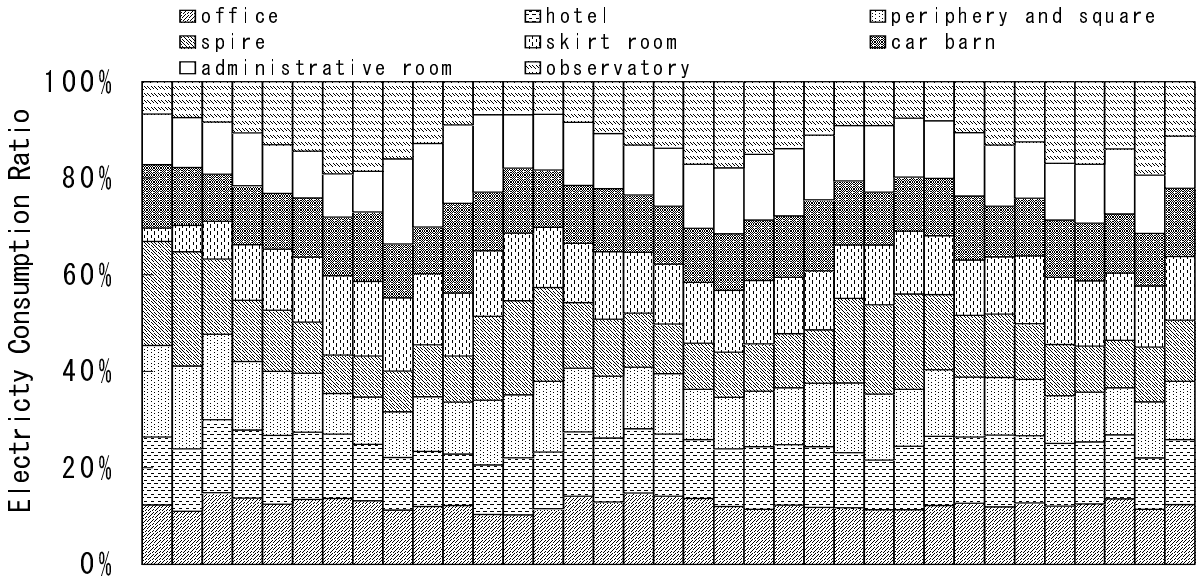

Fig. 5: Annual Electricity Consumption Ratio of 3 Years

Electricity consumption ratio of summer is higher than in the other seasons both at office and hotel. A dditionally, with the large number of visitors, it is seen that power consumption ratio of summer of the skirt room and observatory are increased. On the contrary, about power consumption ratio of the square and the spire, is significant in winter relatively. The ratio of administrative room and car barn is equally-changed.

Figure 6 shows monthly consumptions variety of space cooling, soace heating and hot water, by using general data. Obtained characters can be summarized as follows:

- The heat consumption (space cooling, space heating and hot water) is most siginificant in the hotel, followed with office and the other facilities, account for 58%, 32%, 10% of the whole, respectively.
- About the space cooling consumption, hotel accounts for more than 50% of the whole, and the main for this would be the large share by lodgers at nighttime or involuntariness of energy saving. Compared with this, office occupies 37% and the other faicilities accounts for 11%.
- About the space heating consumption, share of the office and hotel is almost equal with each other. However, about hot water consumption, due to the consumption of hotel exceeds office's dominatly. The possible cause is higher share of shower and laundry, etc. Furthermore hot water consumption is rather higher than space heating.

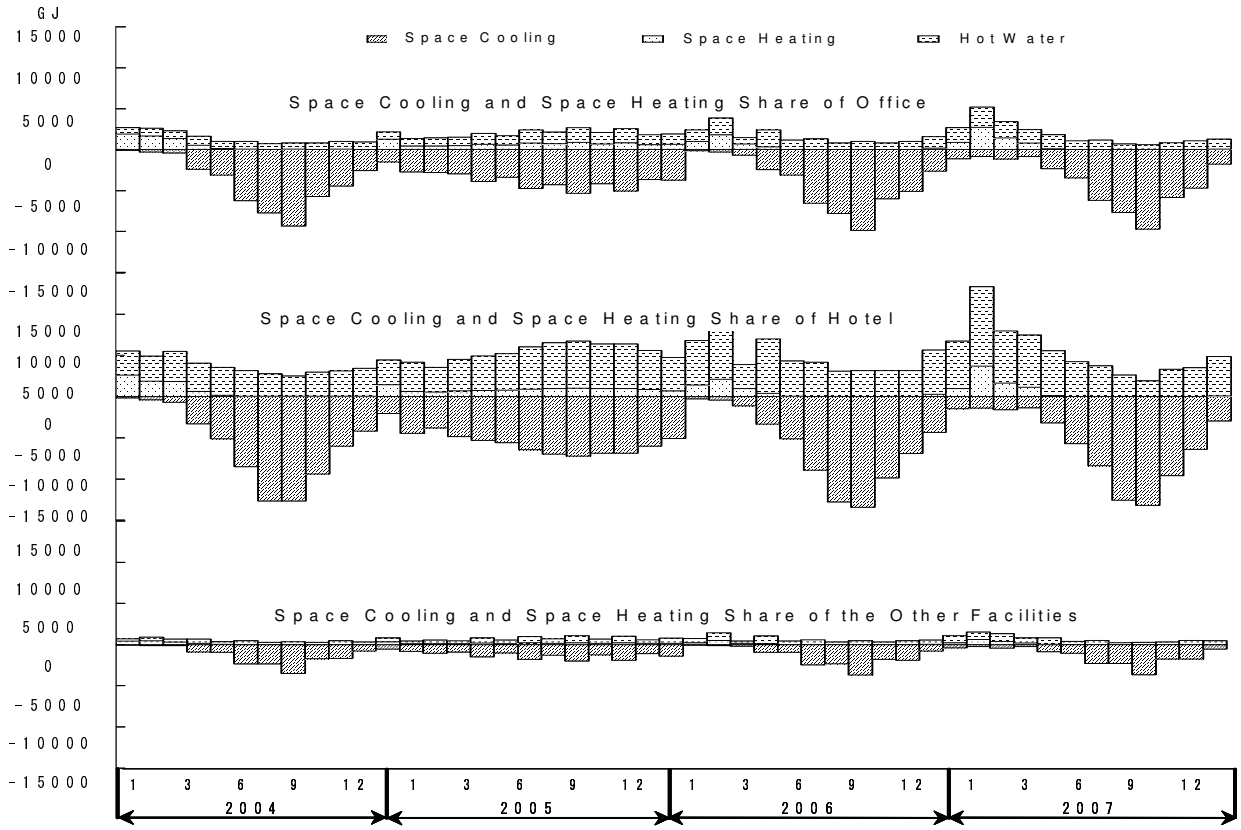

Fig. 6: Annual Space Cooling and Space Heating Share of 4 Years

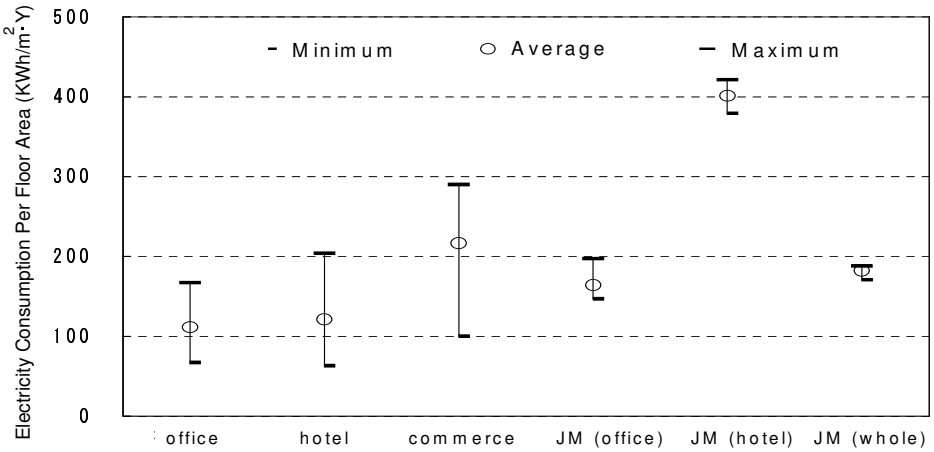

Fig. 7: Comparison of Electricity Consumption Intensity

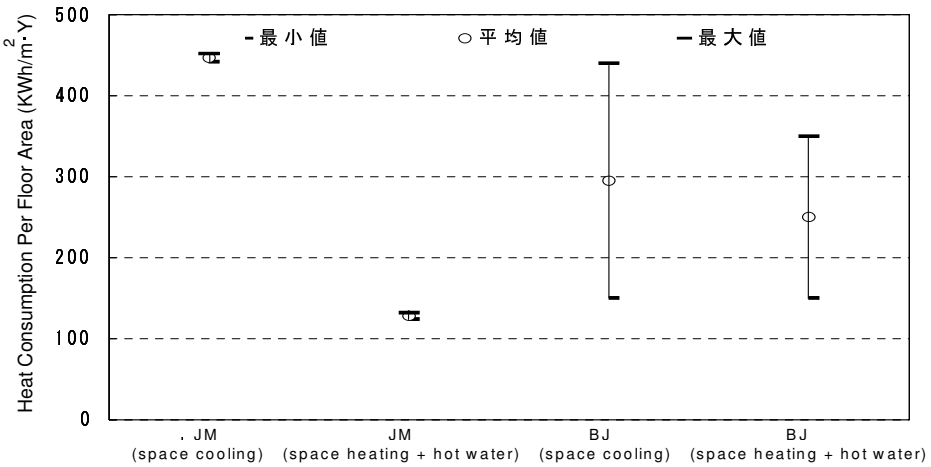

Fig. 8: Comparison of Heat Consumption Intensity

5 COMPARISON OF ENERGY CONSUMPTION INTENSITY

5.1 Comparison of Electricity Consumption Intensity

According to the electricity consumption data, consumption per square is calculated. Comparative objective includes 18 superhigh-rise buildings, 25 first-class hotels and 12 commercial facilities that from the other big cities (Beijing, Shenzhen, etc.) of China [3-4)]. The results as Figure 7 shows, electricity consumption of offices in the other cities are varing from 67 kWh/m^2 to 167 kWh/m^2 per year, and the consumption is varing from a maximum 204 kWh/m^2 to a minimum 63 kWh/m^2 in hotel. Especially, electricity consumption share of commercial facility is dominant and is ranged from 100 kWh/m2 to 290 kWh/m^2 per year. However, electricity mean value of office is 164 kWh/m^2 per year, which is approximately the same as maximum of the other 18 places. Electricity mean value of office exceeds 400 kWh/m^2 per year, and it is 2 times or more of the above-mentioned 25 places, thus it is important to hold a thorough investigation into the causes of the problems on the basis of analysis of subdivision data. Mean value of JM is 182 kWh/m^2, therefore, the share of electricity in complex facility is lower than commercial facility but higher than a single office or a single hotel.

5.2 Comparison of Heat Consumption Intensity

Moreover, space cooling and space heating consumption per floor area are calculated and compared with the consumption in the other complex facilities of Beijing, as shown in Figure 8. The mean value of space cooling and space heating consumption per floor area in JM is 447 kWh/m^2 and 128kWh/m2 per year, respectively. On the contrary, annual electricity consumption per floor area in the other complex facilities of Beijing varied from 150 kWh/m^2 to 440 kWh/m^2.And the average is 295 kWh/m^2, which is only 60% of that in JM. However about heat consumption (space heating and hot water), maxmium of JM is 132 kWh/m^2 per year, which is lower than the minimum value of that in Beijing (150 kWh/m^2). Because of the different meteorological condition of 2 cities, energy consumptions are different even in the same facilities.

6 CONCLUSIONS

In this paper, the present situation of energy consumption of JM in Shanghai is investigated, according to the measured data from 2004 to 2007. Meanwhile, various energy consumptions per floor area are compared with the facilities in the other big cities of China. The results canbe summarized as follows: 1. The electric power which the hotel consumes becomes nearly entire half, space heating and hote water occupy 52%, 49% and 71% of the whole, respectively. 2. In addition, the electricity consumption per floor area of JM is rather larger than that of the other facilities, therefore energy-saving techniques such as intelligent lighting system, frequency converted generator should be considered seriously. 3. The heat consumption per floor area of JM is is become like mean value of the relative object.

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