

# ENERGY IN BUILDINGS IN HONG KONG - A LESSON FOR THE MAINLAND

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## ABSTRACT

This paper discusses how the consumption pattern of occupants and architectural design of buildings affect the building energy consumption. An overview of the building energy consumptions in Hong Kong is presented. Electricity consumption data in Hong Kong may have resulted in various indications and estimates of the inevitable growth in electricity demand. The growth rate varies in different sectors and depends on the end-use pattern together with the economic activity. The increasing standard of living causes greater need of resources and sometimes may lead to abusive consumptions. In the last decade, the electricity consumption by the commercial sector increased by 52%. Not only the expansion of property market enabled the growth, but the mode of consumption and the architectural styles also brought the tremendous consumption. The community tends to chill the indoor environment far below the sensible temperature to avoid complaints in offices and shopping malls, and some buildings are illuminated 24 hours a day for decoration purpose. Wealth enables greater demand of energy while at the same time ignores the impact to the environment. However, the technological advancements in lighting, building materials and the space conditioning system partially compensates the surge of consumption. China is one of the world's most rapidly developing economies and the community is looking for higher standard of living.

## KEYWORDS

Building Energy, Consumption pattern, Energy saving scheme

## INTRODUCTION

The energy consumption in Hong Kong may have implications to mainland China in controlling energy consumption in a long run. China is one of the most rapidly developing economies in the world and the energy demand is tremendous. The improving living standard of the Chinese community and the economic transformation are associated with the rapid growth of energy consumption. Hong Kong is a typical example for economic transformation. The economy switched from the industrial to service sector in the 90's and people have been looking for higher standard of living. The mode of building electricity consumption in China in certain perspective is similar to that in Hong Kong as the service sector is also expanding and people are also looking for better living environment. Hong Kong is a major city of China and it can play an important role to share some experience with policy makers and building professionals for sustainability consideration.

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This paper reviews how the consumption pattern of occupants and architectural features of buildings affect the building energy consumption in Hong Kong by offering an overview of the energy consumption of Hong Kong in the last decade.

## ENERGY CONSUMPTION IN HONG KONG

Hong Kong is located on the eastern side of the Pearl River Delta. Within the territory's area of 1104km<sup>2</sup>, less than 25% of the land was developed. However, the demand of energy is substantial. Hong Kong does not have natural resources and hence all the energy sources are imported from China or other countries. Town gas (a manufactured gas), liquefied petroleum gas, oil, and electricity (from coal, natural gas and nuclear power plant in mainland) are the energy products used in Hong Kong (EMSD, 2006). They respectively took up about 10%, 5%, 33% and 52% of the total energy consumption (around 285,000TJ) in 2006. Electricity dominates the total energy consumption. Around 43% of the total energy consumed was in the form of electricity in 1995 and it increased to around 52% in 2006. The economic transformation from manufacturing to the service sector in the 90's changed the pattern of electricity consumption. The surge of electricity consumption in the commercial sector was driven by this transformation. In 1995, the commercial sector consumed 56% of the total electricity and the ratio increased to around 66% in 2006 as shown in figure 1. On the contrary, the rapid transformation drove the industrial electricity consumption down from 19% in 1995 to 9% in 2006. The ratio was low compared with the commercial and residential sectors. The electricity consumption ratio from the residential sector was relatively stable and it was maintained at around 24-25% in the last decade.

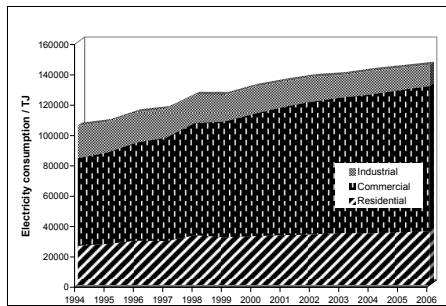


Fig.1, Electricity consumption in different sectors

## BUILDING ELECTRICITY CONSUMPTION IN HONG KONG

Hong Kong is a densely populated city with high building density. The building category accounted for over 90% of electricity consumption in 2006 (CSD, 2007). Most buildings are grouped into categories such as housing, retails, offices, restaurants, etc. The architectural styles of the buildings have been changing in the last decade and this could lead to significant impact on electricity consumption. The building electricity consumption from the industrial sector has been declining in the last decade and it is thus not addressed in our discussion.

### Residential sector

#### Public housing

In 2006, the residential sector accounted for 24% of the total consumption of electricity (CSD, 2007).

The major user categories are the public and private housing sectors. The public housing sector took up around 30% of the total residential electricity consumption and the total electricity consumption in public housing was around 11,000TJ. There are around 650,000 public rental flats in Hong Kong under the administration of Housing Authority and approximately two million people are living in the public housing (HA, 2007). The number of families moving to the public housing increased slightly from 657 thousands in 1995 to 692 thousands in 2006 (CSD, 2007). The Harmony series have been the major construction style of the public housing since 1992 and hence the electricity consumption on the effect of architectural style can be neglected. Figure 2 shows the electricity consumption of air conditioning systems, refrigeration, lighting and other consumption such as lift in public housing. The typical types of air conditioning system used in the public housing are the window and split type air conditioners. The cooling capacities typically range from 7000BTU/h to 24000BTU/h. A sharp peak of air conditioning consumption per family was found in 1998 because it was the warmest year since 1884 as recorded by the Hong Kong Observatory (HKO, 2007). The annual mean temperature was 24°C. Also, the electricity consumption per family from these air conditioners reached another peak in 2001 and then decreased from 2002 to 2004. There are several reasons for this observation. One is perhaps due to the outbreak of SARS in 2003 and people spent more time at homes. We may query that why there was a temperature increase from 2001(23.6°C) to 2002 (23.9°C) but the energy consumption dropped in these years (HKO, 2007). The government introduced the energy efficiency labeling schemes in 1996 in order to provide guidelines for consumers to purchase home appliances such as air conditioners. The scheme has been running quite well and many consumers now follow the suggestions in buying high energy efficiency home appliances. The life time of the window type or split type air conditioner is around 5 to 10 years and it is not surprising to see people start to replace their air conditioners by more energy efficient models, and thus enabling the electricity consumption per family per year started to decrease from 2001. The average annual electricity bill for air conditioner in each of the public housing family decreased from around HK\$1,500 in 2001 to around HK\$1,300 in 2004 if the electricity tariff was HK\$1/kWh. This was about 30% of their annual electricity consumption. The lighting consumption increased slightly from 550 kWh in 2000 to 620 kWh in 2004 in the public housing sector. Most of the public housing families are using fluorescent tubes and compact fluorescent lamps with power ranging from 14 W to 65 W (HEC, 2005). Also, they are used in the public places such as corridors, lift lobbies, etc. The annual electricity consumption on illumination was about HK\$620 and it was around 13- 15% of their annual electricity consumption.

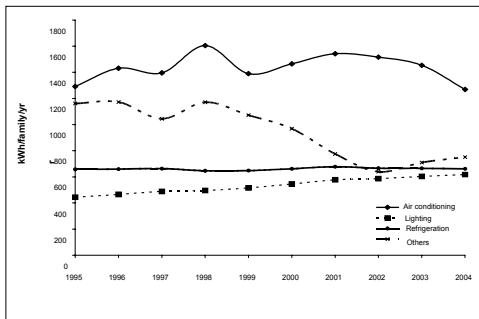


Fig.2, Electricity consumption in public housing

The consumption of refrigeration in public housing was stable in the last decade. It was maintained at around 650kWh/family/yr and led to about 15% of their annual electricity consumption (EMSD, 2006). The other consumption in Figure 2 includes lifts and home appliances such as televisions, washing machines, computers etc. These consumptions per family had showed a decrease since 1998 but in recent years it seemed to be going up again. It should be noted that the enhanced lift technology and the energy efficiency labeling schemes of home appliances might enable the declines of the consumptions starting from 1998 but apparently more demand on these items have been pushing the consumption up again.

### **Private housing**

The private housing was the largest user category in the residential sector, taking up almost half of the residential electricity consumption in 2006. The total electricity consumption per family in private housing was about 18,000TJ in 2006 and it was about 64% higher than that of public housing. There were around 1,103 thousands families living in private housing in 2006 (CSD, 2007) while there were only around 884 thousands families living in private housing in 1995 (CSD, 2006). The increase was far higher than that of public housing. The property markets have been expanding and the economic growth of Hong Kong has been driving people to pursue a higher living quality. More private estates were built with various club house facilities such as indoor swimming pools, gymnasium rooms, golf courts, etc. In addition, many high rise residential buildings have been built around the Victoria harbor since the retirement of the Kai Tak airport in 1997. The architectural style of the private residential buildings has been changed substantially. The property developers are specialized in making use of every inches of the land. In fact 12 out of 20 of the highest skyscrapers in Hong Kong are categorized as residential buildings which were all built after 2000. These building styles with those club house facilities could have significant impact on energy consumptions. Figure 3 shows the electricity consumption of air conditioning, lighting, refrigeration and other consumption per family in the private housing sector. The consumption trend of air conditioning was similar to the public housing sector but the peak was shifted to 2002. The annual consumption from each of the family from private sector was generally higher than public housing. The average floor area per person in public housing is about 11.9 m<sup>2</sup> (HA, 2006). This is smaller than that of private housing (18.02 m<sup>2</sup>). The power consumption of the air conditioning system is proportional to the area needed to be cooled. In addition, the affluence of the people living in private housing also enables higher electricity consumption. Some of the public places such as club houses and lift lobbies, etc in the private housing estates are air conditioned. These extra services and lifestyles increase the annual electricity consumption per family and this was reflected in the figures. Comparing with public housing, the recreational and external spaces in private housing are large and thus the electricity consumption from those spaces is higher.

The annual lighting consumption per family increased substantially from 397 kWh/family in 1995 to 920 kWh/family in 2004. The average lighting consumption from a private housing family was about 1.5 times higher than those living in public housing in 2004. The affluence could be the major reason for this extra consumption. As mentioned previously about the average floor area of private housing, it is generally larger than public housing as the flat area of public housing is arranged by the authority based on the size of the family. Additional illumination may be required for the extra spaces in private housing. Moreover, some of the lighting in private housing is used not only for illumination, but also for publicity and decoration of their properties. The recreational and external areas of some private estates are illuminated even in mid night. Many inefficient incandescent light bulbs are used in these areas

because of their dimming capability. The excessive lighting also creates light pollution to the residences nearby and the situation is even worse during major festivals. Lack of illumination control ordinance enables the excessive usage of lighting and results in tremendous growth of lighting electricity consumptions.

The consumption pattern of refrigeration and others in private housing were similar to that of public housing and the energy efficiency labeling schemes might contribute to the declines.

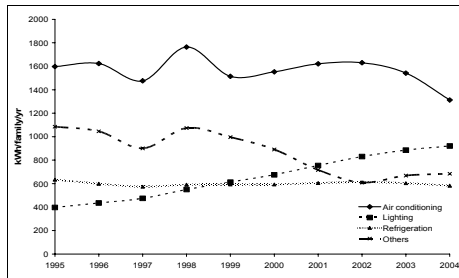


Fig.3, Electricity consumption in private housing

### Commercial sector

The commercial sector includes offices, retails, restaurants, hotels, health care centers, etc. The electricity consumption in this sector shared to around 66% of the total electricity consumption in 2006. The total floor area of the commercial sector increased from 14,045,000 m<sup>2</sup> in 1995 to 17,458,000 m<sup>2</sup> in 2005 (CSD, 2006) and the increase was about 24%. However, the electricity consumption in the commercial sector increased substantially by 59% in the last decade. This growth ratio was far ahead of the floor area growth. Air conditioning and lighting were the major consumptions and they contributed to around 31% and 18 % of the total commercial electricity consumption in 2004 respectively. Figure 4 shows the electricity consumption of air conditioning and lighting in the commercial sector per unit area. The technological advancement of chillers and the switch of air cooled to water cooled chillers compensated the growth on electricity consumption and maintained the air conditioning consumption at around 470kWh/m<sup>2</sup>/yr in the last decade. The surge of air conditioning demand could account from the lifestyle of the community. The increasing living standard encourages the community to spend more for an apparently more comfortable environment. In hot summer, the temperature of an air conditioned restaurant could be as low as 19°C and the temperature difference could be as high as 10-15°C from outdoor to indoor. The operators tend to set the thermostats far below the thermo comfort zone in order to avoid complaints from their customers. As a result, the air conditioning demand surges every year. The lighting consumption in the last decade is also shown in figure 3. It can be seen that the lighting consumption was around 263 kWh/m<sup>2</sup> in the last decade. It is supposed that the lighting consumption per unit area would decrease with the advancement of lighting technology such as the use of electronic ballasts and compact fluorescent tubes. However, this does not seem to be the case and in fact most of the lighting is going beyond the illumination purpose. The practical illumination levels in some retail shops and shopping malls are much higher than the suggested illumination level of 300-500 Lux (LD, 2007). Such a high intensity of light exposure may even have health impact to occupants in the long run. The high intensity external lighting for billboard displays and other advertisements in downtown areas also consumes a considerable amount of electricity. Some of them are illuminated 24 hours a day

creating light pollutions and nuisances to the residences nearby. The lighting overuse has been leading to the surge of lighting demands and the trend will continue if no regulation is made. In recent years many green groups have been advocating on this issue (FOE, 2007).

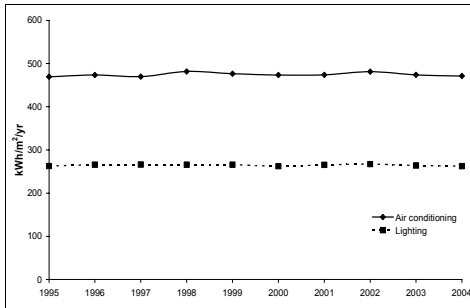


Fig.4, Electricity consumption in commercial sector per unit area

### Offices

Hong Kong is one of the leading commercial centers in the world. The demand of office space is tremendous. There are around 8,916 thousands  $m^2$  office spaces in 2005 and the growth was significant in the last decade (CSD, 2006). There was about 38% increase in office spaces from 1995 to 2005. Offices shared around 14% of the commercial electricity consumption in 2004. The air conditioning, lighting and office equipments contributed to the largest electricity consumption in offices. Figure 5 shows the annual electricity consumption of air conditioning, lighting, equipments and other consumption per square meter in offices. It was found that the consumption by air conditioning was stable. A very slight decrease was observed in 2003. The decrease may probably be due to the outbreak of SARS. The electricity consumptions from the air conditioning equipments contributed to around 48% of the total electricity consumption in offices in 2004. This ratio is high compared with the other sectors such as the residential. Most of the office buildings are sealed and the air conditioners are switched on even in winter. As for cooling system, some small offices use window type or split type air conditioners. While in most of the large office buildings, central air conditioning systems are equipped with air cooled or water cooled chillers. Although the water cooled chillers have higher efficiency than air cooled chillers, there are some limitations in the usage of these chillers such as the conservation of fresh water in the 90's, the space limitation of the buildings and the spread of legionnaire's disease from the cooling towers. In addition, the dressing codes in offices are business suits or dresses with long sleeves. This has a significant impact on the electricity consumption of the air conditioning systems because they need to chill the indoor environment far below the sensible temperature in order to achieve thermal comfort. The low indoor set point temperature implies that more heat is rejected from the buildings. Most of the offices are located in the densely populated urban district with high rise buildings and the heat rejection of the air conditioning system intensifies the heat island effect in the street canyons. The government suggested maintaining the indoor temperature at  $25.5^{\circ}C$  with 60% relative humidity. Considerable amount of electricity could be conserved if every one follows this suggestion. However, the community generally does not seem to follow this suggestion and there is argument that this temperature is too high during summer. The indoor temperature at  $25.5^{\circ}C$  is not practical if only a few people follow. But if the scheme is promoted successfully with most air conditioners in the territory adjusted to that temperature, the community may adapt to this temperature

to some extent based on the adaptive thermo comfort concept proposed by ASHRAE. Figure 5 also shows the lighting consumption in offices from 2000 to 2004. The consumption was steady in this period. This implied that the advancement of the lighting technology may be compensated by the consumption pattern in offices.

Apart from air conditioning and lighting, the office equipments such as computers also consume certain amount of electricity. The equipment consumption per unit area in the last decade is plotted in figure 5. It was found that the consumption increased from 99kWh/m<sup>2</sup> in 1995 to around 102kWh/m<sup>2</sup> in 2004. The majority of the office equipments are computers. Also, the mode of usage creates significant impacts on the electricity consumption. The power consumption of a typical computer is around 120-150W and it is about 20-25W when it enters to standby mode. Most of the computers in offices are entering to the standby mode when they are not in use. Suppose that the computers works for 9 hours a day and the remaining 15 hours are in the standby mode. Around 20-25% of the equipment consumptions can be conserved if all the computers were shut down when they are not in use.

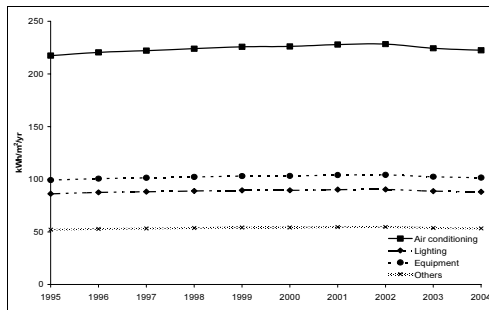


Figure 5. Electricity consumption in office per unit area

### Comparisons with other countries

The world's electricity consumption per gross domestic products (GDP) in 2006 was estimated (Table 1) (CIA, 2007). It was found that the electricity uses per capita in Hong Kong was lower than most of the industrialized nations and this may be due to the fact that over 90% of the GDP was contributed by the non-energy intensive commercial sector. However, the electricity uses per capita in some industrialized nations such as Japan and the European Union (EU) were lower than that in Hong Kong. This implied that the electricity consumption in the commercial sector was relatively high and energy conservation is needed. Currently, the mandatory overall thermal transfer value (OTTV) standard applies to building envelopes and the building energy codes (BECs) are implemented on a voluntary basis. The building electricity consumption may be reduced if the BECs are applied in the mandatory basis. However, public educations can be far more effective than the mandatory schemes (Hui, 2000). In addition to the electricity uses per capita, the electricity uses per person was also compared. China had the lowest electricity usage per person as seen in table 1. People living in some of the rural part of China are off the grid and thus substantially lower the average electricity consumptions. The average electricity consumption per person in Hong Kong was lower than most of the industrialized nations. The high population density might compensate the average electricity consumption and the non energy intensive service sector might also relieve the average electricity consumption.

Table1 Estimated electricity consumptions per capital/person in 2006

Country	Hong Kong	US	China	Taiwan	Singapore	Japan	EU	Australia	World
kWh/GDP US\$	0.21	0.28	0.99	0.51	0.25	0.19	0.21	0.32	0.35
kWh/person/yr	5778	12343	1887	7669	6666	7426	5754	10252	2473

## CONCLUSIONS

The building energy consumption in different sectors including residential and commercial sectors was evaluated. It is revealed that the occupant's consumption pattern and the architectural styles of the buildings can alter the energy consumption significantly. In the residential sector, the electricity consumption per family in private housing is higher than that of public housing. The air conditioning contributes to around 30% of the total electricity consumption for both public and private housing and it has been decreasing since 2002 with the effects of the energy efficiency labeling scheme by the government. The lighting consumption in public housing was slightly increased in the last decade, but the consumption from the private housing was elevated by 132% because of the excessive illumination in the external and recreational spaces. The economic transformation surged the commercial electricity consumptions in the last decade. The air conditioning and lighting are the major consumptions in the commercial sector and they have inclined to a relatively high level recently. The community tends to chill the indoor environment to low temperature to satisfy the occupant needs and the excessive lighting in retail shops and outdoor advertisements may be the possible reasons for the increase.

## ACKNOWLEDGEMENTS

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## REFERENCES

1. Census and Statistics Department-CSD (2006) "Hong Kong Annual Digest of Statistics".
2. Census and Statistics Department-CSD (2007) "Hong Kong in Figures".
3. Central Intelligence Agency-CIA (2007) "The World Factbook".
4. Electrical and Mechanical Services Department-EMSD (2006) "Hong Kong Energy End-use Data".
5. Friends of the Earth-FOE (2007) "Unveil the Pearl of the Orient".
6. Hong Kong Electric Company-HEC (2005) "Buying Guide for Lighting".  
[http://www.heh.com/hehWeb/DomesticServices/ElectricityAtHome/BuyingGuide/Lightings\\_en](http://www.heh.com/hehWeb/DomesticServices/ElectricityAtHome/BuyingGuide/Lightings_en)
7. Hong Kong Housing Authority-HA (2006) "Graphic Presentation on Housing Statistics".  
<http://www.housingauthority.gov.hk/en/aboutus/resources/graphicguides/0..1-1727-2755.00.html>
8. Hong Kong Housing Authority-HA (2007) "Public Rental Housing".  
<http://www.housingauthority.gov.hk/en/residential/prh/0..00.html>
9. Hong Kong Observatory (2007) "The Year's Weather".  
<http://www.hko.gov.hk/wxinfo/pastwx/ywx.htm>
10. Hui, S.C.M. (2000) "Building energy efficiency standards in Hong Kong and mainland China", In Proceedings of the 2000 ACEEE Summer Study on Energy Efficiency in Buildings, 20-25 August 2000, Pacific Grove, California.
11. Labour Department-LD (2003) "A Simple Guide to Health Risk Assessment-Lighting in Offices".