3339

Comparative Study of Beijing, Seoul, Tokyo and Shanghai

Scale of the City

The selected cities of this study can be referred to as mega-cities because of their large population. Prior to the research for these mega-cities, the spatial scale of urban agglomeration in terms of area or population density should be taken into account.

Concerning the administrative boundary, Figure 4-4-1-1 shows the current urban scales of Tokyo, Tokyo ward area, Seoul, Beijing, Beijing ward area, Shanghai and Shanghai ward area in 1997. Except for Seoul, there are two kinds of administrative boundaries of the whole city and ward area (central part), and statistical data is available for either both or one of them. This figure allows us to comprehend accurate statistical values with regard to urban scale of these four cities. Furthermore, the figure provides the future perspectives on how the transportation systems as a whole should be formed in these cities, especially in Beijing and Shanghai. In addition, it enables us to avoid misunderstanding of the definition of built-up area among these cities. More specifically, the boundary of the core ward areas (build-up areas at the center of ward areas) in Beijing and Shanghai is more comparable with Tokyo and Seoul, although the boundary is consistently changed over period and the data availability is much lower.

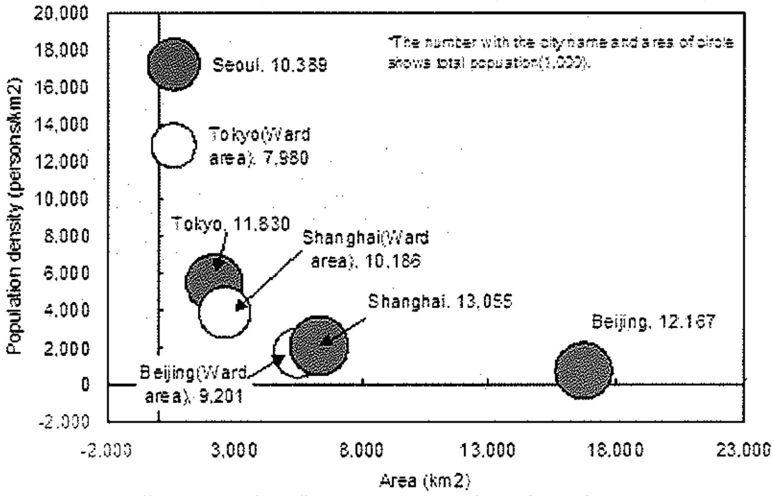
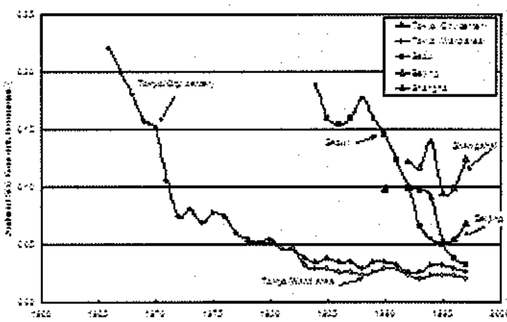


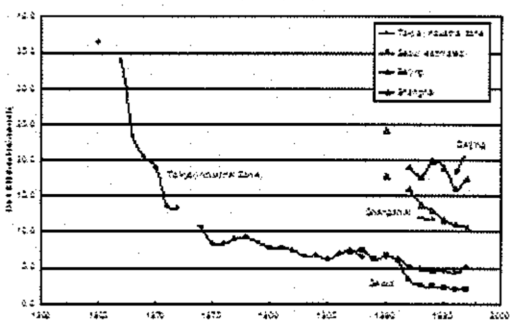
Figure 4-4-1-1: Population Size of the Four Cites

Ambient Air Quality

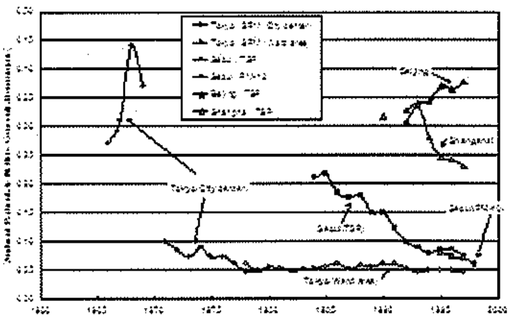
Among various urban environmental issues, air pollution is a major challenge for many cities in East Asia. Public concerns over air quality increases with the rising standard of living as it exhibits direct risks to human health. Major sources of air pollution in large cities are automobiles, although there are other diverse sources such as factories. Air pollution caused by traffic is most notable and serious in mega-cities in which the number of vehicles is increasing much faster than the pace of population growth. Therefore, this study conducts a comparative analysis of air pollution caused by automobiles in four mega-cities in East Asia, i.e., Tokyo, Seoul, Beijing and Shanghai. These four cities have a population of nearly ten million, and provide a good set of comparative analysis of cities which have both similar and distinctive characteristics in terms of transportation mode, land use, legislation for air pollution control, etc.



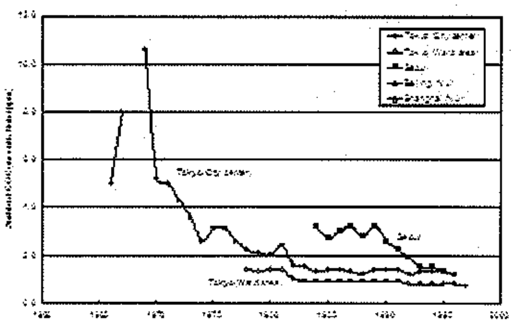
(A) Ambient SOx concentration (mg/m^3)



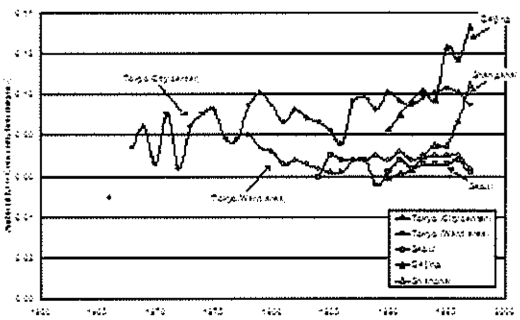
(B) Dust fall ($ton/km^2/month$)[1]



(C) Ambient PM concentration (mg/m^3)[2]



(D) Ambient CO concentration (mg/m^3)



(E) Ambient NOx concentration (mg/m^3)[3]

Figure 4-4-1-2: Comparison of the trends in major air quality indicators in 4 mega-cities

In all of the four cities, despite the government's efforts against the degradation of air quality, the emission of air pollutants from mobile sources is one of the most urgent challenges. The comparison of the ambient concentration of major air pollutants in the cities shown in Figure 4-4-1-2 confirms that the NOx concentration, largely discharged from automobile exhaust gases, still remains at a substantial level, while other air pollutants have to some extent decreased for the past several decades. As compared to the industrial air pollution that has recently been improved by various measures focusing on stationary source of air pollution, the future prospects on the improvement of mobile air pollution in these cities is not optimistic. The underlying reason is attributed to the existing situations in the case-study cities. Concerning urban transportation, it is expected that these mega-cities face the growing transportation demand from both freight and passengers that depends to a great extent on road transportation. Yet, considering the existing conditions in these Asian mega-cities, including rapid increase of automobiles and strong preference of private cars, the improvement of current road transportation system is so far very limited.

Indeed, the municipal governments made great efforts to reduce the use of private passenger cars, while they encouraged people to use public transportation modes. However, as seen in other regions, public transportation policy measures have a limited impact on the change of modal choice and trip behavior at individual level. Therefore, it is apparent that the changes of lifestyle and commuting behavior of individual citizens call for innovative policy measures. Furthermore, the governments in Japan, Korea and China, where the automobile industry plays a key role in their national economy, have to pay attention to the growth of the domestic automobile market. Given the situation, the improvement of the public transportation system towards sustainable urban environment poses new challenges on the issue of urban transportation in the selected East Asian mega-cities.

Transportation

(i) Vehicle Population

Although the motor vehicle fleet is not exactly the same as the frequency of their use, it is one of the reliable indicators to explain motorization. Figure 4-4-1-3 shows the trends of registered motor vehicles in Tokyo, Tokyo ward area, Seoul, Beijing and Shanghai, respectively. The registered vehicles are categorized into two groups, namely, passenger cars and trucks. While buses belong to the passenger car group in China, they belong to trucks in the other cities.

Concerning the number of passenger cars, motorization in Tokyo can be observed to have started since early the 1960s. Then rapid expansion occurred during the period between the mid1960s and the early 1970s. More specifically, between 1963 and 1973, the number of the passenger cars increased by 15.6 percent of the annual average growth rate and grew to 4.3 times as large as 1.7 million. In the 1990s, when Japan experienced the collapse of bubble economy, registered passenger cars did not show much growth in Tokyo. In particular, the number of registered passenger vehicles in the ward area of Tokyo has remained at the level of around 2 million since 1990. This is not simply because the economy has been facing a recession since 1990, but it should be perceived that the capacity of the introduction of new cars is saturated.

The rapid motorization in Seoul has occurred since the early 1980s. Without any discontinuity, the passenger vehicle fleet of Seoul has risen steadily and grew to 1.8 million in 1997. As a result, the past trend of passenger vehicle fleets in Seoul shows a logistic curve known as typical diffusion pattern of durable consumer goods in the market. Since 1995, there have been signs that the rapid increase of passenger vehicle ownership is approaching its limit. Considering that the scale of Seoul is quite similar to Tokyo ward area, the upper limit of registered passenger vehicles in Seoul will be around 2 million, as large as the current level for the Tokyo ward area.

Compared with Tokyo and Seoul, on the other hand, the total number of passenger vehicles in Chinese cities is relatively small, where privately owned passenger vehicles have yet to be popularized among citizens. As of 1997, the number of passenger cars in Beijing was only 16.6%, 28.0% and 32.3% as many as those in Tokyo, the Tokyo ward area and Seoul, respectively. Similarly, Shanghai corresponds to 6.6%, 11.0% and 12.8%. The number of passenger cars in Beijing was twice as many as that in Shanghai in 1986. As a result of recent increases of passenger cars in Beijing, the number increased to more than 2.5 times that in Shanghai by 1997. So far Beijing is leading the motorization trend in China.

Though there are certain gaps in time and saturation levels that are still uncertain for Beijing and Shanghai, four mega-cities show similar growth patterns in terms of vehicle population. The booming periods and growth rate depends largely on the condition of the economy and income levels. In addition, saturation levels are closely associated with land use. In this regard, the availability of parking space is important.

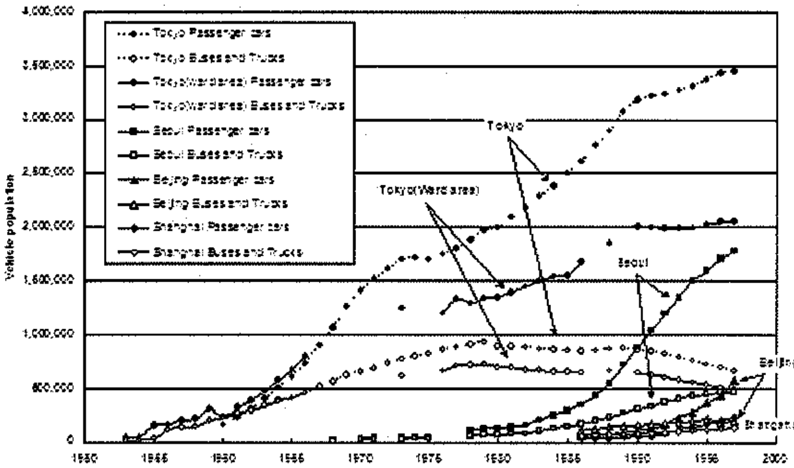
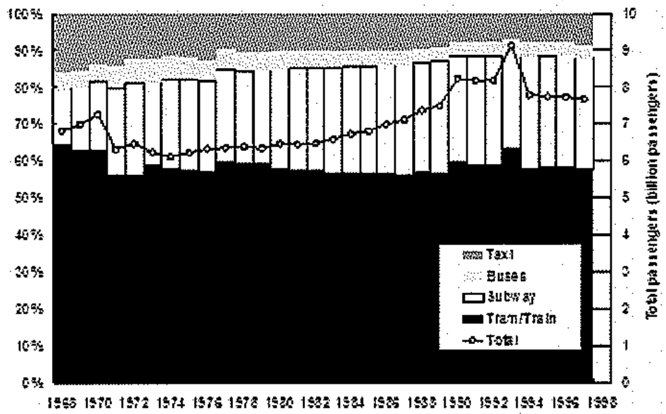


Figure 4-4-1-3: Vehicle Population

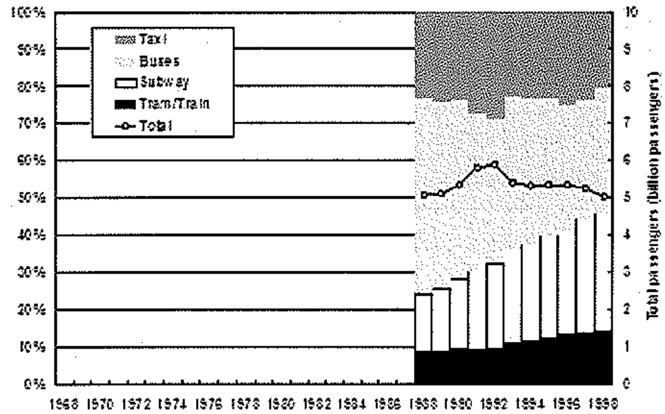
(ii) Public Transportation

Of generated trips and transportation demand, how much can be absorbed by public transit is very important for minimizing the use of private passengers. Whether public transit can provide attractive services or not is the key. Figure 4-4-1-4 presents the total passengers of public transit and their modal splits. Among these four cities, there are apparent differences in characters of transit mode shares.

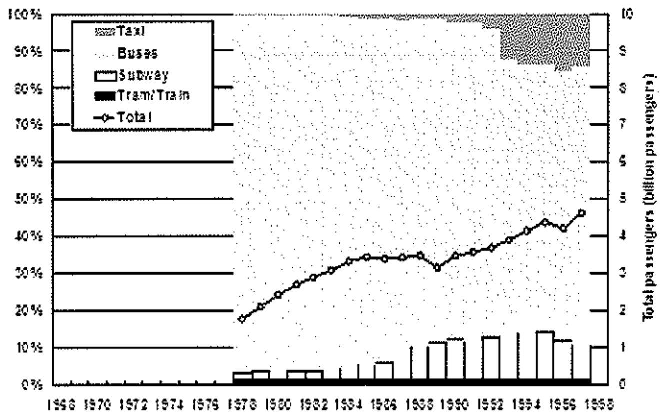
In Tokyo, total passengers have increased steadily since 1974 and peaked at 9 billion in 1992. Railway network systems including surface rails and subway lines in Tokyo are one of the most sophisticated one in the world. The surface rail networks in Tokyo developed before the motorization that came out behind the rail transportation system.



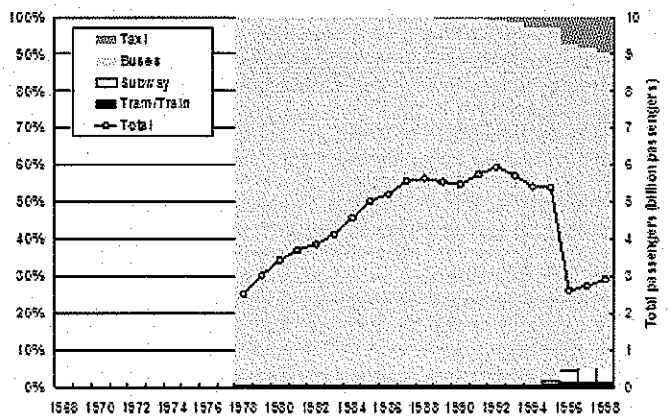
(A) Tokyo



(B) Seoul



(C) Beijing



(D) Shanghai

Figure 4-4-1-4: Trends in Public Transit Modes

As a result, the shares of on road public transit such as buses and taxis have remained small from the beginning. The surface trains have been keeping more than 50% of total share throughout the periods from 1968 to 1997. This is the result of the private sector involvement. When Tokyo experienced urban sprawl, many private rail companies constructed railways from the city center to the peripheral area. Since the government allowed them to make profits on the sale of real estate in order to recover the huge initial investments of railway constructions, they usually formulated the corporate groups with construction and real estate agencies. They newly constructed shopping centers and residential areas around each station contributed to the development of satellite cities and suburb areas. This enables them to provide better services of railway transits with lower fares. Subways run by public organizations expanded their share in passengers of public transit from 15% in 1968 to 30% in 1997.

In Seoul, public transit is much more diversified as compared to the other three mega-cities. In addition, the share of public transit has significantly changed by the shift from buses to subway during recent decades, while total passengers have fluctuated between 5-6 billion. As for road transit, while taxis have kept a certain share of more than 20%, buses have continuously been losing their share from 53% to 34%. Instead, subways have rapidly increased from 16% to 32% during the same period.

People in Beijing utilize public transits more often every year. The total passenger of public transit in Beijing has increased 2.6 times from 1978 to 1997. Public transportation in Beijing used to depend fully on bus transit including trolley buses with a share of 96% in 1978. In the 1990s, public transit started to diversify slightly. Since 1991, the number of taxi companies has increased dramatically from 354 in 1991 to 2,366 in 1997 - by 6.7 times. At the same time, the number of taxis has also rapidly increased from 14,000 in 1991 to 60,000 in 1997. As a result, taxi shares increased to 14% in 1997. Another important public transit method in Beijing is the subway that began operations in 1969. The subway gained shares every year and peaked at 13% in 1995. In order to address the deficit of subway operations, the Beijing government has doubled the fare since 1996. The rapid increase in subway fares caused a sudden drop in the number of passengers. The share of public transit in Shanghai shows a similar trend with Beijing, while substantial subway operations just started in 1994.

The differences of subway performance among these cities are compared specifically. Figure 4-4-1-5 shows the passenger traffic by subway and the total length of subway lines. The total length of subway lines in the Tokyo ward area is 236 km in 1997 that is as long as 1.1, 5.7 and 11.5 times than those in Seoul, Beijing and Shanghai respectively. Moreover, annual subway passengers in Tokyo are 2.5 billion in 1997 that is 1.6, 5.7 and 22.7 times as many as those in Seoul, Beijing and Shanghai respectively. Since the late 1970s, Seoul has constructed subway lines intensively and took just 15 years to catch up to the Tokyo ward area in terms of total length. However, annual passenger traffic has not increased as rapidly as the extension of lines. This relation, that is, the passengers per unit length of subway line, is defined here as subway performance. Tokyo has been keeping at a constant level of subway performance for more than 25 years. This recent aggravation of subway performance in Seoul is caused by the result of rushed subway construction. On the other hand, the performances in Beijing and Shanghai have quickly improved while the subway in Seoul has worsened the performance gradually since 1991. It is found that Beijing uses its capacity of subway lines to the fullest.

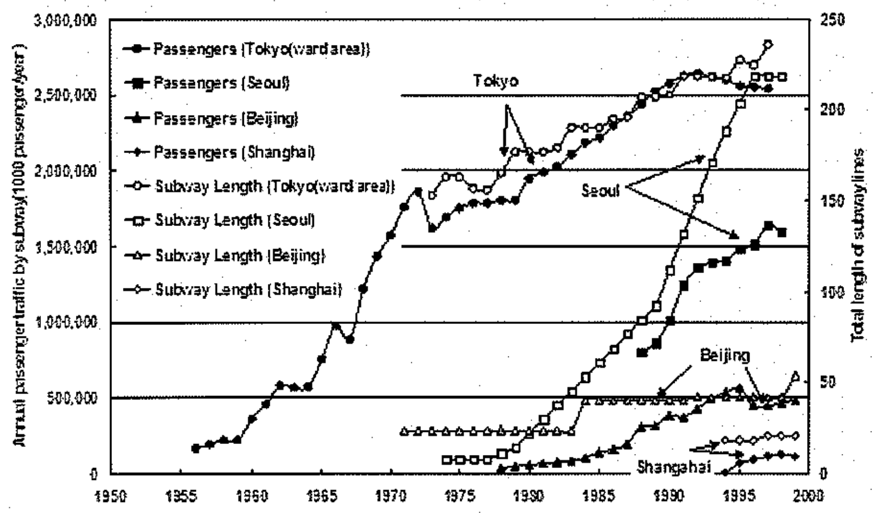


Figure 4-4-1-5: Subway System and Passengers

Hourly Load Curves of Buildings

In the total energy consumption profile in mega cities, the share of commercial building is quite important. Especially, the energy consumption patterns of commercial buildings in the cities like Tokyo and Seoul, which do not have many activities of manufacturing sector, rather have more service related activities. It is also worthwhile to note that the energy consumption patterns of commercial buildings are quite different from the activities of those buildings. Table 4-4-1-1 below shows the results of actual survey conducted in specific buildings in Seoul in 1992. This table indicates the major specifications of buildings, which are related to energy consumption. This survey is the results of one-year measurement of actual electricity and heat consumption. There are four categories of commercial buildings; Hotel, Hospital, Department Store and Office. The first two types are more or less operating for 24 hours, while the last two types are used mainly for business hours. The energy consumption patterns are quite different, depending on the activities of buildings. Therefore, it is critical to consider the load patterns of energy consumption for the commercial buildings.

Table 4-4-1-1: Basic profiles for buildings to be surveyed in 1992

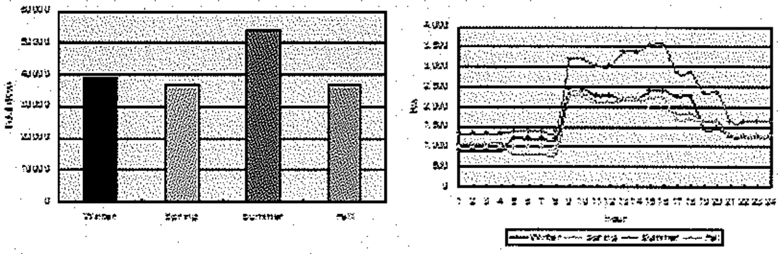
	Hotel	Hospital	Department Store	Office
Floor Space(m2)	176,786	129,273	64,440	299,753
Heating Space(m2)	105,443	102,702	26,411	196,695
Cooling Space(m2)	105,443	95,977	26,411	195,312
Floors	38	16	12	54
Heating/Cooling Method	Central	Central	Central	Central
Capacity of Heating(T/H)	24	40	15	56
Capacity of Cooling (R/T)	4,058	3,005	2,250	6,300

(i) Electricity

The electricity consumption in commercial buildings shows common and distinct characteristics, depending on the types of buildings, as showed in the below figures. First of all, all types of buildings show the higher electricity demand in summer. The main reason is obviously that the demand for cooling energy (electricity) increases in summer. However, the seasonal ratios of peak and off peak are different from types of buildings. For example, in the case of hotel, this ratio is the largest, since the air conditioning depends on each individual guest in the room, which in general requires more electricity demand in summer, compared with that in other types of buildings.

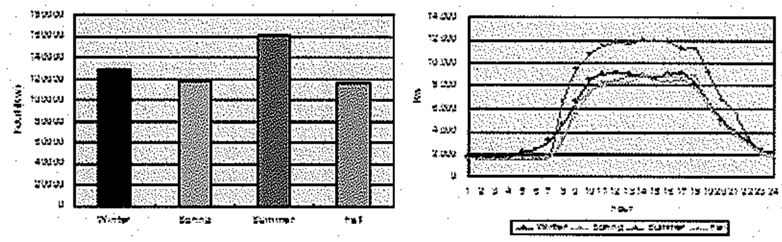
If we compare the hourly load curves by seasons, we also observe that the hourly electricity load patterns are heavily related to the activities of buildings. For example, the buildings for office and department stores use more electricity during business hours, regardless of seasons. During the business hours, the electricity consumption of such types of buildings is more than five or six times larger than off business hours. This observation has strong implication on energy analysis in urban cities. For electricity in urban cities, the load management is also important as much as the electricity consumption pattern itself.

On the other hand, the impact of the seasonal factor on the buildings such as hotel and hospital is relatively smaller, since those types of buildings are operating for 24 hour-bases. Therefore, the hourly load patterns for those buildings are not quite different.



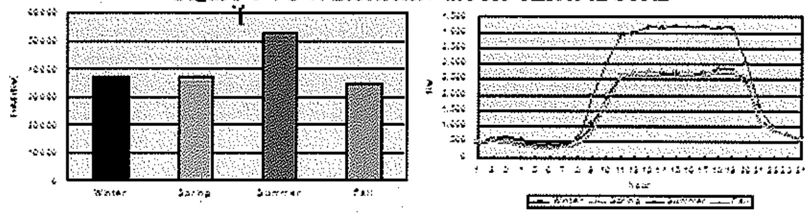
(A) Total per day by season (B) Hourly load curves by season

Figure 4-4-1-6: Electricity use for hospitals in Seoul



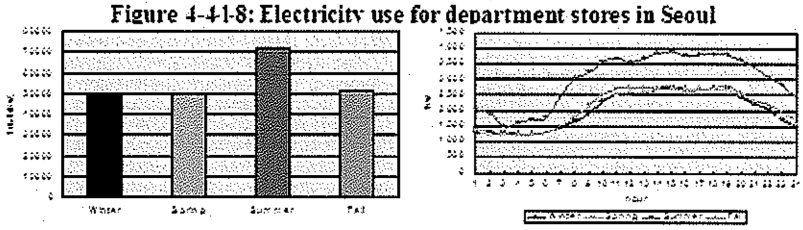
(A) Total per day by season (B) Hourly load curves by season

Figure 4-4-1-7: Electricity use for offices in Seoul



(A) Total per day by season (B) Hourly load curves by season

Figure 4-4-1-8: Electricity use for department stores in Seoul



(A) Total per day by season (B) Hourly load curves by season

Figure 4-4-1-9: Electricity use for hotels in Seoul

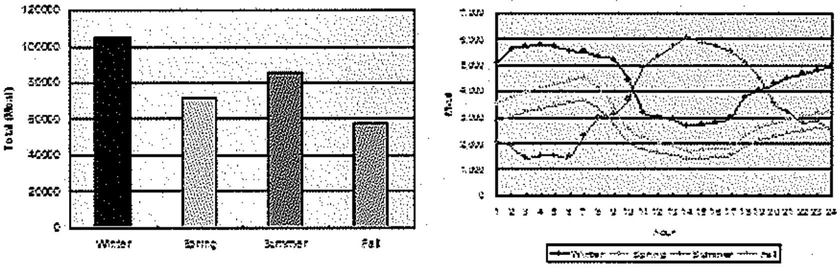
(ii) Heating Energy

The heating energy demand in various types of commercial buildings also shows common and distinct characteristics, depending on the types of buildings, as showed in the below figures. First of all, all types of buildings show the higher heating demand in winter. The main reason is obviously that the demand for heating energy increases in winter. The weather condition in Seoul is quite cold in winter, which requires heating energy demand. On the other hand, the heat demand (cooling demand) in summer is also very high. Depending on the types of buildings, the heat demand in summer is higher than that in winter.

However, the seasonal ratios of peak and off peak are different from types of buildings and this ratio is larger than that of electricity. Another common feature of heat demand in commercial buildings is that in summer during the daytime the peak for heat (cooling) is realized, while in winter this is realized in night time, if the building is used for 24 hours.

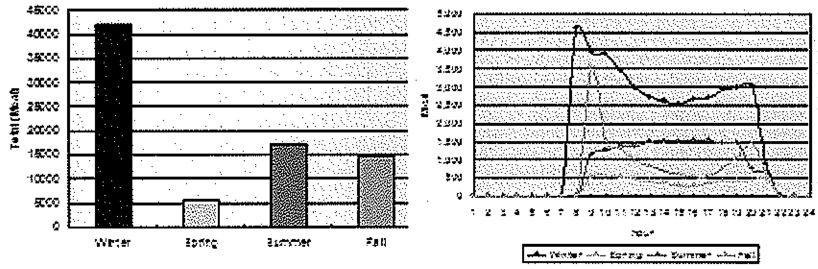
For example, in the case of hotel, this pattern is clearly observed. In the case of hospital, the demand for heat in winter and summer is relatively high and different hourly load patterns can be observed by seasons.

The buildings used during the business hours such as offices and the department store, show the similar hourly load patterns in heat demand as the case of electricity, which is to concentrate the energy demand during business hours.



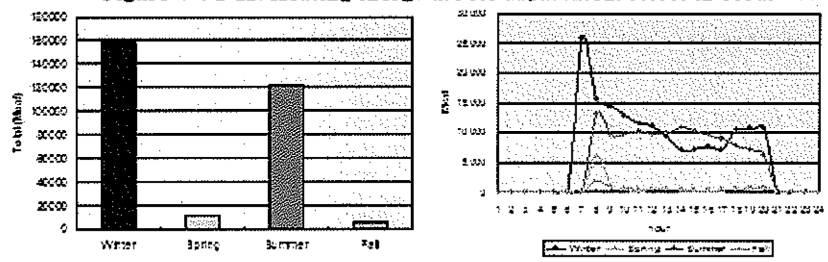
(A) Total per day by season (B) Hourly load curves by season

Figure 4-4-1-10: heating energy use for hotels in Seoul



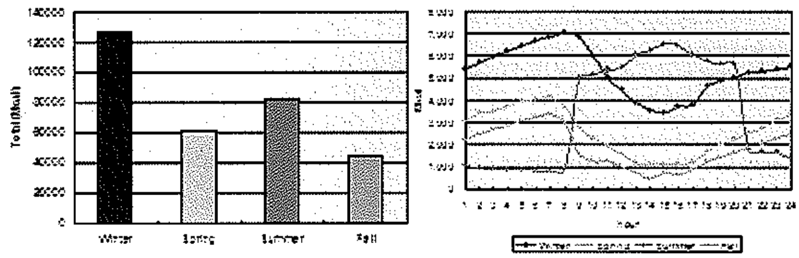
(A) Total per day by season (B) Hourly load curves by season

Figure 4-4-1-11: Heating energy use for department stores in Seoul



(A) Total per day by season (B) Hourly load curves by season

Figure 4-4-1-12: Heating energy use for offices in Seoul



(A) Total per day by season (B) Hourly load curves by season

Figure 4-4-1-13: Electricity use for hospitals in Seoul

Energy Consumption and Factor Analysis of CO_2 Emission

(i) Energy consumption

The final energy consumption of 4 mega-cities in East Asia is presented at the below figures. Due to the data limitation, we show trends for a few year in Chinese cities; Beijing and Shanghai. Here, it should be also noted that according to the definition of Chinese statistics, transportation sector does not cover the fuel use by transportation division of individual business and governmental bodies as well as private vehicle use. Therefore, the total gasoline consumption of all sectors is regarded as more reliable value for the total volume of vehicle energy consumption in China. Based on this consideration, the sectors in Chinese energy statistics are modified.

In terms of energy mixes, for Tokyo, oil has been the major energy source even in 1970's. The shares of town gas and electricity, both of which are considered as clean and convenient energy sources, have increased. The total energy consumption reached at almost 20,000 TOE in 1995.

On the other hand, the energy consumption trend for Seoul is to cover the period of 1990 - 1998. The first distinct feature is that during this period, the coal demand was almost disappeared, due to the tight environment regulation on air pollution in the metropolitan of Seoul. Like in Tokyo, the shares of town gas and electricity have been increased, mainly due to environmental consideration and income effect. However, in 1997, the energy demand in Seoul was peaked, reaching at the almost same level as in Tokyo. In 1998, it was sharply dropped, due to the financial crisis occurred in the late 1997.

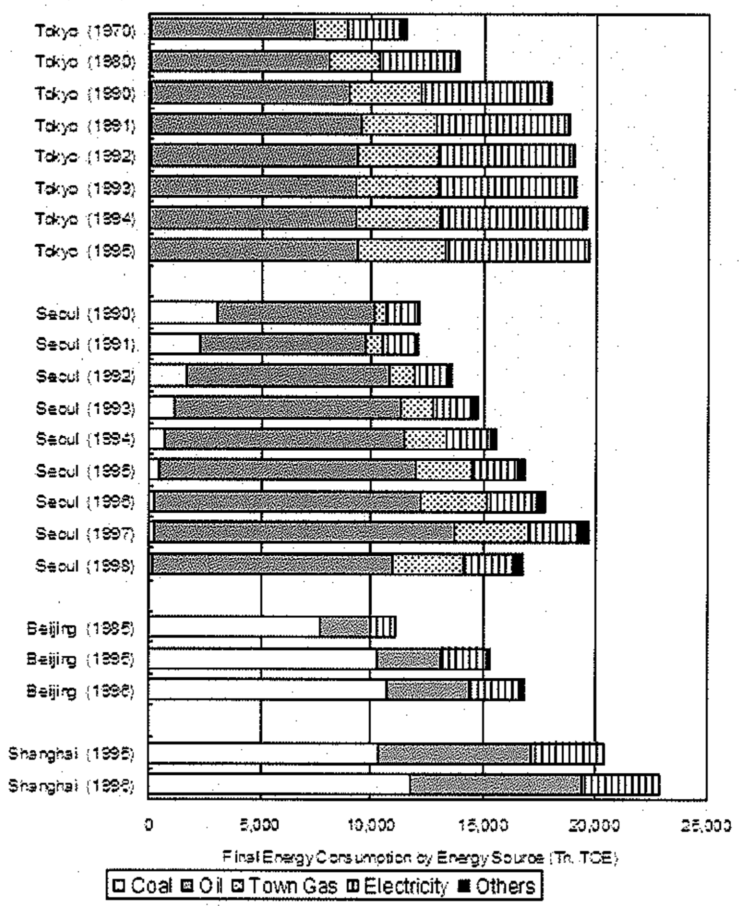


Figure 4-4-1-14: Final energy consumption by energy type

For Beijing, during one decade (1985 - 1996), the energy mixes remained more or less same, but the energy demand was increased. It is worth to note that the coal was the main energy source, which covered more than two third of total energy demand in 1996.

For Shanghai, the share of oil is much larger, since there are more industrial activities in this city, compared with Beijing. The total energy demand is much larger than that of Beijing. The total energy demand in Shanghai is the largest among those 4 mega-cities in this region.

Figure 4-4-1-15 shows the energy demand trend by sectors. In Tokyo, the absolute amount and shares of energy demand from transport sector has steadily increased. The share of residential and commercial sectors in energy demand has been the largest, as we expect this trend in major mega-cities. For Seoul, we observed the similar trend as in Tokyo. The share of residential and commercial sectors is even larger. On the other hand, the share if industrial sector is larger in Chinese cities.

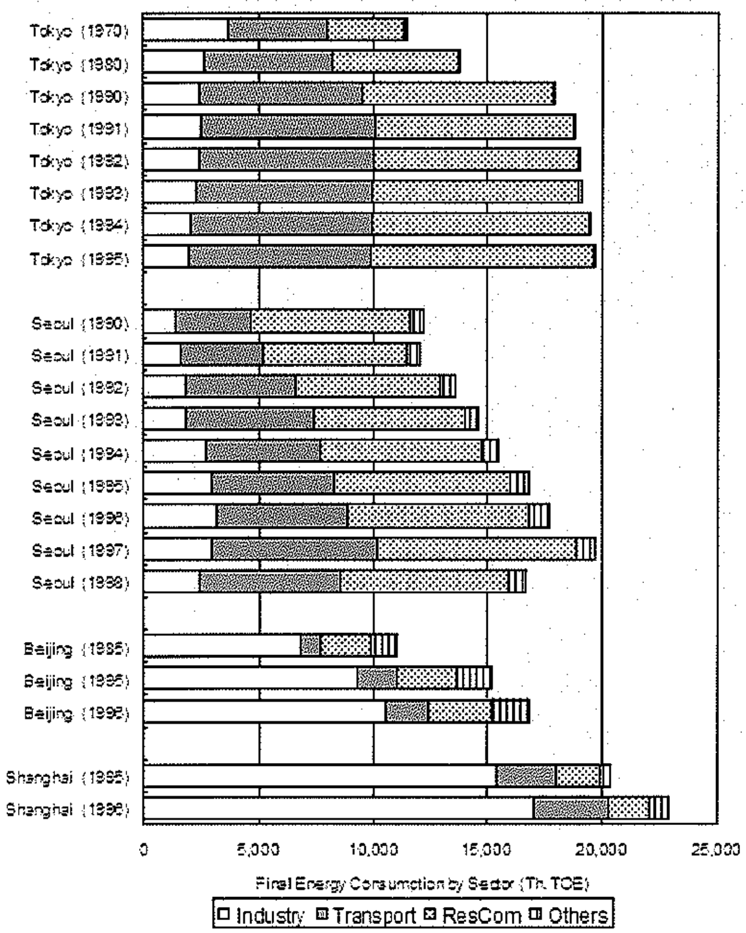


Figure 4-4-1-15: Final energy consumption by sector

(ii) Factor Analysis

There is a method to analyze the factors to affect CO_2 emissions in a specific economic unit, such as a country or a city. It is called 'factor analysis of CO_2 emissions', which was first introduced by Professor Kaya, Y. (Sometimes, it is called 'Kaya Identity'.) This identity can be easily explained by the following equation. The CO_2 emissions can be decomposed into four factors, which are shown in the right hand side of the equation. In other words, The CO_2 emissions can be explained by four factors such as the carbon intensity, energy intensity, per capita GRP (Gross Regional Product) and population. The carbon intensity implies that the content of carbon per unit energy consumption. The energy intensity is defined as the amount of energy to produce one unit of production. Per capita production implies the overall economic performance of a city or country. The trend of population is a kind of a scale variable, which explains the main underlying driving force of any economic activity.

$$CO_2 = (CO_2/E)*(E/GRP)*(GRP/Pop)*Pop$$
$$CO_2 = (\text{Carbon Intensity}) * (\text{Energy Intensity}) * (\text{Per capita GRP}) * \text{Pop},$$

where E is the energy consumption and Pop is the population.

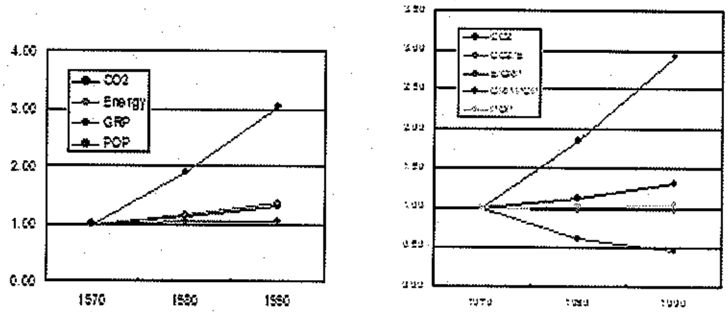
If we differentiate the above equation, the change of CO_2 emissions can be approximately decomposed into the change of those four factors.

$$\Delta CO_2 \approx \Delta(\text{Carbon Intensity}) + \Delta(\text{Energy Intensity}) + \Delta(\text{Per capita GRP}) + \Delta\text{Pop}$$

Hence, we identify the major factors to contribute the change of CO_2 emissions within a specific period. For the empirical study of factor analysis, we applied two cities; For Tokyo, we have data from 1970 - 1990 with 10 year span and 1990 - 1995 with every year span. For Seoul, we have data for 1990 - 1998 for every year.

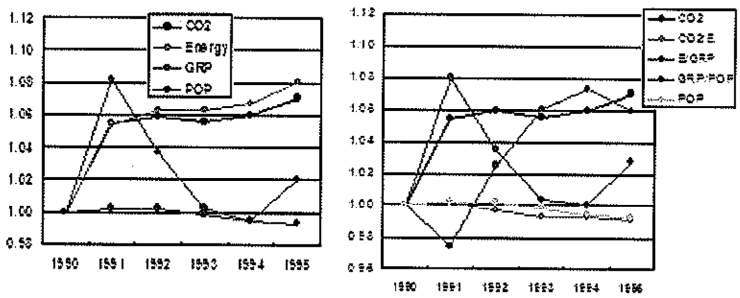
The first set of figures in the following graphs shows the case of Tokyo for every decade from 1970 (Figure 4-4-1-16). As we expect, the economy of Tokyo (GRP) has been increased by three times for two decades. However, the increase of population has been trivial. The energy consumption and CO_2 emissions have been increased with lower growth rates. The right-hand side graph shows the change of indicators in Kaya Identity. By this analysis, we identify which factor is the main contributor for the CO_2 emission increase during the period. Obviously, the per capita GRP increase is the main reason for the increase of CO_2 emission in Tokyo, which implies, in other words, that the expansion of economic activities in Tokyo is the main driver for the CO_2 emission increase in this city. Also, it is worthwhile to note that during the same period, the energy intensity has improved more than 50%, which means that during the same period, to produce one unit of output, about half of energy was required. This is an important contribution from energy sector for slowing down the increase of CO_2 emission. However, the contribution of carbon intensity was trivial, which means that the change of CO_2 emission by fuel switching to less carbon intensive one was trivial, while the change of population was also marginal.

However, this situation is changed, if we applied the same method for the period of 1990 - 1995 in Tokyo (see Figure 4-4-1-17). During this period, Japanese economy has experienced the severe recessions. The GRP during this period has increased by 2 %, while the population in Tokyo somewhat decreased. On the other hand, energy consumption and CO_2 emissions were increased by about 8%. As a result, during this period, the major contributor to the increase of CO_2 was the increase of energy intensity, while per capita GRP affected in negative way. Still, it is important to note that carbon intensity has consistently improved during this period.



(A) Major Indicators (B) Indicators for Kaya Indentity

Figure 4-4-1-16: Major indicators for Kava identity in Tokvo (1970-1990)



(A) Major Indicators (B) Indicators for Kaya Indentity

Figure 4-4-1-17: Major indicators for Kava identity in Tokvo (1990-1995)

PREVIOUS INDEX NEXT

Urban Policy Integration of Energy Related Environmental Issues in Selected Asian Mega-cities