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URBAN ENERGY USE AND GREENHOUSE GAS EMISSIONS IN ASIAN MEGA-CITIES

- POLICIES FOR SUSTAINABLE FUTURE

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CONTENTS

PREFACE

This report is one of the products of the research project entitled “Urban Policy Integration of Energy Related Environmental Issues in Selected Asian Mega-cities” undertaken by the Urban Environmental Management Project of the Institute for Global Environmental Strategies (IGES) with support from a number of researchers from Korea, Japan and China from April 2001 to March 2004. A number of other products, namely, a comprehensive database on four cities, academic journal papers, conference papers and publications in various newsletters and magazines have already been published. For IGES, a strategic policy-oriented research institute, outreach, multi-stakeholder dialogues and capacity building activities are an integral part of its research activities. Researchers in this project have also disseminated research outcomes to city policy makers, national governments and international institutions through various forums of policy dialogue, including events of The International Council for Local Environmental Initiatives (ICLEI), the Kitakyushu Initiative for a Clean Environment, and Clean Air Initiative for Asian Cities (CAI-Asia), as well as a number of scientific circles such as the International Human Dimensions Programme (IHDP) for Global Change Research.

This report is intended to integrate all major outcomes and to provide a holistic overview of the analyses of four cities. For this reason, this report is descriptive and relatively easy-to-read, aiming at an expert, as well as non-expert audience.

During the course of this project, three international conferences were organized in Kitakyushu in Japan, the East West Center in Hawaii, and Kanagawa in Japan. This assisted the project in strengthening international linkages and expertise, as well as facilitated the collection of information. This activity will be further expanded with special focus on urban transportation and will cover many cities in Asia in the future.

ACKNOWLEDGEMENTS

The authors would like to acknowledge a number of individuals who contributed directly or indirectly to the content of this report. In particular, the authors would like to thank Dr. Shinji Kaneko for his support, data collection efforts and estimation of emissions in association with the authors which made this report possible. The authors would also like to thank Professor Kevin He, Dr. Eui-Yong Yoon and Dr. Toru Matsumoto whose contributions are cited in this report. The advice and assistance of Dr. Tae Yong Jung during various stages of this research are gratefully acknowledged. The research outcomes from the work of collaborators used in this report are acknowledged in the relevant section titles of this report. A number of other colleagues from China, Korea and Japan contributed to the data collection of this project, of which this report is one of the outcomes.

The Asia Pacific Network for Global Change Research (APN), START International Secretariat and the AEON Foundation provided significant support to this project over the last three years. This research activity was endorsed as one of the core activities of the Industrial Transformation (IT) Project of the International Human Dimensions Programme (IHDP).

1. INTRODUCTION

The United Nations Framework Convention on Climate Change (UNFCCC), which was adopted in May 1992, sets an ultimate objective of stabilising greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous human-induced interference with the climate system. It urges the parties to protect the climate system in accordance with their common but differentiated responsibilities. The Third Conference of the Parties (COP3), in particular, adopted the Kyoto Protocol in December 1997, which includes legally binding commitments for developed countries to reduce their greenhouse gas emissions an average of about 5% by the target year of 2008 to 2012.

Within the region, the most significant increase of energy consumption and greenhouse gas emissions is expected to take place in mega-cities which have rapidly expanding populations that enjoy higher living standards and material affluence than that of rural areas and smaller cities. Increasing demand for passenger mobility and freight transport will be reliant upon increases in the number of automobiles, which not only create problems such as traffic congestion, air pollution and noise (having serious health and quality of life implications), but also will be a major cause of increasing energy consumption and CO_2 emissions. However, the carbon sink within the mega-cities, primarily urban greenery, is insufficient to absorb emitted carbons. The problems and difficulties that mega-cities are facing today will be those of smaller cities in the coming years, and actions of mega-cities can be a model for other cities. Thus, studies on mega-cities can provide a good basis for countries to consider comprehensive action strategies to promote sustainable development by employing efficient use of energy and resources to reduce environmental load. However, it is conceivable that emission reduction strategies must differ from city to city, and thus no single strategy will work for all situations.

Cities in rapidly industrializing regions of Asia are confronted with multiple tasks for economic development and environmental protection. They tend to place policy priorities to immediate, local issues and to regard global warming as a long-term, distant issue. The nature of energy use and greenhouse gas emissions from cities is not well understood in Asia. In fact, municipal policies to reduce energy consumption will bring multiple benefits to the community. It will help to solve air pollution and traffic congestion problems, and will also facilitate the reduction of CO_2 emissions. Limited research on sectoral energy use exists for industries and urban transportation from the viewpoint of managing air pollution, while the overall energy/emission picture is missing. Energy management at the city level was neither a priority, nor an important topic until recently because energy related decisions are made at the national level. In some cities, especially coal dominated countries such as China, energy restructuring is indeed in the policy agenda of the local governments. Recently, due to the growing concerns of greenhouse gases, efforts are being made to understand such phenomenon at the city level in greater detail. City policy makers are under growing pressure to incorporate greenhouse gases, especially CO_2 emissions into consideration while planning, although any policy measure solely for CO_2 reduction is a distant possibility for cities in Asia, with the exception of selected and relatively developed cities. Integrating energy consideration into policies, either by integrating energy concerns to overall urban development or by synergising measures to reduce air pollution and CO_2 emissions, is important. Efforts should be directed to provide support to these cities either by generating knowledge or by building their capacity to understand the problem and to identify the possible measures to implement sound policies. The prerequisite for systematic actions for this is the analysis of CO_2 emission budgets of cities, their drivers and associated policy analyses.

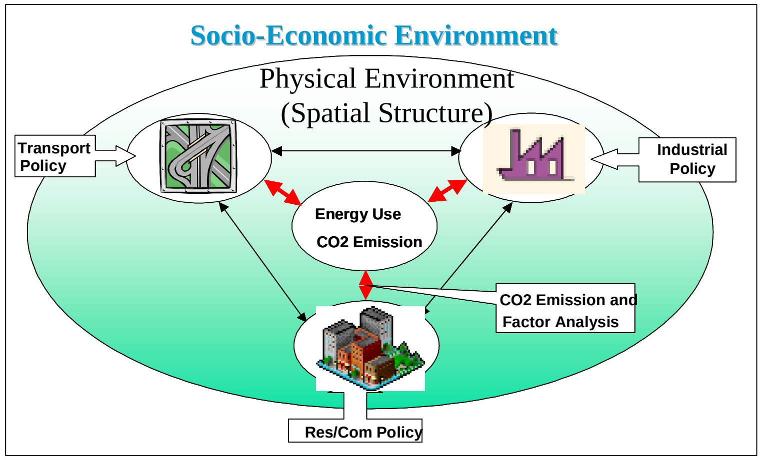


Figure 1.1: Analyses framework

Therefore, the objectives of this report are:

- to clarify the energy use related to CO_2 emissions from selected cities in Asia and to present the perspectives on future challenges at the city level;
- to show the extent of indirect CO_2 emissions to trace the cities' "CO_2 footprints;"
- to study the major driving factors and their past transitions;
- to trace the major challenges in terms of detailed sectoral activities;
- to identify the policy directions and policy challenges in cities; and
- to identify major opportunities and barriers for cities to implement integrated policies

The four mega-cities under detailed evaluation in this report are Tokyo, Seoul, Beijing and Shanghai. The wider perspectives on cities in Asia have been presented in this report from the analyses of these mega-cities.

Table 1.1: Mega-cities under investigation

City	Remarks
Tokyo	The most developed mega-city in Asia, which has modern urban infrastructure, well-organized mass transport systems, and a number of new energy saving technologies for buildings and appliances, and where people's awareness about global warming seems high.
Seoul	A modern city similar to Tokyo, with stricter land use regulation and planning but with a less developed mass-transport system, and larger energy demand for heating in wintertime.
Beijing	The capital city of China, undergoing rapid transformation, with an increasing population, new buildings, and automobile traffic. Preliminary analysis has shown that both Beijing and Seoul are following Tokyo in sectors like transport, but with phase-lag.
Shanghai	The richest mega-city in China, undergoing rapid transformation, with a growing number of new business facilities, increasing automobile traffic and diffusion of affluent lifestyles.

These cities share common characteristics in terms of high population density and are the most important cities in their respective countries. However, they are also very different in terms of a number of factors, such as level of income and development, form of governance, and institutional capacity. In the definition of cities, a number of methods are used, such as political boundaries, functional boundaries, and urban agglomerations, etc., in such studies. Figure 1.2 shows the population density and area of these cities. In this report, the assumed "City" definition of Tokyo, Seoul, Beijing and Shanghai are shown by the dark circles in Figure 1.2; i.e. Tokyo-to (Tokyo Metropolitan Government administered area), Seoul City, Beijing and Shanghai. Beijing and Shanghai are far greater in area than Tokyo and Seoul. However, the boundary of the core ward areas (built-up areas at the centre of ward areas) in Beijing and Shanghai are comparable to Tokyo and Seoul, although the boundary has consistently changed over time.

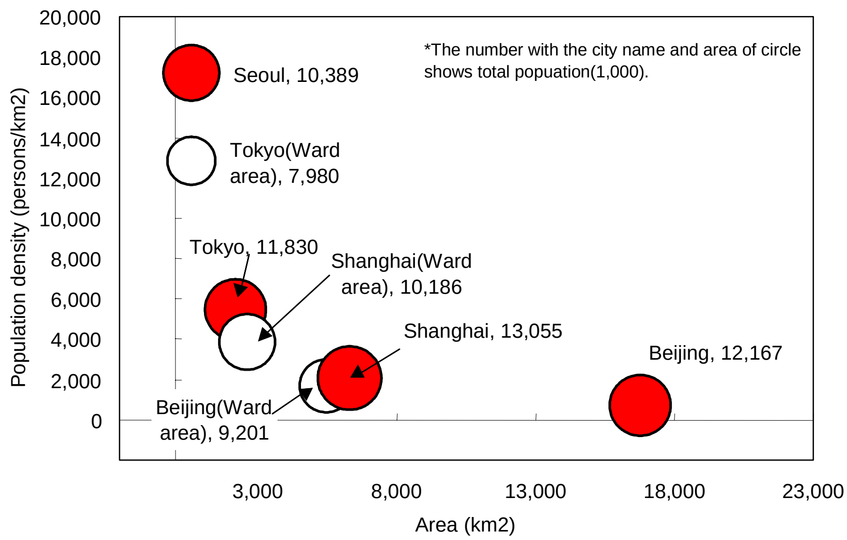


Figure 1.2: Area and population density of case study cities

This report also compiles and analyses the results from the research carried out by the author's collaborators under the framework set by the author in a bid to provide a comprehensive picture of cities. Collaborator's outcomes are clearly mentioned in the texts of the report in relevant section titles.

This report is divided into two sections. Section A is devoted to the understanding of energy use, CO_2 emissions, their major drivers, and their transitions in four mega-cities. Chapter 1, in particular, provides a framework and theoretical base. Section B is devoted to policy analyses which look into the major challenges for cities, their policy directions, opportunities and barriers. At the end, lessons from the four mega cities are outlined and a few suggestions presented to promote integrated approaches.

SECTION A: UNDERSTANDING ENERGY USE, CO_2 EMISSIONS AND THEIR DRIVERS IN SELECTED MEGA-CITIES

2. ENERGY, CITIES, AND SUSTAINABLE DEVELOPMENT

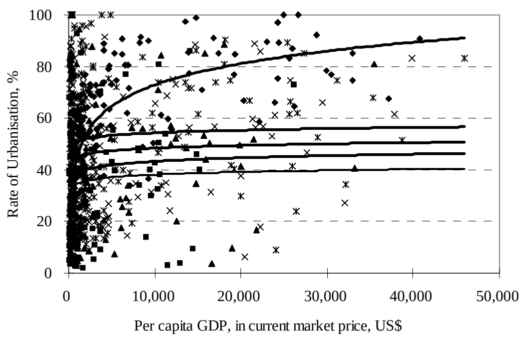
Sustainability and sustainable development have their own context specific definitions. In all those definitions, sustainability, energy use, emissions and cities are closely related with bi-directional linkages. This section tries to trace and highlight such relationships and proposes a policy framework. In particular, this section aims to answer a few questions such as: How are cities and sustainability linked? What determines urban energy use? What is the relation of energy and emissions to economic growth in cities? What is the role of urban policies?

2.1. Urbanisation and Role of Cities in Sustainable Development

Human-imposed threats to global sustainability have two fundamental dimensions: *population growth* and the ever-increasing per capita *demand for good and services*, particularly material needs and energy. Both impose direct and indirect pressures on the human carrying capacity of the Earth. Today, 75% of the population in industrialized countries live in urbanised areas (UN, 2002). Although a small number of the population live in cities in developing countries, cities are the driving forces for development and are centres for power, cultural and societal transformation.

The number of people living in urban areas is increasing rapidly worldwide. In recent decades, such rates have accelerated. In 1950, 30% of the population lived in urban areas, which has increased to 47% in the year 2000 and is expected to increase to 60% by the year 2030. From 2000-2030, virtually all population growth is expected in urban areas and mostly in less developed regions of the world (UN, 2002). Figure 2.1 depicts such phenomenon. In Asia, rapid urbanisation is a distinctive feature. From 1990-1998, the average urban population growth per year was estimated at 3% for East Asia and 3.2% for South Asia, in contrast to 2.1% for the world average (WDI, 2001). Accordingly, the potential of urban growth is tremendous in Asia; it is estimated that in developing countries the population in cities will increase from today's 37% to over 54% by 2030 (UN, 2002). This means, 2.6 billion people will live in Asian cities, exceeding twice the current population of the People's Republic of China and representing 53% of the world's urban population by 2030 (ECOASIA, 2001). Predictions for 2015 show a total of 358 cities worldwide with a population of over a million people, of which 153 are expected to be in Asia (HABITAT, 2001). From an estimated 27 mega-cities (exceeding a population of ten million), 15 such cities will be in Asia. The sustainability implications of these cities will be enormous.

Cities are contributors to the promotion of global sustainability, as well as the impediments to proceed towards sustainability. Since cities are centres of high living standards, cities are responsible for consuming large amounts of material goods, which leads to the over-utilisation of limited natural



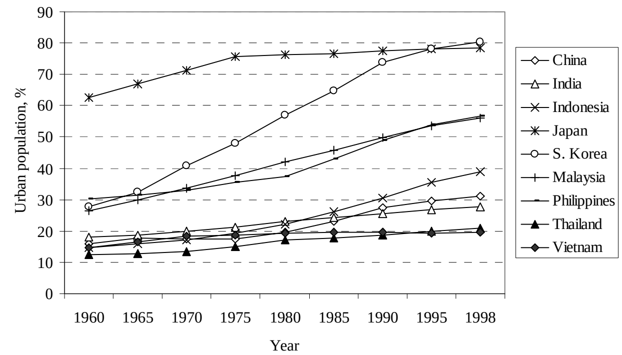


Figure 2.1. World urbanization trend
Source: World Bank Indicators CD-ROM 2001

Figure 2.2. Urban population in selected Asian countries
Source: World Bank Indicators CD-ROM 2001

resources, including energy resources, and emit large volume of greenhouse gases. At the same time, people living in these cities set the direction of future development in all aspects, and therefore, cities can greatly help in the process towards sustainable development. Cities are also engines of economic growth that provide a space for innovation, knowledge and technology, as well as employment. In particular, high population density and massive consumption opens several options to use “compactness” as a means to effectively utilise natural resources and efficient (and effective) urban infrastructural development. For example, compact settlement and high population density in cities may reduce per capita infrastructure and distribution costs, and open up opportunities for economies of scale. Thus, cities can greatly facilitate the implementation of measures to reduce stress to sustainability. Therefore, city and sustainability bring two major environmental issues to the forefront for policy makers: the first is the intensive consumption of energy and materials which affect natural systems and ultimately affect areas and people outside the boundaries of cities to future generations; the second is the exposure of a large and concentrated urban population to worsening urban air pollution, water pollution, solid waste and vulnerabilities related to global climatic changes.

2.2. Determinants of Energy Use in Cities

Energy, in particular, is an important element which plays vital role in sustaining the metabolism of cities. Energy has no conflict with urbanisation; rather, it opens up avenues for their efficient utilisation due to the “compact” nature of cities in terms of population and infrastructure. But, compact cities need complex energy management systems, and therefore challenges for policy makers become more complex. Asian cities have a tendency to acquire high population density in contrast to North American cities, in particular; North American cities are built on the assumption that cheap and abundant energy and land will be available indefinitely. However, the concerns of policy makers dealing with energy focus not only on issues related to availability or its use, but more on its implication after use. Energy is the input to the urban system, but it ultimately produces local air pollutants and greenhouse gases as waste, which exerts serious local and global implications on human health and the natural eco-balance due to their unacceptable concentrations. Therefore, efficient utilisation of energy is the key to conserving depleting energy resources, as well as reducing the level of an array of air pollutants, such as NOx, SOx, hydrocarbons, CO, particulate matters, CO_2, and so on. There are several key factors that determine the extent and nature of energy use in cities, as follows:

Compactness of urban settlement: The compactness of urban settlements influences transportation energy demand and possibly other areas, such as district heating and cooling using cogeneration systems. Urban sprawl, in particular, is detrimental to efficient energy use where low-density suburbs depend on lengthy distribution systems.

Urban spatial structure and urban functions: Urban spatial structure and urban functions affect energy use as they influence mobility demand to meet the needs of urban dwellers. The influence of mixed land use (residential and industrial, or residential and commercial, etc.) on energy is expected to be different from segregated land use. Urban zoning policy and industrial relocation from city centres to peri-urban areas in cities in Asia influence the travel demand and energy use significantly. Similarly, the energy use patterns in commercial cities are different from industrial cities.

Nature of transportation system: The nature of transportation systems is very important as mobility demand is a key aspect of urban life. Historically, cities have transformed from non-motorized transportation to rail based transportation and are currently dominated by automobiles. The energy implications from transportation systems depends on availability of built-in infrastructure for rail and road networks, mass transportation systems, share of public and private travel demand, role of alternative fuel vehicles, share of small-occupancy-vehicles, such as two wheelers (as in India, China, Thailand, Indonesia, etc.) and others. Increasingly, cars are dominating other means of automobile transportation in rapidly industrializing cities due to rising income, attached social stigma for owning cars and inefficient public transportation systems. This is putting pressure on issues such as energy security, as well as local air pollution and greenhouse gases from urban transportation.

Income level and lifestyle: Since cities are engines of economic growth, it is often difficult for policy makers to restrict increasing energy use, especially in rapidly industrializing cities. Past research on the relation between income and energy use at the national scale have clearly demonstrated that there is a strong correlation between per capita commercial energy consumption and gross domestic product. Despite some exceptions, it is generally accepted that per capita energy use increases with income (at some point it may actually decrease, following the inverted Kuznet curve). High income is associated with better lifestyles and more consumption, which affect energy use in or beyond the borders of cities. Consumption oriented lifestyles, in particular, are associated with greater utilisation of natural resources, as well as greater energy use to produce these materials (and hence, more greenhouse gas emissions). Essentially, this is important in the sustainability debate as global sustainability seeks for welfare and equity at all scales (spatial and temporal).

Energy efficiencies of key technologies: Energy efficiency is defined as energy needed to produce per unit of services. Since demand is for "services" but not for "energy," energy efficiency can directly improve or worsen energy use. Some of the technologies that dominate cities are automobile fuel efficiency, appliance efficiencies of key households and commercial sectors related to lighting, heating, cooling, cooking, electric appliances, etc. Such energy efficiency improvements are not merely functions of technology itself, but also of their utilisation patterns.

Industrial process: Energy efficiency of production processes and boilers (industrial energy use) affect energy use, but these factors are not discussed in detail in this paper. However, cities in Asia are rapidly relocating their primary industries to either peri-urban areas or outside of the city borders so that cities are increasingly dominated by the tertiary sector. Small and medium-sized enterprises (SMEs) have been prevalent in many Asian cities, which remain a big challenge for policy makers. Yet the role of local policy makers is limited in this area in South and South-East Asia.

Building technologies and building floor space use: Building related technologies such as air conditioners, district heating and cooling systems, insulation systems and other building energy management systems affect energy use significantly. Services such as lighting and space heating/cooling depend directly on building floor space. Such floor space use depends on a number of factors, such as real-estate market price to business culture and socio-cultural factors.

Waste management: Big-cities, especially mega-cities, are facing an increasing volume of solid wastes. Managing solid waste is becoming increasingly complex in cities. Policy makers are resorting to either incinerators or landfills, but both options emit greenhouse gases. Incineration uses energy and emits CO_2, while landfilling emits methane which is 22 times higher than CO_2 in their effect on greenhouse gases.

Climate factors: Climate factors, especially excessive heat and cold climate conditions, directly affect energy use due to the greater demand of heating or cooling services. Cities in North Asia such as Beijing require more heating energy, compared to cities with temperate climates. Some of the cities in Asia, such as Tokyo and Seoul, also suffer from urban heat island (this is a phenomenon where the core urban temperature is few degrees higher than the suburbs; this creates "hot-spots" in cities), where concentrated urban energy use is one of the major factors for exacerbating urban warming. This sometimes triggers a vicious cycle in summer, where increasing use of cooling devices contributes towards increasing heat island effect even further. Heat island may be beneficial to relatively "cooler" cities by reducing their heating energy demand in winter, but research has shown that the penalties in summer far exceeds the winter gains in cities such as Tokyo, which experiences hot and humid summers.

2.3. Income-Energy-Environment Conundrum and Role of Innovative Policies in Cities

As cities are dynamic systems, it is important to understand the energy and emission transitions of cities over time. Like the human body, cities can be characterized by "metabolism," where energy and materials are used as input and waste as output. In this process, waste production is a function of various driving forces and their interactions. The risk to citizens from exposure to waste is a prime concern for policy makers. Research has demonstrated that risk perception varies with income level and urbanisation, among other factors.

The World Bank (see WDR, 1992) has outlined the following three levels of urban environmental problems that correspond to different levels of economic development: (1) poverty related issues (such as safe water and sanitation) (2) industrial pollution related issues (such as PM and SO_2) and, (3) consumption related issues (such as solid waste and CO_2 emissions). However, this study does not mention much about the chronological evolution of those issues over time or with income growth. Bai and Imura (2001) hypothesizes and shows that in selected cities, cities proceeded through these stages: (1) poverty stage, (2) industrial pollution stage (3) consumption stage and (4) sustainable eco-city stage. This model provides a picture of how selected highly industrialized cities have evolved in the past; however a careful examination of the factors, other than income, are needed which might have contributed to this environmental transition, particularly in the case of less highly-industrialized cities. Without this background, we have no sound theoretical basis for predicting the environmental transition of cities that are currently undergoing rapid economic growth. In particular, we need to consider the following factors in cities, especially in the case of energy related environmental problems:

- The three levels of environmental problems discussed by the World Bank (1992) are associated with a number of environmental problems from energy use and are occurring simultaneously in Asian cities, rather than in stages. This is partly due to the existence of different income classes created by large income disparity among urban dwellers.
- Income is only one factor in a large set of factors (political, cultural, societal, economical, geographical and urban management) that determine the dynamics of urban environmental transition and the associated environmental burdens from energy consumption.
- Evolution theories, such as that discussed above, implicitly supports the hypothesis that the transition of cities follows some fixed or pre-defined path, which in itself is not convincing. Policy implications from such analysis are difficult to use in a practical sense. In reality, each city evolves differently due to a unique set of internal and external factors. IIED (2001) has shown that historical transition cannot provide a model for future urban development when global resources are being depleted and other conditions are evolving.

As an alternative to evolutionary theory, McGranahan et al. (2001) presents a model of urban environmental transition, in which the severity of local, regional and global issues are compressed rather than treated in stages. This provides a casual picture of shifting environmental burdens from the local to the global, from the immediate to the delayed, and from issues that threaten health to issues that threaten life support systems.

Table 2.1 Gross National Product per capita (in US$, 1990)

Country	1965	1990	Average annual growth, %
Indonesia	190	570	4.5
Philippines	529	730	1.3
Thailand	484	1,420	4.4
Malaysia	870	2,320	4.0
South Korea	972	5,400	7.1
Singapore	2,312	11,160	6.5
Hong Kong	2,554	11,490	6.2
Japan	9,313	25,430	4.1

Source: World Bank. (1992) World Development Report 1992: Development and the Environment. New York: Oxford University Press for the World Bank.

Table 2.2 Gross Regional Product per capita of selected Asian cities, 1990 (in, US$ 1990)

City	GRP per capita
Surabaya	726
Jakarta	1,508
Manila	1,099
Bangkok	3,826
Kuala Lumpur	4,066
Seoul	5,942
Singapore	12,939
Hong Kong	14,101
Tokyo	36,953

Source: Kenworthy, J. R. and Laube, F.B. with Peter Newman, Paul Barter, Tamim Raad, Chamlong Poboon and Benedicto Guia (Jr) (1999) An International Sourcebook of Automobile Dependence in Cities, 1960-1990. University Press of Colorado, Boulder.

Income growth of Asian cities has been tremendous, which usually exceeds their national averages (Table 2.1 and 2.2). The Environmental Kuznet Curve (EKC) theory suggests that a rise in income leads to the increase of environmental adversity, and after some point, it decreases environmental adversities, thus resulting into an inverted U shape curve. Many past studies have tested the validity of the Environmental Kuznet Curve (EKC) with different sets of environmental adversities. The validity of EKC seems reasonable for industrial air pollution, particularly SO_2 emissions. Even if the EKC is valid at the national level, the applicability in the context of cities is subject to many factors. Firstly, cities do not have well defined boundaries and their interactions with other places are very intense and not well documented. There is the real problem of obtaining reliable data to check validity or to set boundaries for the city. Secondly, there is a growing trend to relocate major industries away from densely populated areas; what remains in a city are commercial activities, service industry and activities that put greater emphasis on mobility, infrastructure development and households. One of the major sources of air pollution in most cities is urban transportation and industries, which are often entangled with low income class and urban poverty. Thus, an EKC relationship between income and environmental adversity is difficult to establish at the urban level.

The major reason for this anomaly is that when income grows, not only is the scale of growth important, but also the nature of the growth. This question of "How did income grow?" is responsible for the transition in terms of the relation between income and environmental adversity. This places emphasis on two important aspects of development: (1) *the dynamics of the urban transformation process, their evolution, and distinctive internal and external features*; and (2) *the responses from policy makers*. These two issues simultaneously affect urban environmental transition for energy related issues.

Thus, urban environmental problems resulting from energy use are strongly tied to urban management. When environmental problems occur, most policy makers try to solve immediate issues without paying enough attention to the underlying causes. This is true all over the world, but perhaps more so in South Asia, where policy implementation is either weak or does not exist—or the policy itself is not well formulated to address the problem. Therefore, there are wide variations in environmental problems between cities with similar income levels; a well-managed city with medium or low income may be significantly different from a similar city with poor urban environmental management. The lesson is: good policies and better urban environmental governance can do miracles and their role goes beyond economic levels.

Cities are confronted with the dual tasks of economic development and environmental protection, yet they tend to give policy priorities to immediate, local issues and to regard issues such as global warming as long term, distant threats. In fact, municipal policies to reduce energy consumption will bring multiple benefits to the community. It will help solve air pollution and traffic congestion problems, and will also facilitate the reduction of global problems such as emission of greenhouse gases, in particular CO_2. There are many technology and non-technology management options through which the environmental implication of energy use can be minimized while not seriously compromising economic growth. For example, in Japan, the decoupling of environmental problems and economic growth in the 70s and 80s was largely the result of environmental regulations with end-of-pipe and process enhancements (Sawa, 1997). Each city has their own distinguished features to address; the role of policy makers is to explore those policies and implement them successfully.

2.4. Comprehensive Policy Framework for Energy-Environment Management in Asian Cities

Traditionally, energy management has not been a priority agenda for municipal policy makers. Major energy related decisions are usually made by national governments. Accordingly, no comprehensive policy framework exists for energy issues at the city level. Interventions in energy related policies at the local level emerge primarily from either energy availability or from its impact on the environment, namely air pollution. In the case of energy management, often there is no policy framework. Even for urban environmental management, a comprehensive policy framework is lacking in general, and environmental policy response is often fragmented into different sectors and actors without proper coordination.

In recent decades, the need to empower local governments to manage their cities is well understood by national governments and such processes of empowering local governments are underway. Yet, the major role of municipal government is often limited to solid waste management in

Asian cities[1]. In many countries, water/wastewater and air pollution management is the responsibility of the national government, especially in South Asia and South-East Asia. North-East Asia, which is more developed economically, is one step ahead of this trend, where local governments are assuming more authority on all aspects of governance. In China for example, the decentralization of environmental affairs is well institutionalized, where the Environmental Protection Bureaus of each city are responsible for their environmental affairs. These bureaus work under the municipal government in coordination with Provincial Environmental Protection Bureaus, under the framework set by the State Environmental Protection Administration (SEPA). Four cities in China, namely Beijing, Shanghai, Chongqing and Tianjin, are cities with provincial authority and work directly with SEPA. In India, city level environmental bureaus do not exist institutionally. The role of large municipal governments, such as Mumbai, is limited to solid waste and, to some extent, waste water management. Mumbai City exercises some level of authority over air pollution through traffic management only. The Central Pollution Control Board[2] of India exercises much of the pollution control through the State Pollution Control Boards. Most of the industrial pollution is under the responsibility of State Industrial Development Corporations. Similar to the four cities in China, the capital city of India, New Delhi, is categorized as "State," which exercises authority as other states of India (Delhi Pollution Control Board). In Thailand, the Bangkok Metropolitan Administration exercises limited control over air pollution management apart from the management of traffic, the management of one air quality monitoring station, and the in-use vehicle monitoring in association with traffic police. The Pollution Control Department under the Ministry of Natural Resources and Environment is responsible for implementing air pollution control measures in Bangkok. Therefore, close cooperation between municipal governments and national agencies is mandatory for a sound policy framework and policy implementation mechanisms. Apart from the government, the involvement of other stakeholders in policy making and policy implementation process is important. Top-down process alone may not work. Typically, the private sector and civic society (NGOs, media, community groups, consumer associations, etc.) play significant roles in such processes, and without their consensus, policies may not produce desirable effects or may result in failure. Such stakeholder involvement processes in centrally planned countries, such as China and Vietnam, is weak and the government is very strong. In North-East Asia, in general, despite strong governments, some consideration to stakeholders, especially corporate stakeholders is given. Increasingly, policy makers are realizing the need to involve different stakeholders in the policy making and implementation process.

[1] In some cities, waste water management falls under the municipal government (for example, India). This depends on the size and economic or political status of a city.
[2] These are semi-autonomous bodies with representation by different stakeholders. The Ministry of Forests and Environment is the line Ministry.

Most of the policy responses on energy-environment issues (namely, local air pollution and CO_2 emissions) emphasize end-of-the-pipe solutions and, in general, ignore major drivers which cause them. In the case of the transportation sector, major policy efforts are diverted to emission compliance and fuel quality interventions, rather than controlling vehicle ownership, controlling vehicle utilisation rate, and reducing the need to travel through interventions in urban planning. Such end-of-pipe measures are essentially short-term measures which are often favoured by policy makers and political establishments.

Choices of policy instruments, such as regulatory, economic and institutional arrangements, are important to implement policies. Regulatory instruments (command-and-control), in particular, prevailed in the past and are still dominant today. Several cities have tried economic instruments for energy-environmental management for specific problems. These include pricing regulations, incentive mechanisms, and taxes and subsidies applicable to various sectors. Singapore's use of economic instruments to control vehicle ownership and use has caught worldwide attention. Some efforts at the city level for promoting voluntary mechanisms, such as appliance labelling and information disclosure on energy performance of buildings, are being made in Tokyo.

A comprehensive urban energy policy framework seeks for a balanced consideration to short-term and long-term measures and addresses a variety of methods and stakeholders. Figure 2.3 proposes such a framework.

The policy framework in Figure 2.3 accounts for the direct energy use and emission, and accounts for indirect energy use and CO_2 emissions embedded in the electricity use in respective sectors. Cities, especially mega-cities, are centres for consumerism; production of these goods and services usually takes place outside the city boundaries where CO_2 is emitted. Therefore, the city's emission footprint extends beyond its boundaries and cities should be responsible for such emissions. In order to obtain a clear picture of the responsibilities of cities, accounting of indirect energy use is necessary. Policies aiming at indirect emissions are presently unimaginable for municipal policy makers in Asia. In Japanese cities, such policies are being implemented through the government's general policy to create "sound material cycle society." Although explicit policies at local level are not expected at this time, it is important to raise the awareness of policy makers towards this issue.

The causal framework would be: (1) finding available options for the short-term; (2) intervention of appropriate drivers; (3) finding right ways to intervene (4) finding appropriate tools to intervene and to create consensus; and (5) monitoring and feedback.

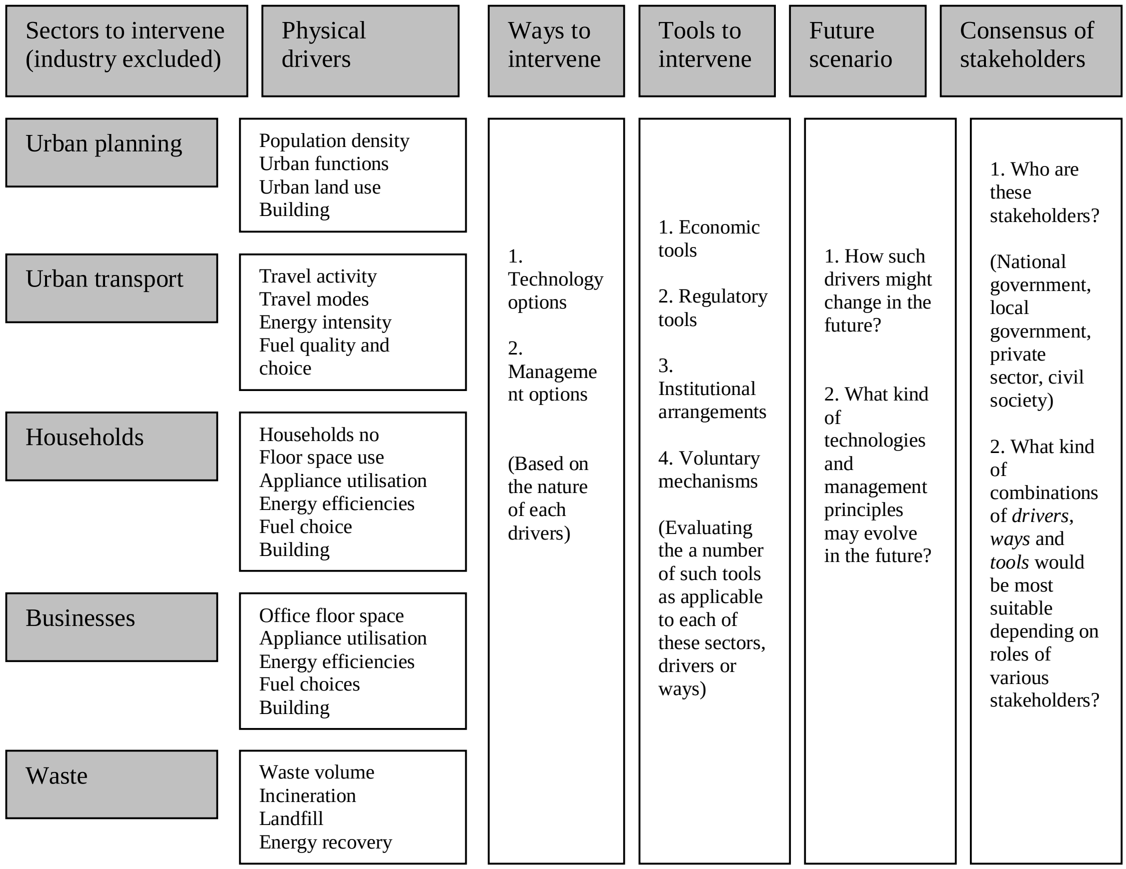


Figure 2.3 Policy framework for energy-emission related issues in cities

3. DRIVERS FOR ENERGY CONSUMPTION AND EMISSIONS

3.1. Introduction

Earlier sections outlined some of the physical drivers in a comprehensive policy framework. Those drivers were mostly *sectoral* in nature. At the macro-level, the major drivers for energy consumption and CO_2 emissions in rapidly industrializing cities are related to lifestyles, and behavioural and socio-economic aspects of urban life. A sound understanding of these drivers is essential for pro-active/anticipatory, as well as end-of-the-pipe (curative), policies. Rapidly industrializing cities, such as Tokyo in the 1970s and 80s, Seoul in the 90s, and Beijing and Shanghai in last two decades, have undergone drastic transformations in the behaviour of such drivers. Some of these drivers are:

- urban demographic changes;
- urbanization pattern and land use;
- income growth;
- structure of economic activities;
- lifestyle and societal transformation;
- materials dynamics and consumption patterns;
- climate and urban geography.

This section describes some of the salient features of such transformation in Tokyo, Seoul, Beijing and Shanghai in last few decades, along with sectoral drivers especially in households, businesses, urban transport and waste sectors.

3.2. Demographic Changes

Urban demographic trends, especially urban population (day and night time) and household number and size, affect scale of energy use. In terms of population, Tokyo has stabilized since the early 1970s; the population of Tokyo's 23 wards, which represents downtown Tokyo, is decreasing. Seoul has experienced unprecedented population growth before the 1990s, but soon after 1990 the population started decreasing. Beijing and Shanghai's population has been growing, especially after 1980, but perhaps less than other similar cities in South-East Asia. Like other cities, much of this growth comes from migrant populations, as the one child policy is strictly enforced in cities in China. In the case of Beijing, changes in the political boundaries of the city have often resulted in drastic population changes. Despite these trends, the number of households is increasing in all of these cities, primarily due to rapidly decreasing household size. The population of Shanghai is greater than Tokyo, but the number of households is smaller than Tokyo. The number of households could be more important for energy use than the scale of population.

Another important aspect of demographic change is the difference in the day and night-time population. Tokyo attracts a significant number of commuting population, which is not counted in the resident population. In Tokyo, 33% of the total workforce commutes from surrounding cities and prefectures, utilising its well-developed surface rail and subways. The ratio of daytime to night-time population has increased from 1.15 in 1975 to 1.25 in 1999, which has stabilized since 1990. Such ratio is as high as 1.41 for the Tokyo ward areas (TMG, 2000). In Seoul however, such ratio is nominal, about 1.04, and is insignificant in Beijing and Shanghai (Yoon and Araki, 2002).

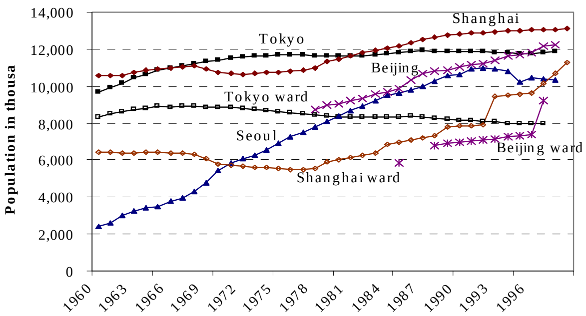


Figure 3.1. Population trend, in thousands

Source: Internal database compiled from statistical yearbooks of cities

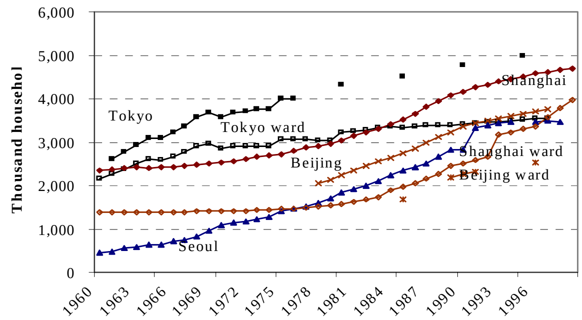


Figure 3.2. Household population, in thousands

Source: Internal database compiled from statistical

3.3. Urbanisation Pattern and Land Use

Urban population density, structure of urban functions (concentration of certain activities, etc.), and urban geography and land use patterns (mixed land use vs. zoning) are important factors for energy use and emission. A compact city for example, may have *smaller per capita energy consumption* due to compact infrastructure; at the same time, the city may have *smaller per capita building floor space*, thus further reducing energy use. This may not always be true, as there are a number of other factors that affect energy use. In Japan, the pattern of energy consumption shows that per capita energy consumption in urban areas, which is denser, is lower than that of non-urban areas (Ichinose et al., 1993) and this phenomenon is common in developed countries. On the contrary, in developing countries such as China and Thailand, the opposite trend is reported (Ichinose et al., 1993). The income gap between urban and rural areas is smaller in developed countries, and therefore the effect of density can be seen. In developing countries, the income gap is “large,” in which the effect surpasses the “effect of density” for commercial energy uses (non-commercial energy uses are not considered in many studies). In later sections, we will show that energy and CO_2 performance (in terms of a cumulative index of economy and per capita energy/emission) of Tokyo and Seoul is better than Beijing and Shanghai, which is partly due to density effect. This is especially true for central business districts of cities. Large cities in China, such as Beijing, have a combination of urban and rural settlements (city definition is based on political boundary) and therefore it is difficult to generalize such behaviour at whole city scale.

Traditionally, the urban structure of Tokyo is *core-central*. Tokyo plans to move from a core-central urban form to a multi-core urban form, which might have significant energy implications. Apart from this, mixed land use is prevalent in Tokyo, which plays an important role in energy use for transportation. Urban zoning for industrial and other activities are common practice in Beijing and Shanghai. The exact implications of relocating industries to designated zones from residential areas on energy use are difficult to quantify but such measures have resulted in the reduction of the concentration of air pollutants in residential areas in Shanghai and Beijing (Stubbs and Clarke, 1996). In Beijing, five ring roads contain urban areas; the first surrounds the "Forbidden City"; the second contains the downtown areas; the third, fourth and fifth ring roads embrace the urban core, urban area and built up areas respectively; beyond the fifth ring roads are suburban and rural areas. These suburban areas are expected to grow substantially, as many new housing complexes are under construction in and around this ring road. Beijing is building fourteen satellite towns in suburban areas outside the fifth ring road. Such plans are expected to increase sprawl and travel demand in the future and may affect energy demand and CO_2 emissions if infrastructure provision remain energy-inefficient. In the case of the Seoul metropolitan area, the most recent urban expansion has taken place around Koyang, Paju, Kimpo, Inchon, Ansan, Sihwa, Sungnam, Anyang and Suwon (Yoon and Lee, 2002).

3.4. Income Growth and Lifestyle Changes

Rapid industrialization in North-East Asian cities has resulted in high economic growth rates. Tokyo has experienced sustained economic growth since the early 1960s. It went into recession from the early 1990s. The financial collapse of South Korea in 1997 had obvious implications for Seoul, but Seoul has re-gained growth since then. The double-digit growth in Beijing and Shanghai has continued since 1990. This has led to an increase in disposable income, which affects the lifestyle of residents, affordability and thus higher energy consumption. Such lifestyle changes are reflected in the consumption of material goods, fashion and leisure activities. Upsurges in the use of electric appliances in households and businesses are described in the next section. Figure 3.3 shows trends of per capita gross regional (city) products in the four cities in last few decades. At the households level, the difference in income is greater in these cities. Figure 3.4 shows the household income for Tokyo and Seoul.

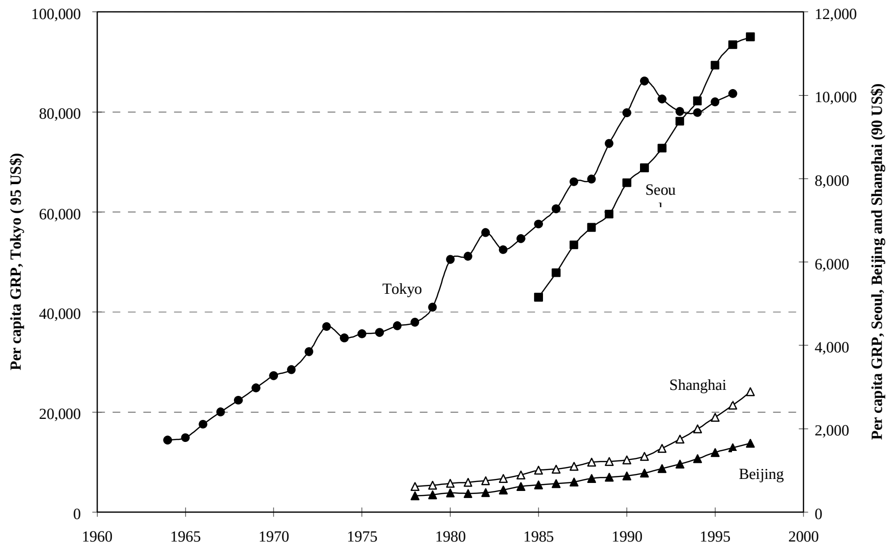


Figure 3.3. Trends of per capita gross regional products for four cities

Source: Internal database compiled from statistical yearbooks

3.5. Structure of Economic Activities and Others

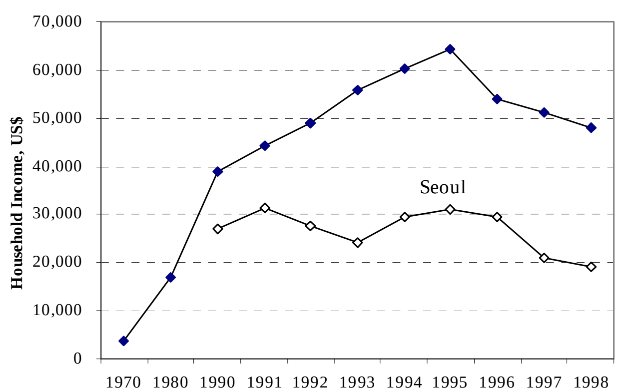


Figure 3.4. Household income (NDIS) in Tokyo and Seoul

Source: Internal database compiled from statistical yearbooks

The gradual shift from primary industries to tertiary and commercial activities has been observed in cities. Growing populations, high population density, noise and environmental problems from primary industries are forcing industries to relocate from city centres to the outskirts and peri-urban areas. At the same time, increases in tertiary sector activities are prevalent in cities with consistent increases of the value-added from tertiary sector. By nature, Tokyo and Seoul are commercial cities but Beijing and particularly Shanghai, are industrial in nature. Accordingly, the industrial sector is expected to play a major role in any measures to reduce energy use and emissions in Beijing and Shanghai, unlike Tokyo and Seoul. The share of the tertiary sector in the total value added of the city has continuously risen in Tokyo from 67% in 1980 to 78% in 1997. Similar trends in other cities are shown in Figure 3.5.

Cities close to the northern hemisphere, such as Beijing, use more energy for heating in winter than Tokyo. In contrast, hot and humid summers in Tokyo drastically increase energy use of air conditioners.

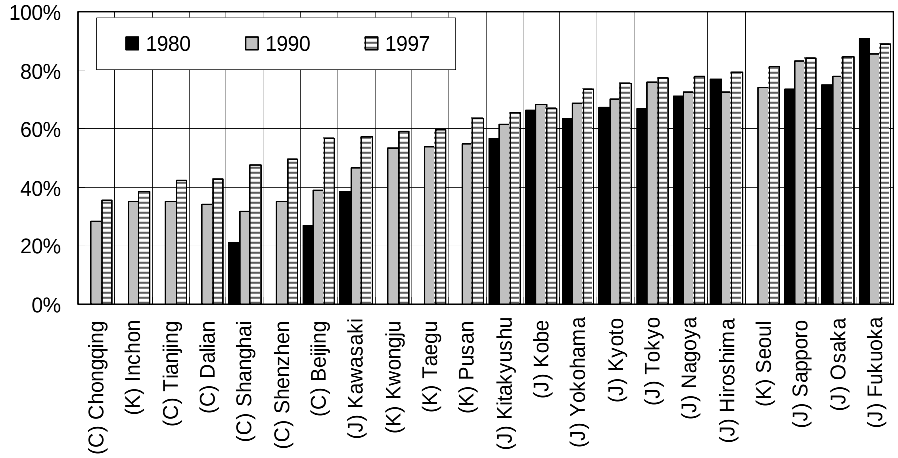


Figure 3.5. Share of value-added of tertiary sector in selected cities

Source: Dhakal, S. and S. Kaneko (2002). Urban Energy Use in Asian Mega-Cities: Is Tokyo a desirable model? Proceedings of IGES/APN Mega-City Workshop on Policy Integration of Energy Related Issues in Asian Cities, 23-23 January, 2002, Riga Royal Hotel, Kitakyushu, Japan, pp 173-181.

3.6. Households and Business Sectors

A number of factors in households influence energy use. Cooking, lighting, electrical appliances, and heating/cooling devices are the major activities whose scale and intensity of use determines energy use. Lifestyles and technology are key issues to be addressed in any measures to reduce energy use from households. Building floor space per household, which is one of the major factors, has not increased significantly in Tokyo in the last two decades (between 50-60 square meters per household from 1980-2000). Such increase has been nominal in the urban areas of all four cities however it has drastically increased in rural areas of Beijing and Shanghai (Matsumoto et al., 2003). Tokyo is more or less saturated in terms of key household appliances[3]. Central heating systems are predominant in Seoul, Beijing, and Shanghai, unlike Tokyo. In the case of Seoul, oil based central heating and cooling systems are popular, while coal is still a major source for residential boilers in Beijing and Shanghai (changes in fuel structure is rapid in households). Energy efficiency has reached a limit so that further drastic efficiency improvement is difficult in Tokyo. Beijing and Shanghai are rapidly

[3] Tokyo: Refrigerator (1.2 per hh), microwave oven (almost 1 per hh), washing machine (1.1 per hh), electric vacuum cleaner (1.3 per hh), TV (about 2 per hh), and video player (1 per hh). Air-conditioner use has gradually increased to about 1.6 per hh, while kerosene heater use has drastically decreased from the early 1980s

catching up with Seoul and Tokyo in appliance use and diffusion level[4]. Building insulation is relatively weaker in these cities, especially in residential houses (compared to Europe and North America), which are responsible for energy losses. Office automation and increasing use of electrical and electronic equipments, especially computerization is one of the major drivers in Tokyo. Since Tokyo is a commercial city by nature, such contribution is predominant. The fuel type, efficiency and nature of boilers used in central heating and cooling systems is another important factor in the energy use of household and business sectors in Seoul, Beijing and Shanghai. Table 3.1 compares some of the technological efficiencies of Shanghai with that of OECD countries.

Table 3.1. Comparison of energy efficiency in Shanghai and in OECD countries, 1998 (Indicative)

	Unit	Shanghai	OECD countries
Coal-fired electricity production	(GJ el/GJ fuel)	0.38	0.40–0.44
Primary steel production	GJ/ton	20–25	18–20
Oil refining	GJ/GJ	0.03	0.03–0.07
Coal-fired industrial boilers 4–10t steam/ hr	(GJ steam/GJ fuel)	0.65	0.7–0.75
Passenger cars	L/100 km	10	8-14
Colour TV	Watts	100-150	70-120
Air conditioners	Kw cold/kw el	3.6-4.4	3.8-5.5

Source: Dolf Gielen and Chen Changhong (2001). The CO_2 emission reduction, benefits of Chinese energy policies and environmental policies: A case study for Shanghai, period 1995–2020, Ecological Economics 39 (2001) 257–270.

3.7. Urban Transportation

3.7.1. Speed and Scale of Motorization

In the transport sector, a growing number of private cars are key drivers for energy use and CO_2 emissions. Motorization in Tokyo started in the early 1950s, with the rapid rise in vehicle ownership in the 1970s. After the 1970s, ownership rates have not increased rapidly. Automobile growth has stagnated in Tokyo ward areas due to saturation; such growth is nominal for Tokyo since the collapse of the Japanese economy in the late 1980s. In Seoul, rapid motorization began only in the mid-1970s and early 1980s, but growth rates have been tremendous, becoming saturated by the mid 1990s, following a typical S-shaped market penetration curve (Figure 3.8). Beijing and Shanghai have rapid rates of motorization as shown in Figure 3.6. Beijing, compared to Shanghai, has a higher scale of motorization. Shanghai started with a low level of motorization but is rapidly caching up, and the gap that existed between Beijing and Shanghai has narrowed in recent years. In relation to the income stage (per capita economic output), Seoul has reached a higher level of motorization at lower income stages, as compared to Tokyo. The case of Beijing is serious; while its income is constantly rising, the inability to shift to rail based mass transportation might put it into a similar situation as that of

[4] Diffusion rate of refrigerator in urban Beijing and Shanghai was 100% in 2000. Similarly, air conditioner diffusion in urban Beijing and Shanghai in 2000 was 60% and 80%, respectively. Diffusion for TV and microware is over 100% in all four cities.

Bangkok in the mid-1990s. Shanghai, in particular, seems to follow Seoul in the per capita vehicle trend. Tokyo, Seoul and Beijing seem to have a 20-year time difference for the same level of motorization; Tokyo in the 1950s, Seoul in the 1970s, and Beijing in the 1990s have the same level of motorization as shown in Figure 3.6 (people per passenger vehicle). This also highlights the

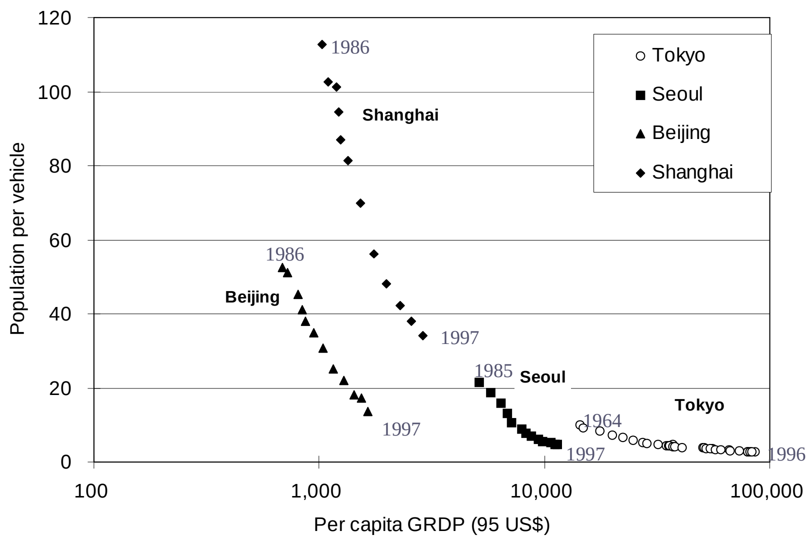


Figure 3.6. Speed of motorization in Tokyo, Seoul, Beijing and Shanghai

Sources: Internal database compiled from various statistical yearbooks

differences in patterns of vehicle ownership in cities, rather than the national context, in different countries. For example, vehicle ownership rate (per person) in Beijing and Shanghai is much higher than its national average, while in the case of Seoul it is almost equal. The national average trailed behind Tokyo until 1970; after that the vehicle ownership rate of Tokyo recorded smaller than national average. Figure 3.7 shows this phenomenon. Interestingly, the point (vehicle ownership of around 4.5 people per vehicle) at which the gap of city and national vehicle ownership is zero seems to coincide, with minor differences in the case of Seoul and Tokyo. It would be interesting to see whether this is true in the case of other cities and if there are any such patterns.

The trends of private vehicles (namely, cars) and public vehicles (namely buses and trucks) are major categories that determine energy use and emissions from urban transportation. Figure 3.8 shows the trends of these two categories. Cars, in particular, are significant because of their larger number and their strong correlation with income growth. The growth of cars in the ward areas of Tokyo, which are denser, has stagnated, while the number of cars in the Tokyo Metropolitan Area is moderately increasing. The number and growth of cars in Beijing and Shanghai, traditionally, was smaller, with Beijing having more cars than Shanghai. After 1990 in particular, the population growth of vehicles in Beijing has increased at a rapid rate. In the case of bus and truck populations, growth is

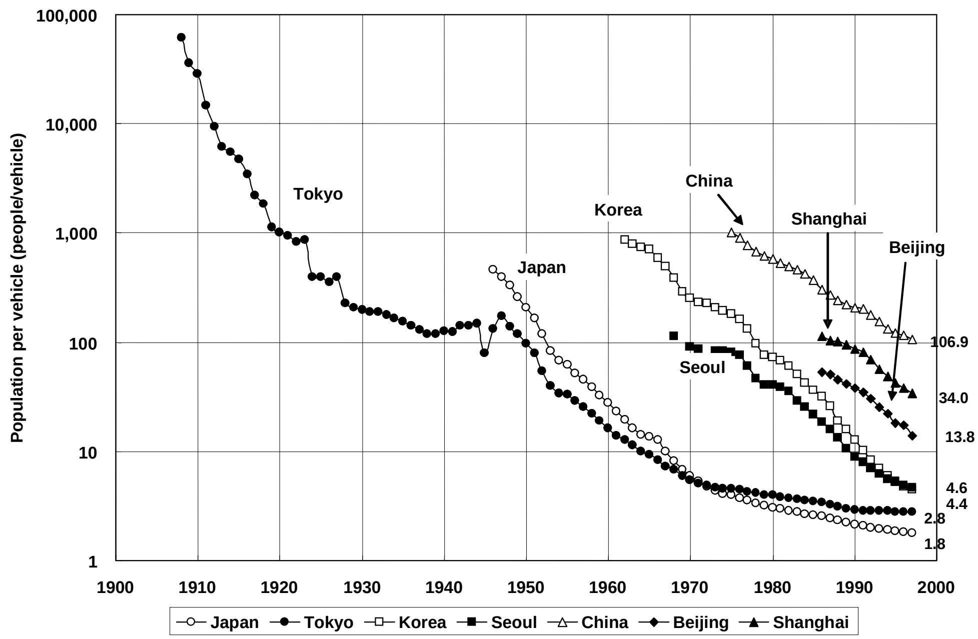


Figure 3.7. Scale of motorization: population per vehicles in Tokyo, Seoul, Beijing and Shanghai

Sources: Internal database compiled from various statistical yearbooks

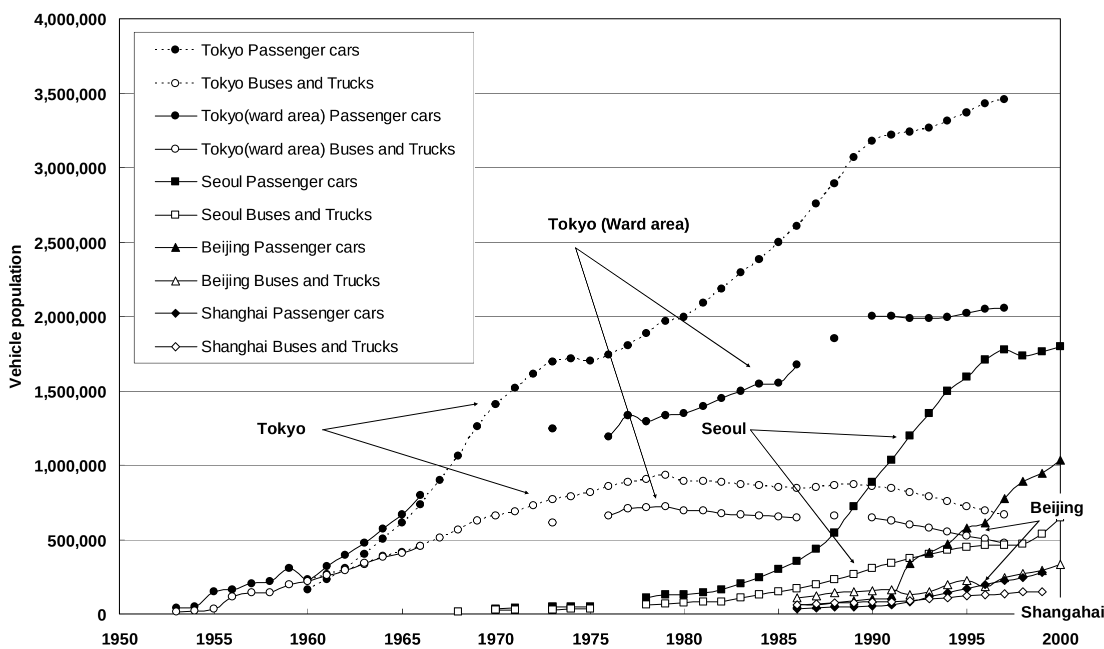


Figure 3.8. Trend of cars, bus and truck population in Tokyo, Seoul, Beijing and Shanghai

falling in Tokyo and more rapidly in its ward areas, probably due to stagnated urban populations in ward areas and greater reliance on surface rails (long distance commuting) and subways for passenger transportation. In Seoul, however, bus and truck populations continue to increase (partly due to smaller long distance commuting populations and fewer subways stops, which would compel people to use buses for commuting). Bus and truck populations continue to increase in Beijing and Shanghai; in particular, light duty trucks in Beijing are increasing at such a rapid rate that policy makers are expected to control it stringently from environmental consideration sooner or later. The growth of taxis in Beijing and Shanghai is tremendous, with numbers increasing from 9,000 to 653,000 in Beijing and 500 to 224,000 in Shanghai from 1980 to 1997[5].

3.7.2. Road and Railroad Infrastructure

Roads play important roles in the urban transportation system. An adequate supply of roads is vital to the smooth flow of traffic. Comparisons of road systems show that Tokyo has the largest per capita road area, which stands at 12 square meters, compared to other cities. Figure 3.9 compares the per capita road area and the vehicle population per km of road length in four cities. It is seen that Beijing and Shanghai have significantly lower per capita road area, as well as the highest vehicle per km of road. Shortage of infrastructure to accommodate such as a moderate level of vehicle ownership is evident in Beijing. Road areas in Shanghai, in particular, has rapidly increased after 1990. In the period of 1979-1999, the road length of Beijing nearly doubled, while vehicles increased seventeen-fold (He, 2004).

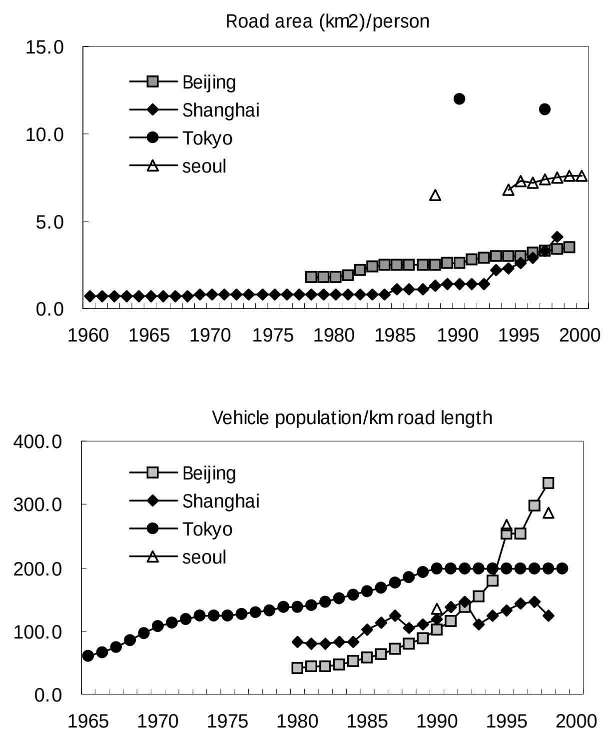


Figure 3.9. Comparison of road infrastructure

Source: Internal database compiled from various statistical yearbooks and other local sources

The Tokyo metropolitan region has a well-developed and well-connected subway and surface rail system of 2,143 km. These rail networks were constructed well before motorization begun and thus did not face fierce competition from motorization. The current state of the subway network is shown in Table 3.2. A closer look at the subway traffic and infrastructure reveals that:

[5] Source: Internal database compiled from various statistical year books and government documents of Beijing and Shanghai

- Before 1990, the rate of subway expansion (length of subway lines) and rate of increase in subway passengers (rate of utilisation) were almost identical in Tokyo ward areas. This insured a high rate of subway utilisation by passengers. However, passenger traffic has stalled or decreased in Tokyo ward areas since the early 1990s. In contrast, the rate of subway expansion (in terms of length) has increased.
- The length of subway lines in Seoul is almost equal to Tokyo, but the rate of subway utilisation is lower. After the completion of four more lines which are currently under construction, the total subway length will be about 280 km.
- Subway construction stalled in Beijing from the mid 1980s to the early 1990s. During this period, the utilisation rate of the existing subway increased. Since the construction of additional lines and expansion of existing lines both stalled, this gave rise to rapid motorization. However, from the late 1990s, urban railway construction has been progressing, with the goal of 254 km by the 2008 Olympic Games. From the current three lines, Beijing will construct ten more lines by 2008.

Table 3.2. Urban railway information in selected cities (2000)

	Beijing	Shanghai	Tokyo	Seoul (1998)
Total length (km)	55.1	65.0	248.7	218
Number of station	45	48	235	115
Number of line	3	3	12	4

Sources: Various statistical yearbooks

3.7.3. Transport Mode

Figure 3.11 shows the share of various travel modes in cities (in passenger times). The structure of travel modes in Tokyo and Seoul (except bus and subway in Seoul) has not changed in recent decades, as compared to Beijing and Shanghai. In contrast to other cities, travel by subway and taxi is very high in Tokyo, while travel by private cars is very small. In Seoul, the expansion of the subway has considerably reduced travel by bus. Travel by non-motorized modes (walking and bicycle) and buses is rapidly decreasing in Beijing, while the rapid rise in travel by private modes is increasing. Travel by car in Beijing increased from less than 5% of total travel in 1990 to almost 20% in 1990; similarly travel by taxis has increased significantly (He, 2004). Shanghai has also witnessed a rapid increase of private car travel

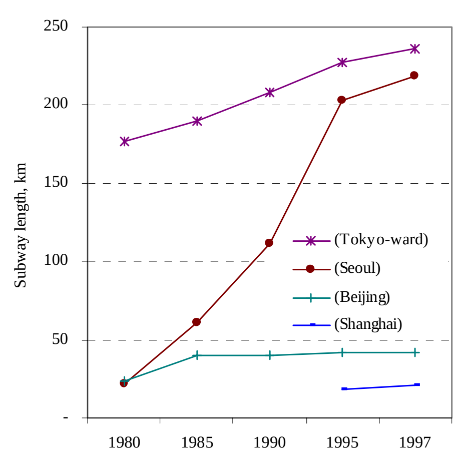


Figure 3.10. Subway length in selected cities

Sources: Internal database compiled from statistical yearbooks and other sources despite stringent control; such increase, however, is less than Beijing.

- In Tokyo, rail accounts for about 45% of total passenger transportation (1998).
- In Seoul, roads account for about 70% of passenger transportation (1997).
- In Beijing and Shanghai, roads account for over 95% of passenger transportation (including non-motorized mode in 2000).
- Increases in private and low occupancy modes, such as cars and taxis in Beijing and Shanghai, are placing pressure on available road infrastructure.

While there is an increase in volume of total travel, the share of travel by buses has decreased in Beijing, as demonstrated in Figure 3.11, however, the actual number of buses is increasing. From 1990-1998, the number of buses increased by 87%, but passenger traffic increased by only 22% (He, 2004). This shows that there has been considerable improvement in the "comfort" of bus travel compared to the past, but at the same time, it highlights the inefficiency in the public traffic sector to attract passengers due to service quality (such as punctuality, distance of bus stations, etc.). The increase in taxi travel suggests that a considerable number of passengers are looking for better service and efficiency from public transportation.

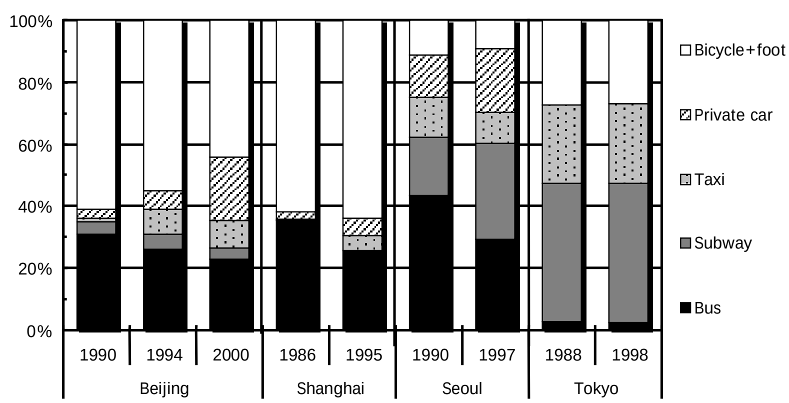


Figure 3.11. Variation of transport mode in the cities

Source: Internal database compiled from statistical yearbooks and other sources

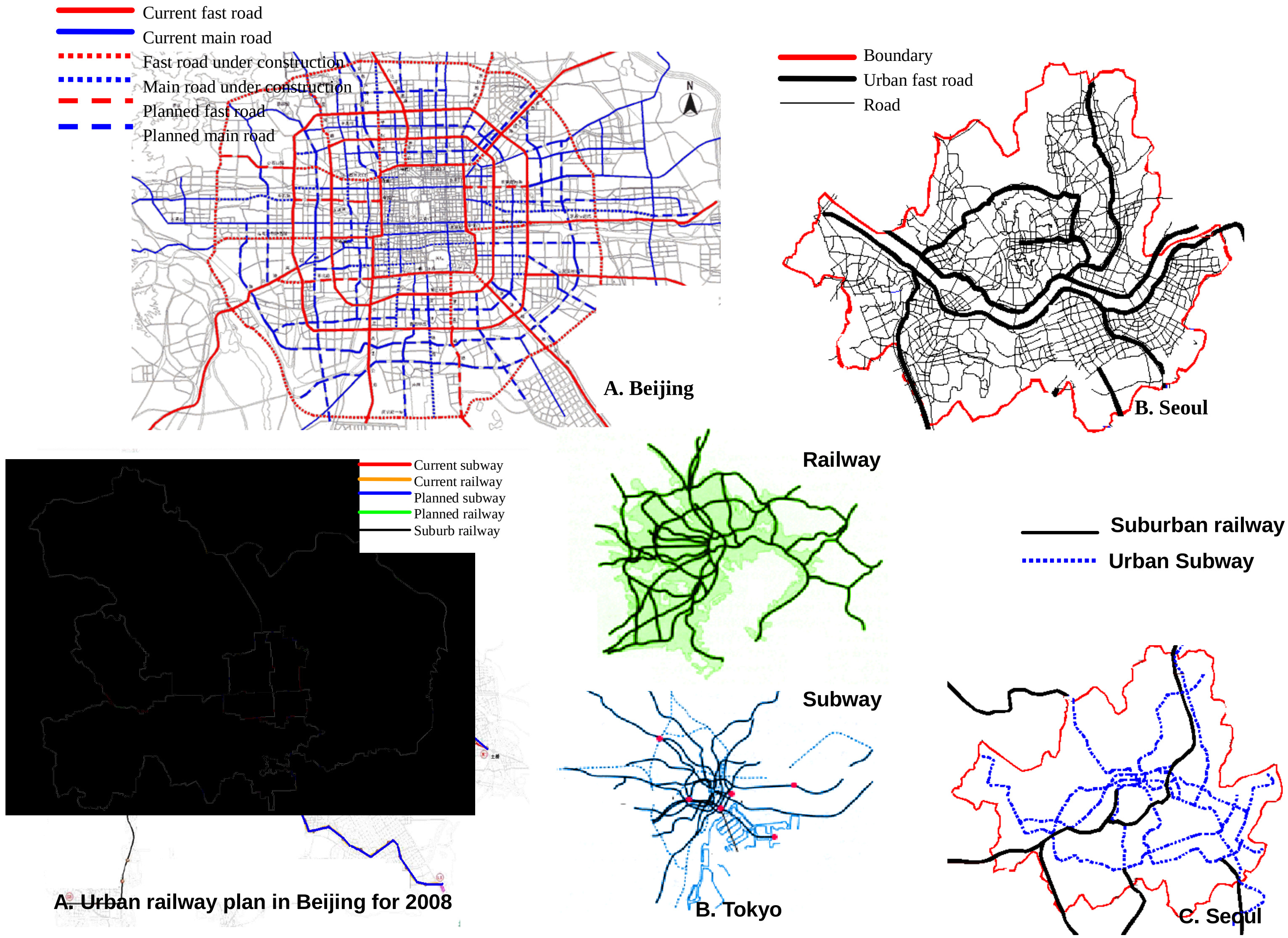


Figure 3.12. Graphical sketch of road and rail networks in Tokyo, Seoul, and Beijing

Sources: Compiled from various sources, mainly He (2004), Tokyo Urban Transport: Akio Okamoto

3.8 Waste Management[6]

Municipal waste management is becoming an increasingly serious challenge to urban policy makers due to increasing volume. Whether waste is recycled or incinerated, it requires energy and the resulting emissions from energy use are not insignificant. Waste disposal methods, incineration or landfill, have advantages and disadvantages from a waste management perspective, but the choice of such methods affect the type and amount of greenhouse gas emissions. Waste disposal in landfills produces methane which is 22 times more harmful than CO_2 in its global warming potential. At the same time, incinerators use additional energy to incinerate waste, thus producing CO_2 from energy use, as well as from the waste that is burnt. Such choice is not solely motivated by the viewpoint of greenhouse gas emissions. Additionally, incinerators

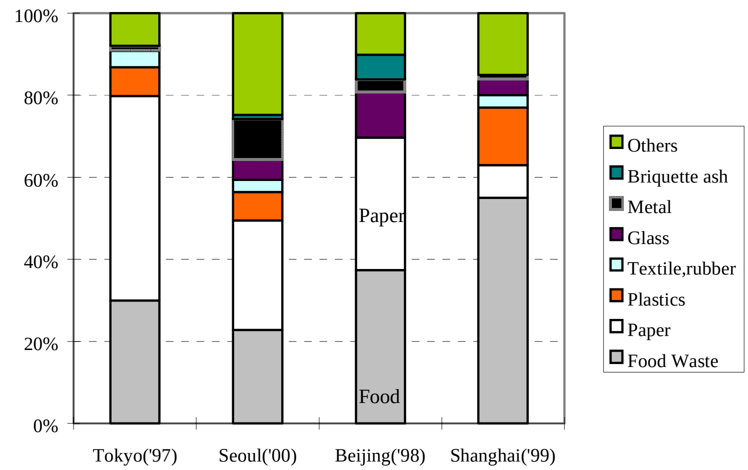


Figure 3.13. Waste composition in cities

Sources: Internal database compiled form different sources

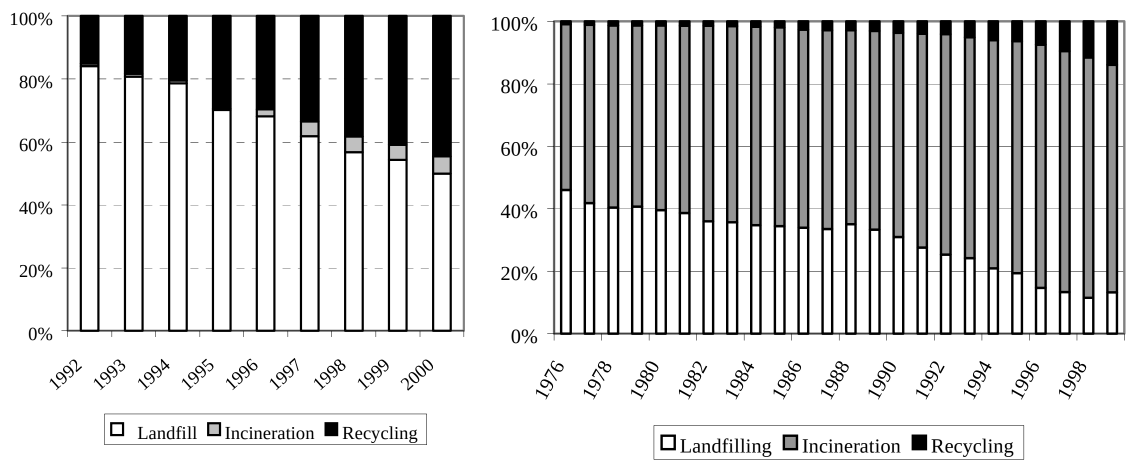


Figure 3.14. Method of treatment for municipal solid waste in Seoul (left) and Tokyo (right)

Sources: Internal database compiled form different sources

6 Based on commissioned report by Dr. Eui Young Yoon and Sunghan Jo, see Yoon and Jo (2003a) and presentations in Hawaii Workshop (see Yoon and Jo, 2003b)

allow for energy or heat recovery. If such heat or energy is used for producing power, a major part of CO_2 would be recycled which otherwise would have been released.

Therefore, the major drivers here are composition and volume of municipal solid waste in cities. The per capita waste generated in Tokyo, Seoul, Beijing and Shanghai in 1999 was 1.13, 1.06, 1.107 and 1.04 kg/person/day, respectively. Such waste volumes have been decreasing in Tokyo since 1989, and Seoul from 1992[7], while rapidly increasing in Beijing and Shanghai. Figure 3.13 shows the share of various waste compositions in the four cities.

The shares of waste recycled, landfilled and incinerated are important from energy and emission considerations. Incineration is increasing in Tokyo over time; over 85% of waste is incinerated with 18 incinerators. However, in Seoul, the majority of waste is landfilled. As of 1999, Beijing has six landfill sites, two composting facilities and one incineration facility. Most of the waste goes to landfills. Similarly, in Shanghai, only two landfill sites exist without any additional treatment facilities. Little attention is being given to waste in Beijing and Shanghai at the moment; however, looking to the current rates of economic growth and waste generation growth rates, these cities will face serious waste problems soon.

Source reduction is often shown as the most effective method for reducing greenhouse gas emissions (ICLEI, 1999). Table 3.3 shows that source reduction is followed by recycling, while landfill and incineration (without heat recovery) produce more greenhouse gases.

Table 3.3. Net GHG Emission from Source Reduction and MSW Management Options

Emission Counted from a Waste Generation Reference Point (MTCE/Ton)

Material	Source Reduction	Recycling	Composting	Combustion	Land filling
Newspaper	-0.91*	-0.86	NA	-0.22	-0.23
Office paper	-1.03	-0.82	NA	-0.19	0.53
Aluminium cans	-2.98	-3.88	NA	0.03	0.01
Glass	-0.14	-0.08	NA	0.02	0.01
PET	-0.98	-0.62	NA	0.24	0.01

Source: USEPA (Sept. 1998). Greenhouse gas emission from management of selected materials in municipal solid waste. P. Es-12.

[7] Seoul data shows that there is drastic reduction in waste volume in 1992. Such huge data discrepancy was due to the fact that until 1991 data was based on volume to garbage trucks, and after 1992, it was based on weight. However, after 1992, MSW in Seoul has decreased consistently.

4. ENERGY USE AND CO_2 EMISSION IN CITIES AND FUTURE CHALLENGES

4.1. Introduction

The analyses of energy and CO_2 emissions on the national scale have been conducted in uncountable published literature; at the city scale, only a few such analyses are reported. Such city scale studies that try to cover the urban sectors comprehensively are yet under the stage of methodological development; usually they focus on either estimating urban energy or CO_2 inventory of specific cities outside Asia (McEvoy et al.,1997; Kates et al., 1998; Baldasano et al., 1997; Bennett and Newborough, 2001; Newman, 1999; ICLEI, 1997). This section presents a picture of energy use in cities and their energy related CO_2 emissions, including past trends and future scenarios. However, the focus of this paper is on CO_2 emissions from energy use, rather than energy use itself. This section also quantifies and analyses the role of selected driving factors in total and sectoral (transportation, households, and businesses) CO_2 emissions. As mentioned in the beginning of this report, the role of indirect emissions could be significant in cities, as cities consume large quality of material goods. For such discussions, while it is understood that "consumption" oriented analyses would have been more powerful, the outcomes of the Input-Output Table based approach is cited in this report due to limitations on existing studies. The aim of this section is to clarify the picture of CO_2 emissions and their future scenarios. While doing so, this section also discusses some of the future local environmental challenges in the cities because the driving factors for CO_2 emissions will also exert pressure on air pollution and urban warming phenomenon.

4.2. Challenges and Barriers for Capturing an Exact Picture and for Comparison

In estimation, major limitations emerge from the difficulties of obtaining city scale data, which is partly due to the fact that major policy decisions on energy related issues are made at the national level. Major technical limitations to estimate CO_2 emissions come from the differences in *political boundaries* and *functional boundaries* of the city. Therefore, most studies only focus on selected sectors of the city, mostly transportation and building sectors. This section addresses comprehensive city scale CO_2 emissions for selected East Asian cities that have seen unprecedented industrialization in the last few decades.

The lack of quantitative and qualitative information at the city level analyses is not a new phenomenon, especially when decisions related to energy use are often not made at city level. However, the selected cities discussed in this paper have the best data available in the Asian context. Despite this, comparability of information, data definition problems, and methods of organizing information and data are barriers for comparative analyses. Urban scale analyses have their own generic problems in Asia:

- Certain types of information are often available for political boundaries of the city and other information at different scale (such as metropolitan region) of the city.
- Some cities, especially in case of Chinese cities, have their own definitions of terms and have their own methods of aggregation into sub-sectors and sectors which do not follow internationally used definitions by the International Energy Agency or other multilateral institutions.
- The classification of various driving forces for energy use and emissions, such as structure of energy balance tables, vehicle categories, indicators for travel demand, structure of regional Input-Out Tables, etc., are different from city to city.
- Since "city" is a political definition, a city may have "rural" and "urban" populations inside the "city." This is especially the case for Beijing and Shanghai. This makes analyses often difficult to explain.
- Emission factors are crucial elements in energy-emission estimations. Many of the emission factors are either not available (thus compelling the use of IPCC factors) or too aggregated.
- Information gaps are so large in the majority of Asian cities that many of the ICLEI sponsored estimations of energy and CO_2 emissions in Asian cities are often limited to corporate-emissions from municipality services rather than emissions from municipality as a whole.
- Comparing cities is often a difficult task. The choice of indicators is often controversial as each comparison has different implications, such as total emissions vs. per capita emissions; per capita emissions vs. emissions per unit economic activities, and so on.
- In many cities in Asia, the role of the municipal government is downplayed within their political boundary due to the lack of management capacity and the lack of proper decentralization of political governance. In addition, urban sprawl and the expansion of the city beyond the "original city" is taking place, but municipal governments do not govern expanded areas. Therefore, analyses from political boundaries alone cannot create a complete picture of energy use or emissions.
- Energy use and emission problems are often interlinked with neighbouring cities and policy analyses at one political boundary using information from that city often leads to limited impact.
- Frequent changes in the political boundary of the cities are observed in case of many cities, including Beijing. This makes it difficult to compare information and data over time.

Despite these generic problems, information availability for a political boundary is reasonably good for Tokyo, Seoul, Beijing and Shanghai. Even in case of Beijing and Shanghai, since they are two of the four cities in China that exercise the authority of a province, the city scale information base is reasonably good. Despite this, most of the analyses in this report centre on the year 1998 and before, where data is readily available.

4.3. Energy Scenario in Cities

In general, energy consumption in Tokyo, Seoul, Beijing and Shanghai is increasing, with the exception of Beijing in 1997 and Seoul after the Asian financial crisis. Beijing seems to have followed the national trend, which reports that energy consumption and more specifically CO_2 emissions decreased after 1996. However, there is an ongoing controversy whether this reduction in China is real or has resulted due to accounting problems. In Beijing, the total energy consumption has increased by 15% from 1998-2002 (Wu, 2004).

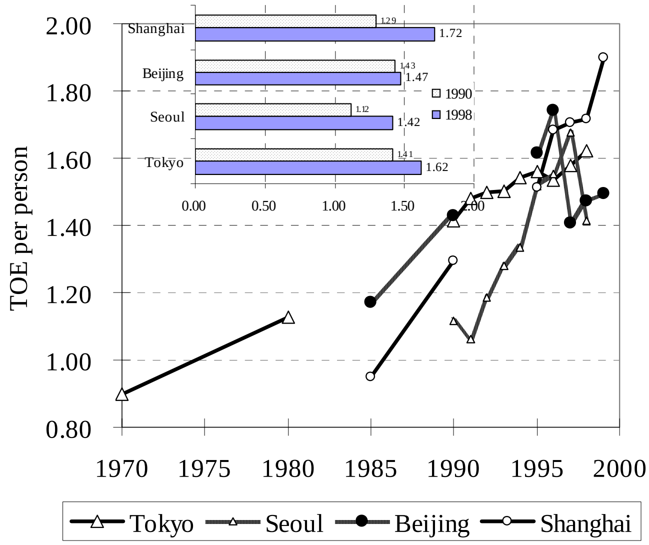


Figure 4.1. Per capita energy consumption

Sources: Internal database compiled from published energy balance tables of four cities

Figure 4.1 shows that the per capita energy consumption of these cities is consistently increasing and are converging towards a common point in recent years. This means that developing cities such as Beijing and Shanghai are rapidly approaching and even surpassing developed cities such as Tokyo and Seoul (Since 1998, Seoul's per capita energy consumption decreased due to the financial crisis in 1997. It is currently recovering.)

In Tokyo, energy consumption has increased about 85% in last three decades. Oil, urban gas and electricity are major energy sources and coal has almost been eliminated. Electricity use, in particular, is rising compared to other fuel types, both in terms of share and absolute volume, and oil is decreasing. Industry has played a nominal role in Tokyo in recent years (about 10%; national share is about 40%), unlike Beijing and Shanghai, where it contributes over 65% and 85%, respectively. Most of the energy use is by transportation and businesses in Tokyo. Within the business sector, offices consume a majority of the energy, followed by restaurants whose gap has significantly widened in last two decades due to increasing share of offices. Energy consumption by restaurants has decreased since 1995, most likely due to the economic recession.

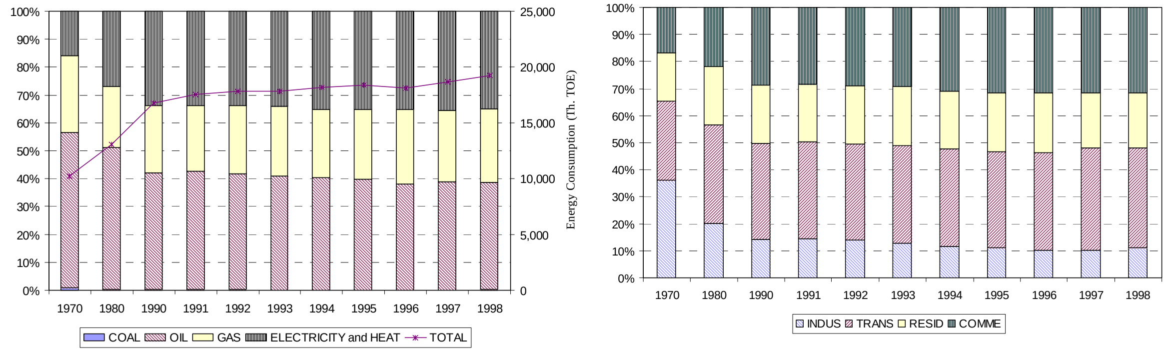
Seoul is very distinct in its high share of oil use; in recent years, coal has been eliminated and substituted with gas and electricity. Residential households consume the majority of energy in Seoul, followed by urban transportation. The provision for district heating is rapidly expanding in Seoul. In 2001, over 350,000 households used district heating which is expected to increase to over 430,000 households by 2007 (Jung, 2004). The structure of energy use in Beijing and Shanghai has not changed significantly.

The major characteristics of the energy profile in these cities are: (1) electricity share is somewhat increasing, (2) coal dominates energy use, and (3) the share of transport sector is between 5% to 10%. Despite high economic growth, the primary industry is shrinking in Beijing and Shanghai; significant economic growth is coming from the tertiary sector, which balances the energy profile to some extent, so that per capita energy consumption does not overshoot in these cities (as triggered by economic growth). In Beijing for example, coal consumption of the secondary industry is growing in total final consumption, which is consistent with the economic growth trend of the secondary industry. Beijing replaced small coal-fired boilers to gas-fired boilers in residential sectors, and accordingly, coal consumption in this sector has reduced from 4.0 million tons in 1995 to 2.8 million tons in 1999[8]. The use of natural gas has risen dramatically in Beijing and Shanghai in recent years but still accounts for a very small share. In Shanghai's energy structure, 6-7% reduction in coal shares has taken place from 1995-2000, which is largely substituted by oil. Therefore, rapid change in energy structure has taken place after 1998.

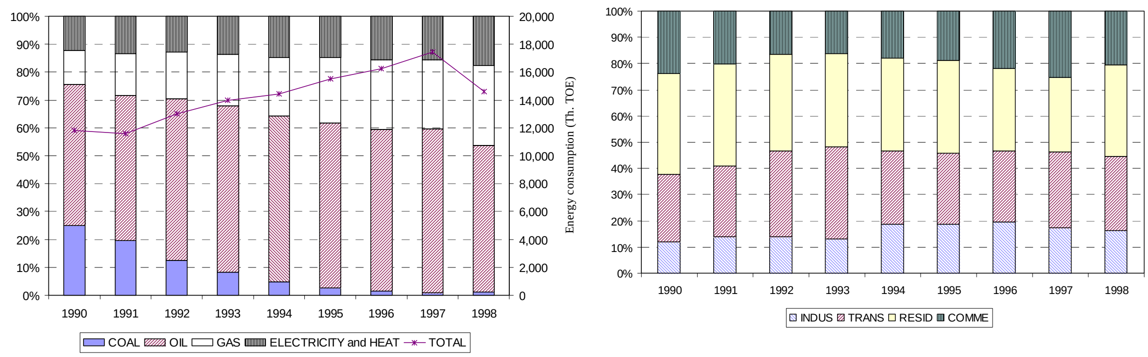
4.4. Transition of CO_2 Emissions in Cities[9]

CO_2 emissions from energy use in cities follow more or less the same pattern as that of energy consumption with the exception that fuel choices alter the emissions structure from that of energy consumption structure (see Figure 4.2 and Figure 4.3). The comparison amongst the four cities shows that Tokyo emits 1.5 times more CO_2 from energy use than Seoul, but Beijing and Shanghai emited 1.4 and almost 2 times more than Tokyo in 1998, respectively. Emissions from Tokyo have increased more than two times in the last three decades, with about a 2 % annual average growth rate (1970-1998). During that same period, the annual average growth rate of economy (GRP) was 6.87%. In 1990-98, the annual average growth rates of CO_2 emissions for Tokyo and Seoul were estimated at 0.7% and 0.8%, respectively. The emission growth rate before the Korean financial crisis in 1997 was almost 4.5%.

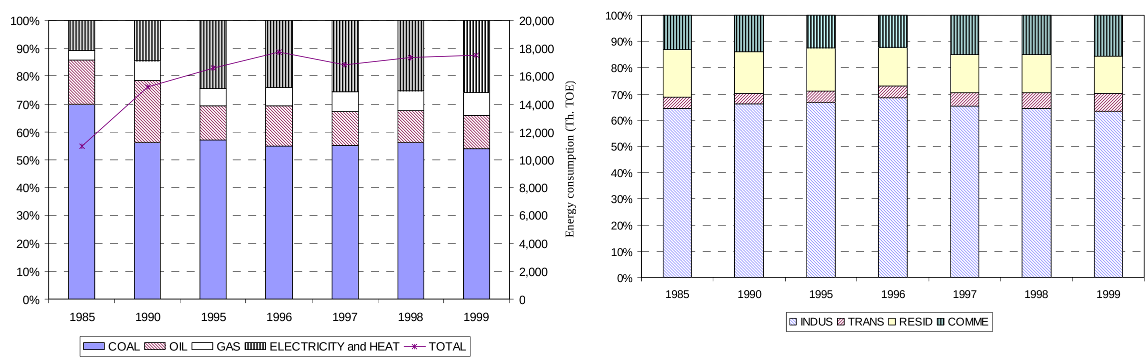
[8] Beijing Statistical Yearbook 2000, Beijing Statistical Bureau: Chinese Statistical Press, 2000.
[9] CO_2 emissions estimation was carried out in collaboration with Dr. Shinji Kaneko.



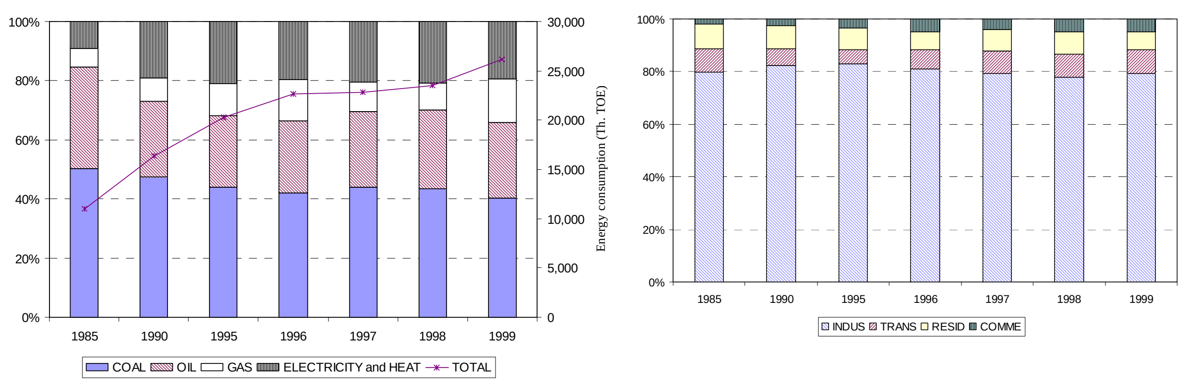
Energy consumption in Tokyo



Energy consumption in Seoul



Energy consumption in Beijing



Energy consumption in Shanghai

Figure 4.2. Energy consumption in cities

Sources: Internal database compiled from energy statistics of cities

Table 4.1. Economic and emission transitions in cities

City	1970-80	1980-90		1990-1998	
		1980-85	1985-90	1990-97	1997-98
Tokyo	High economic growth (8.5%) Moderate emission growth 2.5%	High economic growth (6.3%) Moderate emission growth (2.3%)		Negative economic growth (-0.4%) Low emission growth (0.7%)	
Seoul				High economic growth (5.9%) Moderate emission growth (4.5%)	Negative economic growth (-16.3%) Negative emission growth (-19%)
Beijing			High economic growth (7.5%) High emission growth (6.5%)	High economic growth (14.5%) Low emission growth (2.7%	
Shanghai			Low economic growth (2.3%) High emission growth (11%)	High economic growth (20%) High emission growth (5.6%)	

Definition for high and low are subjective, over 5% is taken as high in this table for comparison purpose.

Economic growth is one of the major drivers for emissions. Past trends have shown that the economic recession in Tokyo has not reduced the volume of emissions, although the growth rate decreased because emissions in Tokyo are strongly related to lifestyle (automobiles and transportation), office automation and building systems. However, in Seoul, the economic collapse has had a major impact on emissions. Emissions growth in Beijing and Shanghai decreased in recent years despite large economic growth, particularly in Shanghai, due to ongoing fuel switching, rise in productivity, improvement in energy efficiency and changes in the economic structure.

In Tokyo, the transportation and commercial sectors, mainly offices, are responsible for the majority of CO_2 emissions. In the last three decades, the share of the industry sector has consistently declined from 30% to 10% and the volume of emissions has also decreased. This is due to the relatively smaller scale of industrial activities in Tokyo, as it is principally a commercial city and the gradual dominance of tertiary sector within the industrial sector. The share of tertiary industry in total industrial value added has increased from 67% in 1980 to 77% in 1998[10].Mainly, oil and electricity (CO_2 emissions based on average electricity generation mix) are responsible for the majority of CO_2 emissions.

[10] TMG : Tokyo Statistical Yearbook, Annually published (1970-2001) by Tokyo Metropolitan Government, Tokyo, Japan.

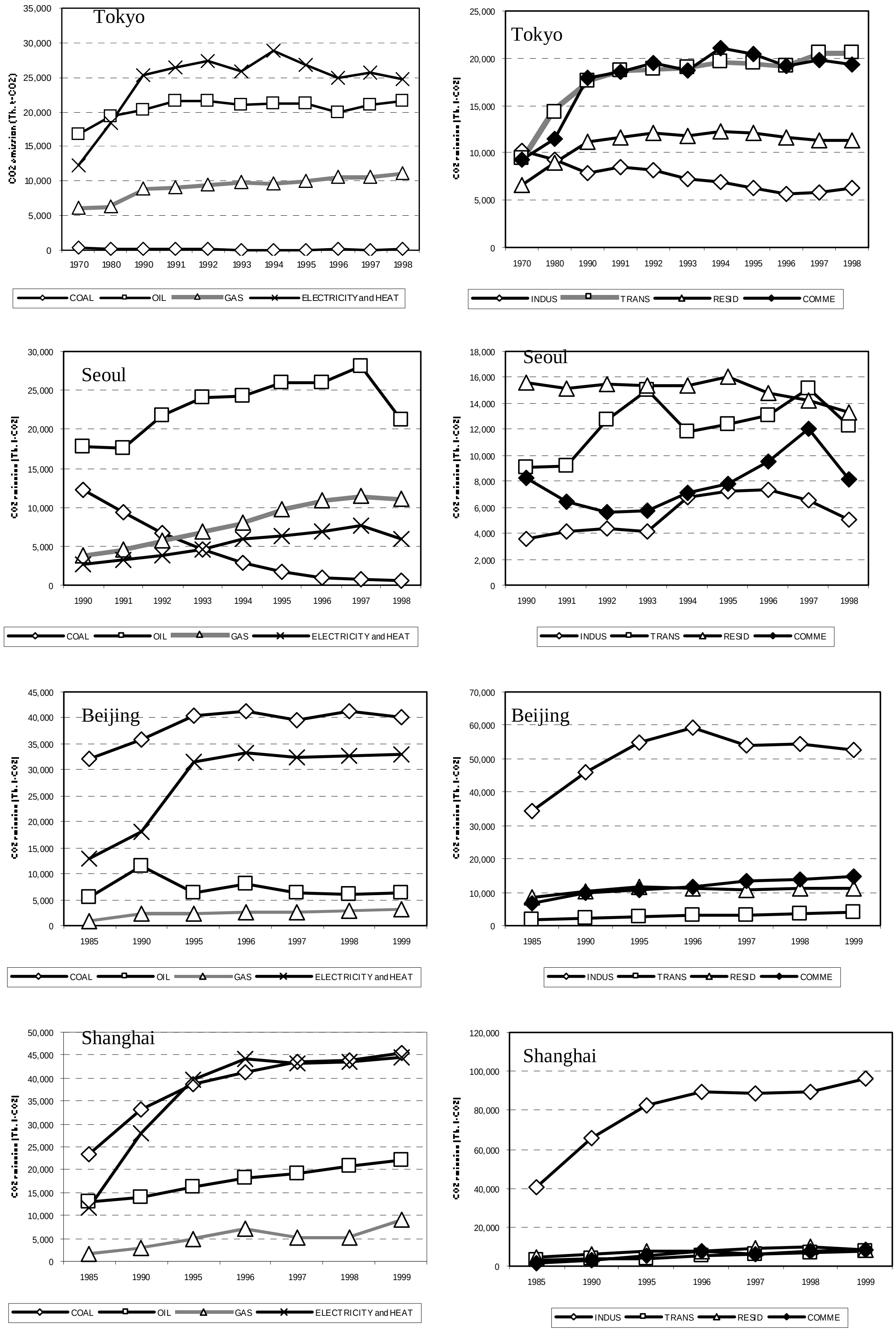


Figure 4.3. CO_2 emission from energy use in cities

Like energy consumption patterns, transportation and residential households are responsible for the highest emissions in Seoul, while the residential sector's share and volume has decreased in recent years. The economic collapse in Korea seems to have contributed to the reduction of emissions from businesses and transportation more significantly than any other sectors. Small contributions from the industrial sector in total emission can be partly explained by the dominance of tertiary sector. The share of the tertiary sector in industrial valued added has increased from 74% in 1980 to 81% in 1997 (Korea National Statistical Office, 2000 and 2001). Similarly, oil contributes to over 55% of total CO_2 emissions due to its dominant use in buildings and the transport sector; unlike Tokyo, most of the large buildings in Seoul use oil based centralized heating systems. The rising share of emissions from gas and electricity has replaced that of coal (35% to 3% in 1990-98) in recent years, while the share of oil has not changed considerably.

Emissions in Beijing and Shanghai are mostly dominated by industrial activities whose shares are as high as 80% in Shanghai and 65% in Beijing in 1999. The share of transport was about 5-6% in 1999. The structure of emissions in these cities has changed only slightly between 1985 and 1999, with the exception of a nominal increase in the share of businesses and transportation. Although the share is very small, the annual average emission growth in the transport sector (about 11% in both cities) is high enough to alarm policy makers. Increasing use of gas has raised its share in total emissions in recent years, but coal remains the major factor behind emissions since most of the electricity comes from coal. Shanghai is distinct from Beijing in emission structure by fuel types due to a larger share of emissions from oil and gas.

The fuel mix of electricity production is an important factor for the volume of CO_2 emissions. The majority of electricity in Beijing and Shanghai comes from coal, but in Tokyo and Seoul, other forms such as nuclear, natural gas and oil account for significant shares[11].

4.5. CO_2 Emissions of Cities Per Capita and Per Unit Economic Activities

Figure 4.4 evaluates the performance of the cities in terms of CO_2 emissions per capita and CO_2 emissions per unit economic activities. Due to data problems, CO_2 emissions could only be depicted for selected north Asian cities (Tokyo, Seoul, Beijing, Shanghai, and large Japanese cities), OECD countries and major non-OECD countries. In Figure 4.4, the desired situation over time is the transition of the city towards its origin.

[11] City scale figures for Seoul and Tokyo are not available in this report. The national average energy mix in electricity production for 1998 in Japan is coal (19.5%), oil (16.5%), gas (21%), nuclear (32%) and others (11%); and in Korea is coal (42%), oil (7%), gas (11%), nuclear (37.5%) and others (2.5%).

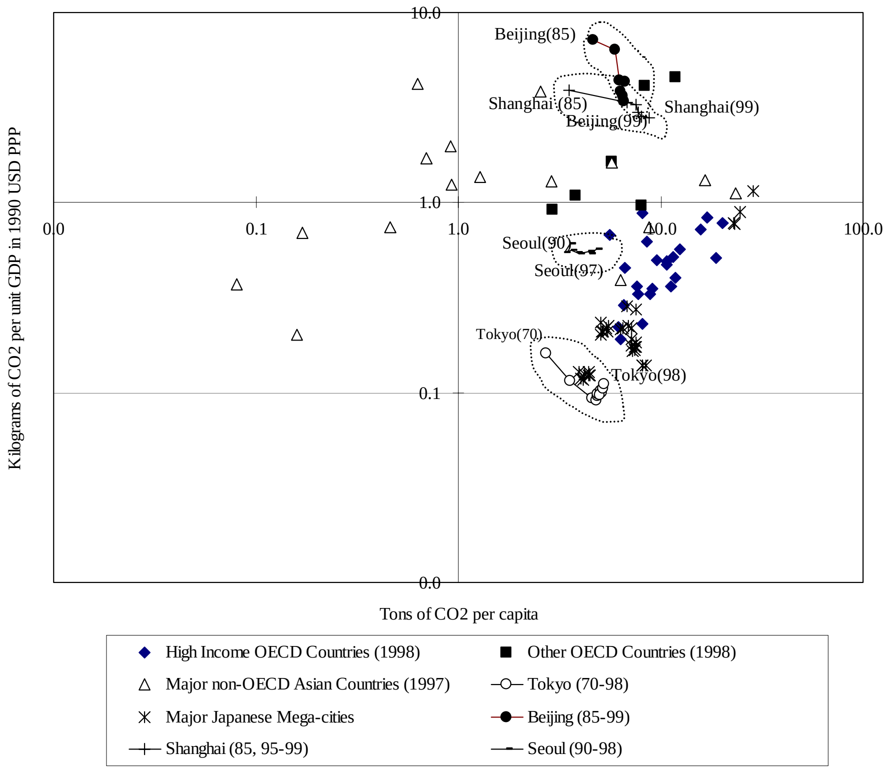


Figure 4.4 CO_2 emission in per capita and per unit GRP/GDP (in log-log scale).

Source: Dhakal, S., S. Kaneko and H. Imura (2002). An analysis on driving factors for CO2 emission from energy use in Tokyo and Seoul by Factor Decomposition Method. Environmental Systems Research, Volume 30, pp 295-303. Japan Society of Civil Engineers.

The comparison reveals that the performance of large Japanese cities is better in general than other cities and countries. The performance of Tokyo is outstanding. In recent years, especially after 1990, the performance of Tokyo is seen to be slightly worsening, mainly due to the slowing down of the economy and inability to cut down CO_2 volume. In Tokyo, the slowing down of the economy is not reducing emissions significantly because the share of the industrial sector is small in total CO_2 emissions. CO_2 per unit of economic activity in Seoul is found to stagnate between 1990 and 1997 but CO_2 per capita is increasing. Beijing and Shanghai's CO_2 performance in terms of economic activity is improving rapidly. However, CO_2 emissions are found to slightly increase in per capita terms. Reducing CO_2 emissions in per capita seems to be a major difficulty for cities, and all cities have clearly failed in that pursuit.

In deriving per capita CO_2 emissions in Figure 4.4, the daytime population was used. However, studies have reported that 33% of the workforce of Tokyo commutes from outside Tokyo[12]. The ratio of daytime to night-time population in Tokyo and Seoul is 1.25 and 1.04 in 1999, respectively (Yoon

[12] TMG: TDM Tokyo Action Plan. Tokyo Metropolitan Government, Tokyo, 2000.

and Araki, 2002). Should such commuting populations be included in per capita estimation, the performance of Tokyo would improve further (not shown in figures here).

This suggests that Tokyo is already operating at a relatively better performance stage. In that sense, Tokyo might be able to serve as a desirable model for rapidly developing mega-cities, particularly cities in North-East Asia. However, each city grows differently and, in reality, one city cannot serve as a complete model for another city—only suitable elements can be utilised. The responsibility for future CO_2 emission reductions for Tokyo may be higher than other cities due to its anticipated contribution towards meeting Japan's Kyoto commitment (6% reductions of 1990 level). Bottom-up modellers have demonstrated that significant reductions in Tokyo are possible with different technological measures (Hanaki, 2002). If such technological measures could be implemented in the future, Tokyo's performance might improve further.

Despite the fact that these four cities are yet to converge in terms per capita emission, they are converging in terms of per capita energy consumption as in Figure 4.5 and 4.6. The structure of energy use therefore plays a most important role in the profile of emissions. Tokyo and Seoul, in particular, seem to converge, while the trend in Shanghai is rapidly growing. Being less industrialized than Shanghai, the speed of increase in per capita emissions in Beijing is smaller than Shanghai.,

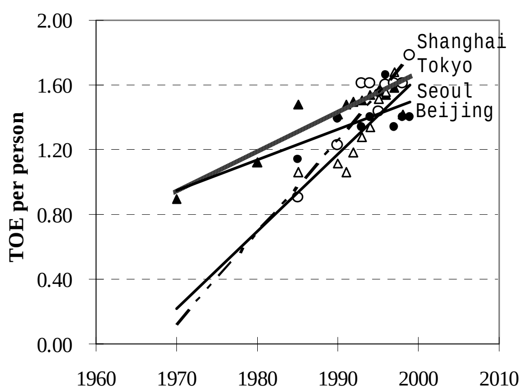


Figure 4.5.Trend of per capita energy consumption

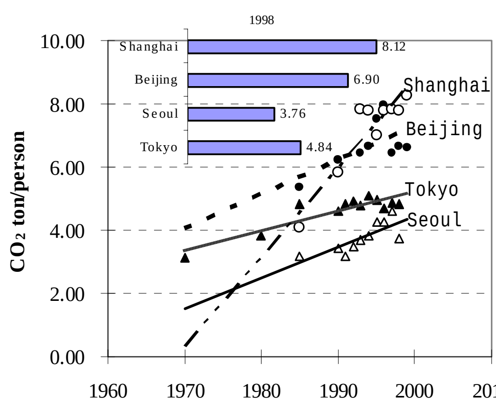


Figure 4.6.Trend of per capita energy consumption

4.6. Factors' Contribution in Historical CO_2 Emissions

Factor decomposition method is a widely used tool to see the relative contributions of various factors on CO_2 emissions. In this section, CO_2 emissions have been decomposed into four factors, namely, carbon intensity effect, energy intensity effect, income effect and population effect.

The economic activity, i.e. income effect, is the major driving force behind the changes in CO_2 emissions in Seoul during its period of economic growth, as well as economic recession. In the case of Tokyo, economic activity was the major driving force behind the majority of emissions in its high growth period, but its contribution to reduce emissions in economic recession periods is smaller (Figure 4.7). Tokyo experienced an economic recession after the so-called bubble-burst in the late 1980s, while Seoul experienced an economic collapse in 1997 as shown in Figure 4.7.

Carbon intensity effect indicates the role of fuel on emissions due to the transition to the different "fuel ladders" or to cleaner fuels. In Tokyo, though carbon intensity effects and population effects were responsible for slightly increasing emission in the 1970s and 1980s, their contribution was negligible in the 1990s. Unlike Tokyo, the carbon intensity effect was responsible for reducing a large amount of emissions in Seoul during the high growth period (1990-97), but its contribution was negligible in the recession of 1997-98. Energy intensity, which indicates the direction of technological changes and structural shift of activities, is responsible for the reduction of emissions by large

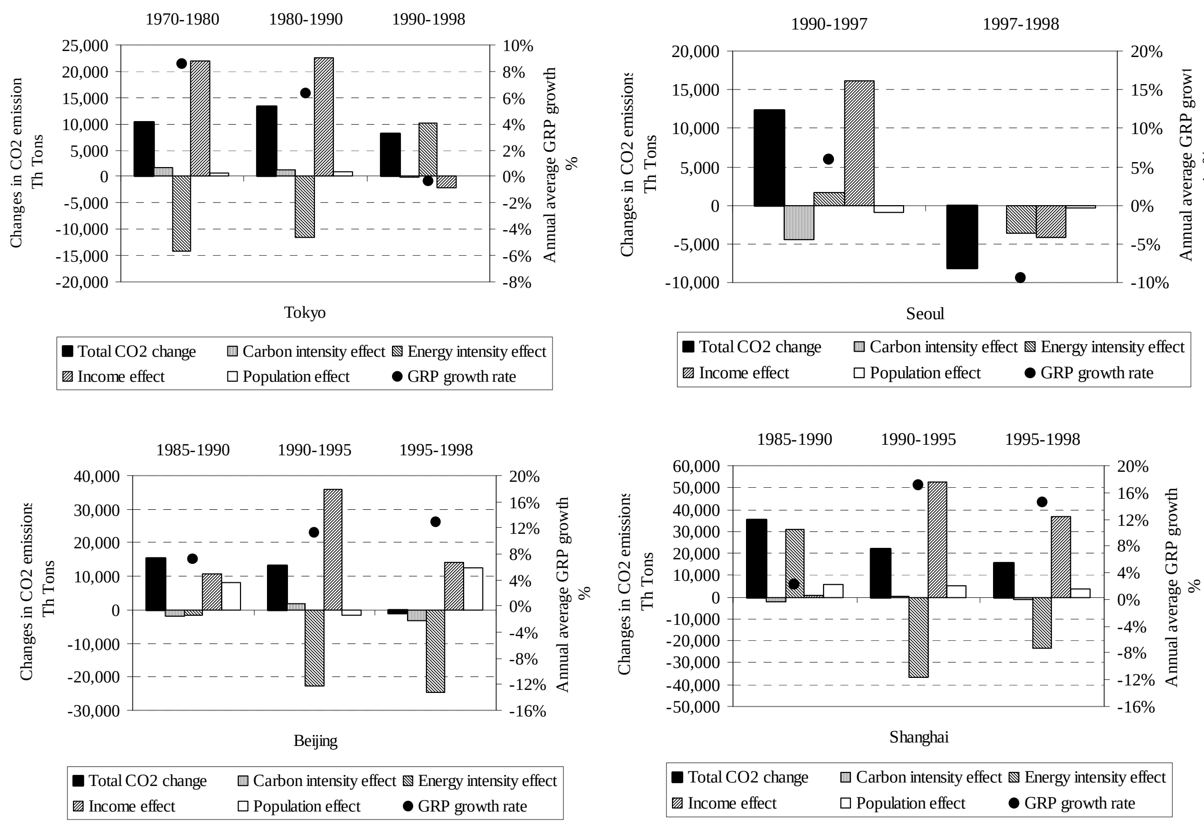


Figure 4.7 Factor decomposition of total CO_2 emissions from energy uses

Source: Dhakal S., S. Kaneko and H. Imura (2003). CO2 emissions from energy use in East Asian mega-cities: Driving factors, challenges and strategies. Proceedings of IGES/APN International Workshop on Policy Integration towards Sustainable Energy Use for Cities in Asia, 4-5 February 2003, East West Center, Honolulu, Hawaii.

amounts in Tokyo during economic growth periods. However, it contributed in an opposite way during recession periods. The role of energy intensity effect is found to be the opposite in Seoul as compared to Tokyo. In Seoul, it produced a negative effect (increased emissions) during economic growth period, but a substantive positive effect (reduced emissions) in the economic recession of 1997-98.

Income effect seems to be responsible for reducing CO_2 emissions in Tokyo in the 1990s. The contribution of energy intensity in reducing emissions has decreased over time in Tokyo since the early 1970s; it was responsible for major increase in CO_2 emissions in the 1990s. Apart from energy intensity, carbon intensity was responsible for significantly reducing emissions in Seoul. Shifting the structure of energy consumption from coal to oil and electricity is major reason for the positive contribution of carbon intensity (The share of coal has changed from 28.8% in 1990 to 1.3% in 1998 (KEEI, 1998).)

Due to unprecedented economic growth, it is obvious that income effect is the major factor behind increasing emissions in Beijing and Shanghai. Energy intensity is found to be the major driving factor responsible for reducing emissions after 1990. Some of the reasons for this could be due to the increasing productivity and improvements in energy efficiency in these cities. Since coal continues to dominate the energy sector, CO_2 emission benefits from the carbon intensity effect seems to be evident only after 1995 due to fuel switching. The role of population effect was small in Shanghai but in the case of Beijing it is contributing significantly.

In the transportation sector (not shown in any Figures), the vehicle population effect is responsible for the majority of CO_2 emissions in all four cities. In the case of Seoul, the vehicle utilisation effect (travel demand per vehicle) was primarily responsible for reducing emissions, but in Tokyo, the energy intensity effect was primarily responsible. For the residential sector (not shown in any Figures), the effects of contributing factors to CO_2 emissions are different for Tokyo and Seoul, primarily due to the differences in building heating and cooling systems and fuel switching. In Tokyo, most of the emissions from the residential sector are attributed to household income effect, unlike scale effect (household population effect) in Seoul. Similarly, in Tokyo, the energy intensity effect is responsible for reducing emissions, but in Seoul, fuel quality effect and income effect are responsible. In Beijing and Shanghai, carbon intensity and energy intensity effects contributed to the reduction of emissions, while income and household population effects were mostly responsible for increasing emissions from 1985-90. In the case of Shanghai, the emission volume increased in 1995-98 unlike Beijing; energy intensity actually contributed to increase emissions. For the commercial sector (not shown in any Figures), the labour productivity effect is dominant in increasing CO_2 emissions in high growth periods, and energy intensity for reducing CO_2 emissions in Tokyo and Seoul. In Beijing and Shanghai, the energy intensity effect contributed to reducing emissions only in the period from 1990-95. The labour productivity effect contributed to increasing emissions in the 1990s (less labour but more machines and energy).

However, the meaning of decomposition analysis should be traded carefully. For example, changes in CO_2 emissions in the transport sector would have resulted only from changes in gross energy consumed per unit of passenger travel demand, while keeping all other factors constant. Such effects are only "what if" analyses. Their behaviour should be closely co-related with actual policies.

4.7. Indirect CO_2 Emissions Embedded in Material Consumption[13]

To minimize the contribution of cities to global environmental change, reductions in direct emissions alone are not enough. Cities consume large amount of material goods, which indirectly affect outside places where manufacturing and resource-extraction takes place. In the case of global issues such as CO_2, it does not matter where emissions originate. Therefore, cities should be judged by their contribution to *"total environmental load,"* which means indirect emissions embedded in the consumption goods in cities could be large enough to outweigh the direct emissions. A similar concept is now being used in analyzing other sectors, such as water use. “Virtual water” has become a common term amongst professionals to promote reductions in water use in cities where freshwater is becoming increasingly scarce.

An Input-Output (I-O) Table based estimation of indirect energy demand shows interesting results for Tokyo, Beijing and Shanghai. In the case of Tokyo and Shanghai, indirect energy demand is more significant than direct energy demand.

Figure 4.8 deals with energy demand, however, a city does not always “consume” but it consumes a significant proportion “to supply” material goods to other places in the form of export products. The relation between direct and indirect energy of which a city is “responsible” are different from city to city depending on the scale of industrialization and type of industries. Based on this notion, the CO_2

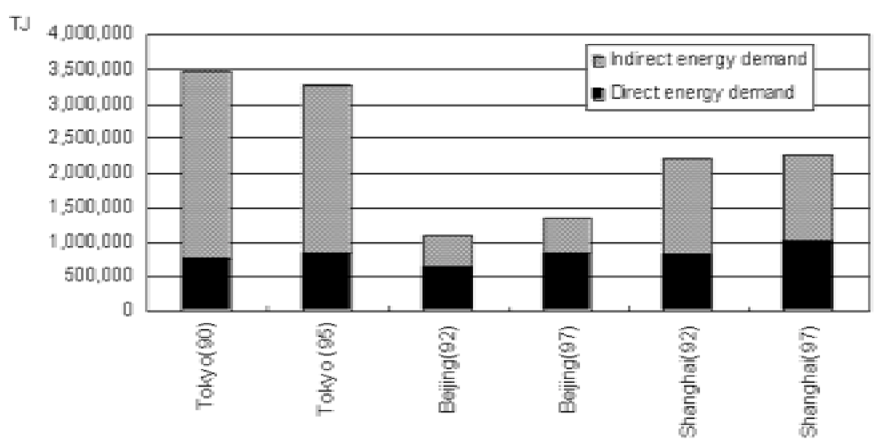


Figure 4.8 Direct and indirect energy demand of selected cities

Source: Kaneko S, H. Nakayama and L. Wu (2003). Comparative study on indirect energy demand, supply and corresponding CO2 emission of Asian mega-cities. Proceedings of IGES/APN International Workshop on Policy Integration towards Sustainable Energy Use for Cities in Asia, 4-5 February 2003, East West Center, Honolulu, Hawaii.

[13] Indirect energy and emission analyses were principally carried out in collaborations with Dr. Shinji Kaneko.

emissions for which the city is responsible are those which are emitted as a result of direct emissions, plus CO_2 emissions embodied in material goods that are consumed in the city after subtracting exported material goods. Table 4.2 shows that indirect emissions in Tokyo are large enough to outpace direct emissions, while Tokyo is responsible for about 68% of the total emissions.

Table 4.2. Direct and indirect CO_2 emissions in selected Asian cities

	Tokyo		Beijing		Shanghai	
	1990	1995	1992	1997	1992	1997
Total emission (1990 Tokyo as 1), Direct and indirect	1	0.9	0.5	0.4	1.2	0.98
Share of indirect emission, %	78	71	50	43	66	49
Share of responsible emission in total emission %	68	72	96	82	69	80
Responsible emission (1990 Tokyo as 1)	1	1	0.7	0.5	1.2	1.1

The figures in this table are preliminary estimations based on I-O Table analyses. The figures should be taken as indicative only.

In earlier sections, we showed that emission volumes of Beijing and Shanghai are 1.4 and 2 times that of Tokyo, respectively, however after accounting for indirect emissions, it is revealed that Tokyo's contribution to CO_2 emissions is greatly underestimated (Figure 4.9).

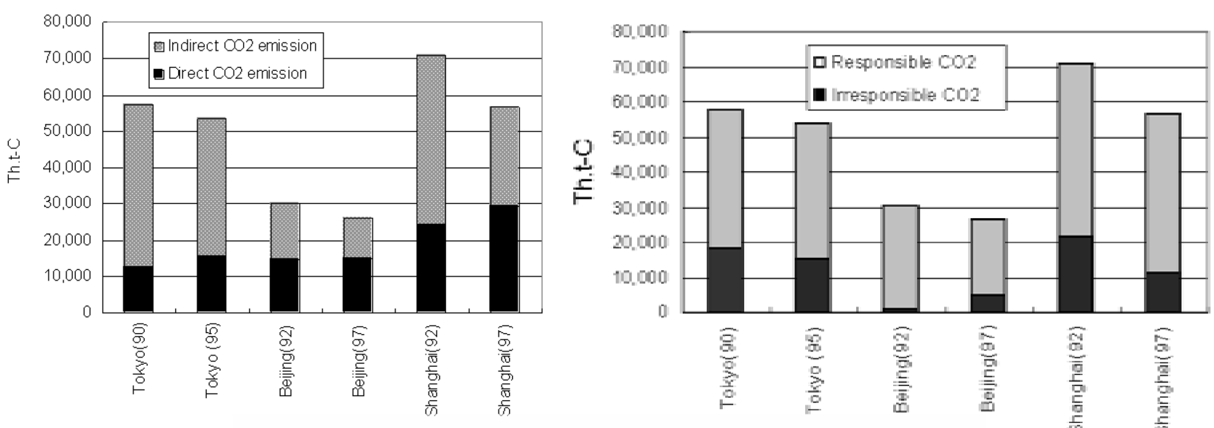


Figure 4.9. CO_2 emission in selected Asian cities

Source: Kaneko S, H. Nakayama and L. Wu (2003). Comparative study on indirect energy demand, supply and corresponding CO2 emission of Asian mega-cities. Proceedings of IGES/APN International Workshop on Policy Integration towards Sustainable Energy Use for Cities in Asia, 4-5 February 2003, East West Center, Honolulu, Hawaii.

4.8. Sectoral CO_2 Emissions and Future Scenario

Road transport**:** Bottom up modelling for energy use and CO_2 emissions for road transportation of the four cities reveals interesting results.

- The vehicle population in Beijing and Shanghai is as low as $1/10^{th}$ that of Tokyo, but their total fuel consumption is about 1/3 to 1/2 that of Tokyo because of lower fuel efficiency and larger vehicle mileage travel.

- The vehicle population trend of Tokyo and Seoul is slower and there are few structural changes in vehicle composition.
- In Beijing and Shanghai, a much smaller vehicle fleet emitted a higher amount of pollution in 2000.
- The role of light duty gasoline vehicles in particular, is expected to rise dramatically in Beijing and Shanghai in the future.
- A 2.4 increase in oil consumption from road transportation is expected in Beijing between 2000-2020; oil consumption in Shanghai will double[14] (Figure 4.10).
- Even under such an optimistic scenario (see the last footnote), future emissions of CO_2 from urban transportation from these cities would be tremendous as in Figure 4.11, which is far from decreasing absolute volume. However, meeting such a scenario is not easy despite the wishes of policy makers. In this Figure, only the vehicle population is considered, which will be saturated in the future, and improvement in energy performance will reduce emissions, however, other factors such as structural change towards larger sized engines, which is Tokyo's present trend, is not included. The purpose of this Figure is to show the speed with which CO_2 emissions from other cities, especially Beijing and Shanghai, might increase.

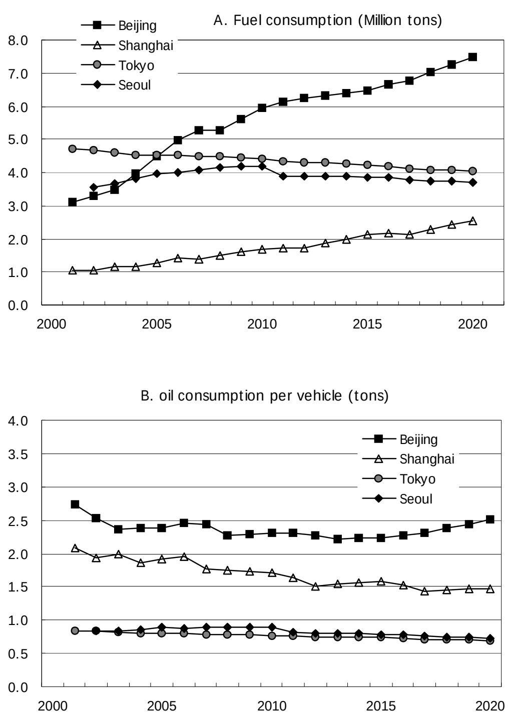


Figure 4.10. Fuel consumption of road transport.

Source: Commissioned report prepared by Dr. Kevin He

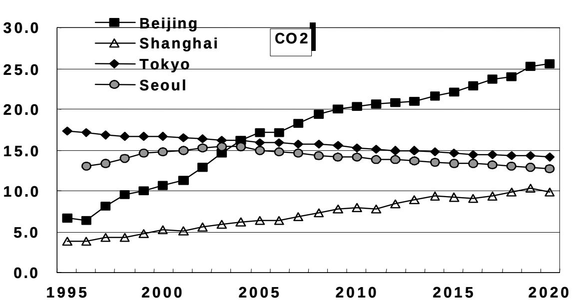


Figure 4.11. CO2 emission, in million tons, from road transportation (indicative only)

Households and businesses: The residential CO_2 emissions of Beijing, in particular, is expected to surpass all three cities in the future, while Shanghai is likely to catch up Tokyo[15]. Lifestyles[16] and

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[14] *Beijing and Shanghai*: Progressively implementation of EURO 2, EURO 3, EURO 4 and EURO 5 in 2003, 2005, 2010 and 2015, respectively, for new vehicles; controlling in-use vehicle emissions strictly; full shift to CNG buses and taxies by 2020; 200 km urban railway; increase in vehicle speeds etc.

appliances[17] are cited as measures that could reduce the maximum volume of emissions in Tokyo. In the case of the commercial sector, the emission volume of Shanghai is expected to increase drastically. Stabilizing the absolute volume of emissions is likely to be a very difficult task in these cities. Tokyo and Seoul are already saturated in terms of CO_2 emissions from residential households and commercial sectors; although they are not increasing greatly, reducing emissions would not be an easy task. Japan has committed to the Kyoto Protocol to reduce GHG emissions by 6% of the 1990 level. Large cities such as Tokyo play a key role in any efforts to reduce GHG emissions. Stabilizing alone would not be enough for these cities.

4.9. Waste Treatment Method and Utilising Waste Heat for District Heating

Earlier sections discussed waste volume and composition of waste, and the various issues surrounding waste and GHG emissions. In Tokyo, 18 incineration plants operated by the Bureau of Waste Management of the Tokyo Metropolitan Government process about 87% pf post-recycled and 100% of Bureau collected wastes as of 1998. In Seoul, only 5% of the total waste is incinerated, but Seoul has 27 incinerators with total capacity of 52,957 kg per hour as of 1999 (With the exception of Yangchun and Nowon, all other incinerators are small). Therefore, the utilisation of waste heat and steam from incinerators in other services such as district heating could play an important role in reducing GHG emissions. In Tokyo, heat generated from incinerators at Ohi, Hikarigaoka and Ariake plants is supplied to Tokyo Heat Supply Co., Ltd. and the Tokyo Seaside Heat Supply Co., Ltd. for heating and cooling of cultural centres, citizen halls, and sports centres in neighbouring areas. From these facilities, steam is converted into electricity and sold to Tokyo Electric Power Co., Ltd. In FY1996; 690,980,000 Kwh of energy was generated—45% of which was sold at a total cost of 2.69 billion Yen in 1996 (TMG, 1999).

The comparison between the cases of utilising waste heat to district heating systems verses LNG based centralized system is made for Newon incineration plant in Seoul (1999: Capacity 33,333 kg/hour; treatment amount 79,936 tons; construction cost 64,666 million Won; 1,200won = US$1) and Minato incineration plant in Tokyo (Capacity 600 ton/day) in this study following IPCC recommended methods. Avoided CO_2 emissions and possible benefits from CDM mechanisms at the rate of US$50/tC are estimated as:

Tokyo: Fuel economic standards for vehicles as set by Japanese government

[15] From commission work of Dr. Toru Matsumoto

[16] Promotion of energy-conservation in residences, such as switching off unnecessary lights, efficient use of heating and cooling equipment, etc. (attitude survey by Japanese Government has revealed that 16% energy can be saved by such factors)

[17] Efficient air conditioning devices (compressor improvements, heat exchangers, intelligent control), refrigerators (conversion of DC motors, better insulation, door gasket, inverter-technology), efficient lighting and improved standby power

Table 4.3. Comparison between two incineration plants in Seoul and Tokyo

	Nowon plans- Seoul		Minato plant- Tokyo	
	Utilising waste heat directly	LNG based boiler for centralized heating	Utilising waste heat directly	LNG based boiler for centralized heating
LNG (toe)	211	10,589	105	3,215
Total GHG in tC equivalent[a] (emitted from waste input[b])	134 (14,983)	6,800	67 (52,654)	2,064
CDM gains(with US$ 50/tc	US$ 333,300		US$ 99,850	

[a] Including CO_2, CH_4 and N_2O
[b] This is excluded because this carbon will be emitted anyway for treatment whether heat is extracted or not

The results above were not carried out in detail. But, as intended, the results show that greenhouse gas benefits from such utilisation should be an important consideration, especially since issues such as CDM and emission trading are emerging as a tool to facilitate the reduction of greenhouse gas emissions. The cost and viability of district heating depends on a number of factors. At the same time, matching of supply and demand of heat, steam, etc., is necessary.

Apart from incinerators, landfill gas utilisation from landfill sites could be a viable option for reducing greenhouse gases, especially methane. This is especially important for Seoul, Beijing and Shanghai, which has limited role for incinerators and depends mostly on landfilling.

SECTION B: LOCAL PRIORITIES, RECENT POLICY DEVELOPMENTS, OPPORTUNITIES AND BARRIERS

5. CITY POLICY MAKERS AND CO_2 EMISSIONS

The prime focus of city and municipal policy makers is on local environmental issues such as solid waste management, air quality management and wastewater management. Despite this, there is a growing international need to incorporate global environmental concerns into local policies. Authorities in developed cities such as Tokyo realize that cities are centres of high population density, business activities, mobility demand, and rapidly growing lifestyles and they are expected to contribute significantly to energy demand and CO_2 emissions. Although local issues are prime targets for local authorities, carefully and well placed plans and programmes can simultaneously reduce local air pollutants, improve energy efficiency, and reduce CO_2 emissions. However, formulating such strategies is not easy. Developed nations of Annex-I[18] are still struggling to formulate response strategies at national levels. Such expectations from cities at the moment should be minimal. There are many challenges in cities; some of those core challenges are:

- lack of awareness among local policy makers on global issues;
- lack of scientific studies, inventories of energy and CO_2 emission, and related information;
- financial, human and technical resource limitations even to tackle urgent local air pollution;
- priority questions in resources allocation; and
- citizen's awareness.

Despite such limitations, mega-cities, especially in North-East and South-East Asia, are aware, to some extent, of the need to reduce CO_2 emissions. In a mega-city such as Tokyo, the volume of CO_2 emissions exceeds that of many nations. Tokyo's contribution to CO_2 emissions[19] is about 1% that of all developing countries (TMG, 2002). The growing trend of decentralization is empowering local authorities to tackle their own problems.[20] Such power shifts have become evident in the last few decades in both the developed and developing world. Accordingly, policy makers in cities, especially large cities, have many avenues under their jurisdiction to reduce CO_2 emissions and energy demand. In this context, this section presents the following discussions:

- *Local environment priorities and challenges* in Tokyo, Seoul, Beijing and Shanghai, and significance of the issues of greenhouse gas emissions
- *Recent development in policy dimensions* at the city level in relation to GHG emission concerns, with special focus on Tokyo and Beijing (these cities respectively represent a developed city and a rapidly developing city)

[18] Belonging to Annex I of United Nations Framework Convention on Climate Change
[19] Direct CO_2 emissions as a result of energy use
[20] Many nations have already enacted Self-Governance Act for local bodies. There is a growing trend to empower and strengthen local authorities to tackle local issues. In the area of environment, so far, the management of solid waste has already been delegated to local authorities in many developing Asian countries. The areas of air quality and wastewater management are slowly being addressed. Local governance

- *Opportunities and barriers for policy integration* for local governments and for different scales of environmental governance: The national government's response and overall set-up is important to enable local authorities to act in Asia because national government has been a prime mover in many instances. With this view, some perspectives on domestic policies for greenhouse gas abatement in Japan (and to a lesser extent, other cities) are put into perspective in this paper. Some discussions also highlight the role of international institutions.

is well established in East Asia (such as Japan, China, Korea, Taiwan) and is rapidly gaining momentum in South-East Asia and South Asia.

6. LOCAL-GLOBAL ENVIRONMENTAL PRIORITIES AND CHALLENGES

6.1. Local Air Pollution Priorities and Challenges

Increasing energy demand and emissions of local air pollutants have severe implications on air quality. Depending on the city, the concerns from individual pollutants are different. Particulates of various sizes are a common concern for most of the large cities in Asia. Some of the cities in Asia have been overly exposed to NOx; controlling NOx, even in developed cities, remains a contiguous task. In industrial cities that use coal as a major source of energy, trans-boundary environmental problems are serious threats, where acid rain may accelerate the problem of desertification on a regional basis. SOx emissions are usually associated with coal use in stationary sources such as power plants, industries, domestic and commercial boilers, and so on. In the case of NOx and PM, mobile sources are becoming increasingly responsible for emissions. Some of the cities are even diversifying the energy sources with the view of replacing one form of energy with another, based on availability and energy security.

6.1.1. SOx, NOx and particulate problems

The trend of air quality shows that Tokyo was successful in reducing the concentration of SO_2 drastically between the mid-1960s to the early 1970s, and Seoul after 1988. Beijing and Shanghai, in particular, suffer from higher concentrations of sulphur dioxide and particulate emissions compared to other cities as shown in Table 6.1. Rising emissions of air pollutants would further aggravate these parameters. Since coal continues to dominate the industry and energy sector as a whole in Beijing and Shanghai and the economy is growing at rapid rate, the development and implementation of serious policy efforts are inevitable, should policy makers wish to bring these parameters to acceptable limits.

Table 6.1. Air quality in selected cities, in micrograms per cubic meters

City	Particulates (1997), mg/m3	Sulphur dioxide	Nitrogen dioxide
Beijing	377 (TSP)	71 (2000)	126 (NOx, 2000)
Shanghai	229 (TSP)	46 (2000)	91 (NOx, 2000)
Tokyo	45 (ward, SPM)	20 (ward 1997)	94 (city centre), 64 (ward) (NO_2 1998)
Seoul	72 (TSP), 68 (PM10)	31 (1997)	62 (NOx 2000)

Source: Statistical yearbooks of cities
TSP: Total suspended particles

Box 6.1. Issues and concerns in the current development paths and transitions in South Asia from energy and transportation

Mapping key physical issues

The major energy, environmental, and transportation issues in South Asian cities include increasing energy use, CO_2 (carbon dioxide) emissions, and localized air pollutant emissions—especially PM10 and dust, whose concentration far exceeds WHO guidelines, along with rapid motorization, growing traffic congestion, and increasingly overburdened public transportation systems.

Two-and-three wheelers, the majority of which are run on two-stroke engines, dominate South Asian cities. In recent years, some efforts have been made in Dhaka, Kathmandu, and a few other cities to phase out the two-stroke two- and three-wheelers. In the quest for cleaner air for citizens, the judicial system has been forced to intervene in ordering the use of CNG in public transportation in New Delhi. There are currently efforts underway towards CNG conversion for three-wheelers in Dhaka. In Kathmandu, battery-operated three-wheelers have replaced the smoke-belching diesel three-wheelers for commercial operations. These changes represent a transition towards cleaner vehicles and fuel. However, at the moment, the role of cleaner vehicles seems to be largely limited to niche sectors.

Improvements in the public transportation system are progressing at a slower pace in the region in general. At the moment when private vehicles are increasing at an alarmingly high rate, the efficiency and coverage of public transportation remains poor. Traffic management and road conditions have not improved at the pace of the growth in vehicle number.

Though vehicle emission standards and regulations are in place for new vehicles, the majority of the problems arise from in-use and old vehicles. Old vehicles perform poorly in terms of energy use and emissions; they are of significant concern in the region. Yet, socio-political dynamics and public acceptability have prevented phasing out of old vehicles from the streets in the region. Much debate centres on the lack of financial capacity, but policy makers have not been able to even implement those measures that do not demand much financial resources. In major cities in the region, the local air pollution situation has worsened to such an extent that the problem is visible even without the need to refer to scientific data. The scientific data confirm what is obvious to all: air pollutants, energy and CO_2 emissions in cities in the South Asian region are all on the rise.

Lack of scientific understanding

The lifestyles of urban dwellers in Asian cities are becoming more and more energy intensive. Consumption of material goods and water is on the rise. Over-motorization is also an over-reliance on commercial energy use, and electrical and electronic equipment are common features of cities. There is little understanding of the various forces leading to these changes and the strategies that can be adopted to mitigate their impact on the environment. The energy footprint of cities (taking into account direct and indirect energy use and emission embedded in consumption) is rarely studied at the city level. Existing policies have typically not addressed the issues with such a comprehensive approach.

A huge gap in existing knowledge, credible scientific information and data related to energy use and emissions exists in the region. Some research exists on urban transportation issues but the depth and coverage of this research is limited. For example, data on local emission factors of transport modes, and vehicle population along with age and engine size does not exist in many cities. There are also a number of technical and non-technical gaps in understanding. The roles of technological and non-technological options and measures have not been clarified.

Scientific studies in the urban sector in areas other that transportation are even more scarce. Efficient ways to manage energy use in buildings while keeping the level of amenities intact are rarely studied. Some limited work on CO_2 emissions from municipal waste has been carried out, but, in general, research on city-scale energy use and emissions do not exist. Since policy makers are largely unaware of the full range of issues, a situation is created where scientific findings seldom influence actual policies. Lack of sufficient research has also hindered the influence of scientific studies on policy making.

Box 6.1. Issues and concerns in the current development paths and transitions in South Asia from energy and transportation (continued)

Policies and institutions

Policy failure (due to a combination of market failure and institutional failure) is a common phenomenon in South Asia. Institutional arrangement for policy formulation and implementation remains a key issue. Inefficiency of government-affiliated enterprises and related cost-recovery problems hinder public transportation restructuring, as well as the provision of correct signals to the market for private sector participation. Incorrect incentive systems mostly distort the market. Most of the policies have been reactive rather than proactive and an over-dependence on short-term and ad-hoc policies often results in a chaotic situation. Too much emphasis on end-of-pipe solutions has also been witnessed in the region.

Serious reform in the public transportation system is a key need in the cities, along with an appropriate system of incentives. In addressing transportation energy use and equity issues, of even more serious concern is the pattern of land development that is beginning to emerge in the region. The policy needs to be in place for appropriate land development patterns that are consistent with transit and non-motorized modes of transportation. The American pattern of suburban sprawl comes packaged with all the seductive powers of Hollywood, but carries with it a tremendous societal and environmental cost for all cities worldwide. Policy makers and researchers need to look to environmentally sustainable cities like Zurich, Curitiba, and Singapore for measures to unlink economic growth from environmental degradation.

A slow pace of economic growth in comparison to East Asia and South-East Asia prevails in South Asia and this partly hinders reforms as transportation issues are intertwined with low-income groups and equity issues. Due to slow economic growth, improvements in processes and productivity related to the production and consumption system are hard to achieve.

Since the market is not well established for environmental services, policymakers are unable to utilise market-based mechanisms for influencing changes. This has led to an over-dependence on a command-and-control approach, although more efforts are being made to use market approachs, especially in areas relating to urban physical infrastructure. Regulatory and governance issues are the key issues facing South Asia: the regulatory provisions are not adequate and institutional problems hinder policy implementations.

Key transition needs in South Asia and research questions

Following are the key observations on South Asian transition needs. These perceived transition needs are consistent with the concepts of the Industrial Transformation project.

Interventions other than end-of-pipe management: As mentioned above, most of the interventions are happening at the end-of-pipe and interventions in the system are key transition needs, especially from the policy perspective. Modal shifts from clean vehicles to clean transportation systems, the drive towards energy-efficient buildings, a watershed approach to urban water management, and switch from energy use to clean energy use are the key needs. Usually end-of-pipe policy interventions are reactive and systems interventions are proactive in nature. Awareness and research are observed in this direction but the trend is still insufficient.

Shifting from strong government interventions to strengthening multi-sector and multi stakeholders: Some efforts are underway, especially in the public transportation and water sector (infrastructure sector). Awareness creating and capacity building of the society as a whole to address environmental problems is a key need in the region. This shifts the burden of problem solving from the *specialists* to the *society*, thus relieving the financial burden and reducing the scale of the problem.

Changing the management philosophy: This transition seeks a change in the driving philosophy from minimization to optimization. Institutions and policies should play a key role in such changes.

Use of market-based approach while keeping equity issues at the forefront: The need to create systems for a market-based approach and promoting public-private partnerships is evident in South Asia. This also helps to overcome some of the infrastructure-related constraints. Getting polluters to pay principle-based fees and tariffs and taxes without distorting the market are essential moves. However, regulatory and institutional reforms for such a transition are a necessary prerequisite.

Source: Dhakal and Norman (2003)

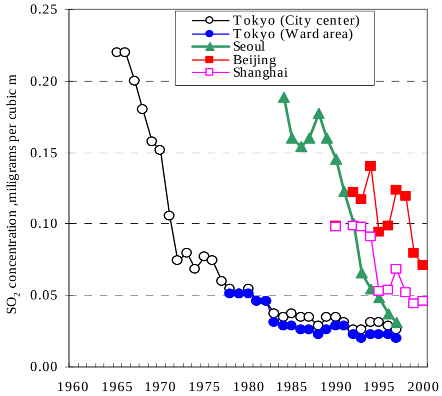

Figure 6.1. SO_2 concentration trends

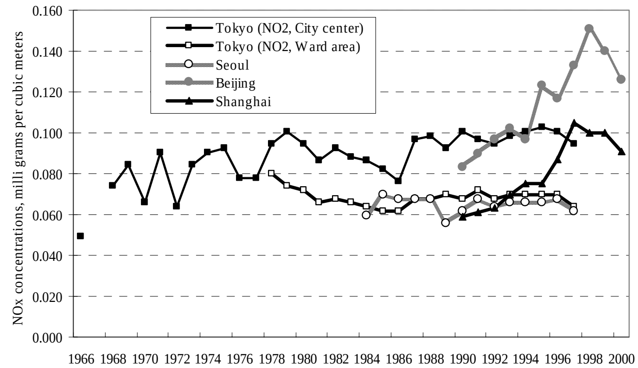

Figure 6.2. NOx concentration trends

Tokyo has been successful in reducing concentrations of key air pollutants related to industry in the last three decades, which includes dust, carbon monoxide and sulphur dioxide. However, it has been struggling considerably to control suspended particulate matters, nitrogen dioxide and photochemical oxidants. Most are essentially emitted by businesses, households and lifestyle related activities. Therefore, a number of other problems other than greenhouse gases are of the highest priority in Tokyo, such as controlling diesel vehicles. Most Japanese cities, including Tokyo, suffer from SPM and NOx problems. Diesel vehicles were responsible for almost all particulate matters and about 70% of NOx emissions in Tokyo in 2003 (TMG, 2003). A past estimation shows that automobiles were responsible for 67% of total NOx emissions, of which 73% was contributed by trucks and buses in 1995 (TEW, 1997).

In Seoul, SO_2 and PM10 are not a major concern because they are within the WHO recommended guidelines, and in last two decades, their level has been decreasing with an increasing supply of clean fuel, better road pavements, etc. However, the level of NOx (especially NO_2) and ozone are increasing, primarily due to the increase in volatile organic compounds and slowing traffic flow in roads.

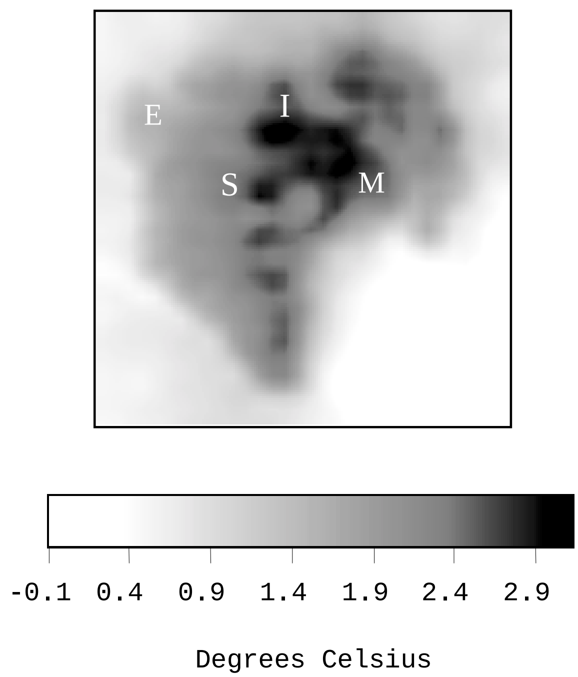

Figure 6.3. Contribution of energy use to urban heat island in Tokyo wards (32x37 km) at 9 pm for typical calm summer day in July (M: Marunouchi, S: Shinjuku, I: Ikebukuro, E: Itabashi), 2000

Source: Dhakal and Hanaki (2002)

6.2. Nature of Urban and Global Warming Challenges and Available Options

6.2.1. Urban warming challenges and options

Apart from air quality, energy use also affects other local problems, such as urban warming (often called "urban heat island"). "Urban heat island" is the term used to describe a condition where temperatures of urban areas are higher than those of its surrounding rural areas (about 2-7ºC). In the past, this phenomenon had been observed during winter in high-latitude cities, mostly in Europe and North America, but today it is increasingly affecting many tropical cities during summer. Energy use is one of the major factors for worsening urban warming; this results in heat stress, increase in cooling energy demand, increase in ozone (smog) events and associated economic implications. In Seoul, urban warming is becoming a growing concern and the number of days which exceed acceptable ozone levels is increasing. In 1995, it was reported that only five days exceeded acceptable ozone levels; this increased to 33 days in 1997 (Kim, 2004).

While global warming is a distant priority for local policy makers, direct and indirect pressure from the national government's Kyoto commitment and public sensitivity to urban warming has created a favourable situation for local policy makers to act in Tokyo. Tokyo is suffering from "urban heat island" phenomena, whose impacts are aggravated especially in the summer (Dhakal and Hanaki, 2002). It is evident from the measurements made by the Tokyo Metropolitan Observatory that the number of nights over 25ºC has increased from 14 days in the early 1960s to 32.4 days in 2000 (TMG, 2003). The vicious cycle of urban warming, resulting in the increase of air conditioners and high rate of discharging such waste heat to the urban environment, has had a significantly toll on health and economics.[21] Various measures are possible to alleviate heat island effects through interventions in buildings, land use and energy systems (Dhakal, 2002). It is significant to note that in Tokyo, key downtown areas such as Marunouchi and Ikebukuro are reported to have significantly higher temperatures than other parts of Tokyo; the maximum contribution of energy use to heat island is reported at 3.4ºC (Dhakal and Hanaki, 2002). In Shanghai, the rural and urban temperature difference is reported at 2.7ºC (Shu et al., 1997). Seoul is increasingly affected by urban heat island problems, and accordingly, Seoul Metropolitan Government is actively studying various measures. Increase in energy consumption in the future is likely to aggravate such phenomenon. The interventions to improve urban warming such as energy management and increasing use of urban green space reduce CO_2 and enhance CO_2 sink.

[21] Studies by Lawrence Berkeley National Laboratory in USA has estimated such cost figures in terms of ozone, smog incidences, additional electricity use and resulting economic valuations. See: http://eetd.lbl.gov/HeatIsland/

6.2.2. Nature of greenhouse gas management challenges and available options

In previous sections, we concluded that commercial and transportation sectors are responsible for the majority of emissions in Tokyo. The commercial sector includes large-scale businesses such as office blocks, department stores, hotels, retail businesses and others. Office buildings and restaurants, in particular, are responsible for the majority of energy consumption (TMG, 2002a) in commercial sectors. Despite the economic slowdown, emissions are rising in Tokyo[22]; the fact that such a consistent rise comes from non-industrial sectors makes these challenges more serious for local policy makers. Office automation and an increasing use of computers and other office appliances, together with air conditioning systems, are the major sources of CO_2 emissions from large-scale businesses and offices. For the transportation sector, there is a structural shift towards larger cars in Tokyo; therefore, despite significant improvements in fuel efficiencies of different car-sizes (while meeting existing standards) and non-increasing per capita car ownership, CO_2 emissions from automobiles are increasing consistently. In Tokyo, heavy weight vehicles (gross weight over 2.5 tons) account for about one third of emissions from all automobiles, yet, those vehicles are not subject to any existing standards (TMG, 2002b).

Therefore, the major options for policy interventions are in businesses operations, buildings (in particular, office buildings) and the transportation sector in Tokyo. Energy and CO_2 interventions to urban households can be done through appliance efficiency improvements, fuel pricing mechanisms and building energy efficiency standards using the market. Lifestyles can be influenced through campaigns and awareness-raising. These are perceived challenges from direct emissions. Yet, we are talking about direct emissions and only those emissions that are embedded in electricity use. However, for city policy makers who are working to reduce direct CO_2 emissions (because it not a local issue), any policies to address such embedded emission in material use would only take place in the distant future. With the enactment of a law for “Material Recycling-Oriented Societal Development” in Japan however some action may be possible from such perspective. Despite these challenges, the emission performance of Tokyo, in terms of per capita and per unit gross regional product, are better compared to other East-Asian cities such as Seoul, Beijing and Shanghai (Dhakal et al, 2002a). Reasons for this could be: compact settlements; well-developed rail-based mass transportation infrastructure; efficient electric appliances and automobiles; the city’s function as a commercial, rather than industrial hub; and mild winters and summers, among others.

[22] This is based on data from 1970-1998. At the national level the peak for CO_2 emissions was in 2000, a 2.7% decline in 2001 from 2000 has been reported. However, the author has not carried out such estimation for Tokyo. Over 30% of electricity use in Japan comes from nuclear energy located to plants in north; in the case of Tokyo such nuclear shares must be quite high in reality, although authors used CO_2 intensity of electricity at the national average. After the Tokaimura nuclear accident in 1999 and several others, nuclear plants have been shutdown in recent years and CO_2 intensity of Tokyo’s electricity must have increased significantly.

In Seoul, fuel switching in industries and buildings has contributed significantly to reducing CO_2 emissions in the last decade. Unlike Tokyo, Seoul uses central heating systems in buildings. The potential for improving energy efficiency and fuel switching are high because in the past, fuel switches were mainly from coal to oil and, to some extent, from oil to gas. Road transportation and private cars are another area of concern in Seoul. Heating is an area which, through district heating systems, can reduce emissions.

For Beijing and Shanghai, industry, buildings and urban transportation are sectors with great potential for interventions to reduce GHG emissions. In both cities, fuel switching in industries is a viable option. Building insulation, efficiency improvement of electric appliances and fuel switching for central heating systems can also play important roles in reducing energy, local emissions and GHG emissions. Energy inefficient building designs, materials and construction persist despite construction booms in these cities since 1990. Some improvements have been made in recent years, especially after 2001, in response to new regulations from China's Ministry of Construction, yet, old practices continue (Feng, 2002). There are a number of other associated problems such as; disconnection of heating cost and household income; lack of market infrastructure and regulations; and lack of know-how for energy efficiency improvements (Feng, 2002).

GHG emissions from urban transportation may seem low at the moment for both Beijing and Shanghai. However, massive investment in the transport systems is planned for the coming years, which brings about greater potential for energy use, air pollution and CO_2 emissions. Compared to other mega-cities, private cars are in relatively little use now however Shanghai and Beijing are already suffering from serious air pollution problems from urban transportation. Furthermore, China's growing economy and WTO membership is likely to increase income, reduce tariffs for automobiles (due to competition and trade barrier reductions) and enhance credit facilitation mechanisms for purchase of new cars. Thus, urban planners in Beijing and Shanghai are already projecting a three-to-fourfold increase of cars and trucks by 2020 (Zhou and Sperling, 2001). Transportation in these cities is highly dependent on road transportation infrastructure, especially in Beijing. The Chinese Government is increasingly viewing private vehicle growth, automobile industry[23] and infrastructure development as a driving force which can stimulate personal consumption for economic growth. Accordingly policies to stimulate private vehicle use such as purchase loans, reduced fees for vehicle use[24] and lengthening the useful life of passenger cars from 10 to 15 years are being implemented (Lin, 2003). In Beijing, massive transportation infrastructure is being planned ahead of the 2008 Olympic Games and ambitious goals exist for environmental management. Key management challenges to control two-stroke engine based two and three-wheelers exists in these cities.

[23] In 1998, China was ranked 10th in automobile production in the world. Produced 2 million vehicles in 2000.
[24] Chinese government stopped collecting 238 different fees related to vehicle use. See http://finance.sina.com.cn

Potential countermeasures in the transportation sector include a switch to alternative fuels (e.g. compressed natural gas—CNG); promoting electric and hybrid vehicles; increasing average vehicle speed through traffic management; increasing the fuel efficiency of cars and improving fuel quality; improved public mass transportation systems and limiting private cars; and appropriate land-use planning. These measures should contribute to reducing travel demand, trip length and frequency.

In Beijing, light duty gasoline trucks and cars are expected to become a key component in future reductions of energy demand and CO_2 emissions. However, car-limiting policies for new vehicles alone would not be sufficient in Beijing and Shanghai; greater efforts are needed to control vehicles in use and to reduce vehicle mileage. Efficient public mass transportation systems are inevitable for these cities. Car-limiting policies are difficult to implement in Tokyo and Seoul. For improving fuel efficiency, fuel quality and end-of-pipe technology at vehicle tailpipes, there is a limited scope for further drastic improvement in Tokyo and Seoul, but the most promising way is to implement policies that motivate people to change their lifestyles (such as driving behaviour), and to set up a system of economic instruments, such as parking fees and congestion pricing.

The prospects for implementing countermeasures in the building sector are also enormous in these cities. This includes improvements in building insulation, appliance efficiency, and efficient central heating systems. Government policies can target building codes, laws, and standards for promoting appliance efficiency. Simple measures such as changing from incandescent lamps to fluorescent lighting can save a great amount of electricity. The scope for improvements in appliance efficiency may be much less in Seoul and Tokyo than in Beijing and Shanghai. The use of renewable energy such as solar panels for hot water production, appropriate temperature settings for heating and cooling systems and avoiding wastage of electricity are key in conserving energy.

7. POLICY DEVELOPMENTS, COUNTERMEASURES AND POLICY CHALLENGES IN CITIES

7.1. Policy Trends in Cities

Policymaking and policy implementation is a complex process. Although there could be several countermeasures that can address energy demand, local pollution and GHG emissions, mobilizing a mix of different policy instruments suitable for local conditions is a key challenge to policy makers. Policymaking and policy implementation becomes more challenging in cities in developing countries, which face severe technological, financial, regulatory and institutional constraints. One strategy of a city does not work well in other cities due to the differences in various prevailing conditions. Often, even if beneficial policies are in place, institutional failure to enforce and implement the policy is a core problem in many cities in Asia. Tokyo and Seoul are well-managed cities compared to other cities in the region. Beijing and Shanghai also have good institutional structures for policy making and implementation; decentralization for environmental governance in Beijing and Shanghai is far better than many cities in South-East and South Asia. All of these four cities have constitutional mandates to fully govern the local environment. Despite these advantages, policy barriers and constraints exist. Better regulations, greater use of economic instruments and market based approaches, innovative financial mechanisms based on public-private partnerships, and increasing institutional capacity to implement policies are necessary.

There are several successful experiences in building and transport related policies implemented elsewhere that could be useful to these cities. For example, Singapore has a successful experience in integrated land use, transportation and vehicle emission control strategies. Singapore mainly implemented strong policies to restrain vehicle numbers and use through congestion pricing and other policy instruments. Shanghai has implemented a similar capping of vehicle numbers with some success. Successful examples in Singapore are described in APPENDIX A. A successful introduction of battery operated vehicles in Kathmandu, although at a smaller scale (by charging batteries with electricity largely drawn from hydro-power), shows that various “niches” for clean fuel needs to be tapped and promoting such measures is a complex process (see APPENDIX B). APPENDIX C describes the step-by-step implementation of various measures in Kitakyushu City to control SOx emissions. A choice and balance between curative (end-of-the-pipe approach) policies for short-term problems and pro-active approach policies for the long-term is essential.

Comprehensive and focused policies on greenhouse gas mitigation do not exist at the city level in Asia. However, recently many cities in relatively developed countries such as Japan and Korea have started formulating such policies. Japanese cities are obliged to prepare countermeasure plans by law and several cities are opting to make such countermeasure plans. Tokyo is ahead of all cities in Japan;

although it has not enforced mandatory greenhouse gas mitigation plans, Tokyo is trying to integrate this into a number of areas such as building energy performance plans, urban warming mitigation plans, appliance efficiency improvement plans and road transportation. No such concrete plans have been formulated in Seoul, but the Seoul Metropolitan Government is weighing the various options and trying to find avenues to begin. Shanghai and Beijing's focus is on air pollution and fuel switching from coal to better quality coal or natural gas; in this process, they have large potential to cut back CO_2 emissions without having any explicit CO_2 countermeasures. In essence, they do not have any explicit policies or targets for CO_2 reduction like other developing countries in Asia.

Thus far, the synergy and conflict between air pollution mitigation and CO_2 mitigation is poorly understood in these cities. Energy efficiency improvement always helps in reducing CO_2 emissions however the choice of fuel and structural shift of activities and fuel type may not necessarily produce synergy between air pollution and CO_2 emissions. Such aspects are largely neglected not only by Beijing and Shanghai but also by Seoul and Tokyo. Apart from the above, the use of market based mechanisms, such as trading, are not on the policy agendas in Tokyo and Seoul for any plausible CO_2 reduction and countermeasures are likely to overly rely on efficiency improvements in the energy sector. The following section describes in detail the policy initiatives in few cities, namely Tokyo and Beijing.

7.2. Japanese Domestic Policies and Implications for Local Governments

Japan's commitment to the Kyoto Protocol is a 6% reduction in greenhouse gas emissions from 1990 levels. From 1990 to 2000, greenhouse gas emissions had already increased by 8%. That means, a reduction of 14% from 2000 levels is necessary to meet the Kyoto commitment. In May 2002, the Japanese Diet ratified the Kyoto Protocol. The burden now lies not only with the national government; without cooperation from local governments it would be impossible to meet such goals. The *Law Concerning the Promotion of the Measures to Cope with Global Warming*[25] clearly seeks the assistance of local governments to play effective roles; Article 4 mentions the responsibilities of the local governments as follows: "1. Local governments shall promote policies to limit greenhouse gas emissions and to enhance sinks in accordance with the natural and social conditions of their areas. 2. Local governments shall take measures to limit greenhouse gases emissions and to enhance sinks in their own business activities, and strive to provide information on policies specified in the paragraph 1, and adopt other measures so that enterprises and residents in their areas are encouraged to take activities to limit greenhouse gas emissions and to enhance sinks." Article 8 seeks the cooperation of

[25] Promulgated in October 1998. "Shared responsibility" is the key term in Japan's policy where the roles and responsibilities of all stakeholders (local governments, citizens and private sector) are emphasized. The basic policy has four principles (1) contributing to both economy and environment (2) step-by-step approach for

local governments to formulate action plans on local government's businesses activities (publishing the action plans and implementation status).

Japanese national CO_2 emissions hit a record high in 2000 (1.237 billion tons), 0.2% higher than 1999. CO_2 emissions in FY2001 were down by 2.7% than in 2000 (JFS, 2003). Towards such a huge task of complying with the Kyoto commitment, the salient features of policies of the Japanese Government thus far can be summarized as follows:

- enactment of comprehensive regulatory framework: Law Concerning the Promotion of the Measures to Cope with Global Warming was promulgated in 1998; from 1999, the Japanese Ministry of Environment (then, Environmental Agency) started the implementation of law by developing basic policies. A new guideline for measures to prevent global warming was issued in March 2002.
- promotion of domestic discussions, awareness to stakeholders and activity promotion centres
- promotion of voluntary actions plans[26]
- national-local linkages: facilitation to local governments
- promotion of energy efficiency improvements and consolidation of other laws such as Law Concerning Rational Use of Energy and their measures[27]
- promotion of a package of more than 100 measures

Despite these measures, however, the core issues related to implementation are not clear thus far. In effect, Japan lacks concrete measures compared to other similar nations, especially those in Europe. Some of the shortcomings of the domestic policies are outlined as:

- lack of realistic and comprehensive policy packages and too much emphasis on sectoral approach, especially industry and construction (buildings)
- over reliance on technology intervention and energy efficiency improvement policies: approaches are too traditional to meet stipulated commitment
- slow progress towards market-based mechanisms (such as carbon tax) and mandatory domestic emission trading (likely to start in 2005)
- policies unable to address lifestyle and consumption related issues, especially in transportation, and households
- slow progress for institutional coordination towards effective measures, especially various government ministries and their units

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policies and measures (3) shared responsibility amongst stakeholders, and (4) ensuring international cooperation.

[26] Keidanren (Japan Federation of Economic Organizations) established the voluntary action plan in June 1997.

[27] This includes, energy management, improvement of appliance efficiency (top runner approach, hybrid vehicles, etc.)

7.3. Policy Trends in Tokyo

Policy makers in Tokyo are well aware of the urgency of CO_2 related policies. Tokyo is working on a comprehensive strategy to combat urban and global warming simultaneously, which has also been reflected in institutional arrangements inside the Tokyo Metropolitan Government.[28] A recent survey in Tokyo concluded that more than 90% of respondents felt threatened by rising temperatures in the city and were concerned about global warming.[29] 96.3% respondents indicated their willingness to cooperate and would accept some inconvenience, if necessary.[30]

Despite such positive response, framing global issues for local interest is not easy. One of the three basic principles set out by the TMG in its *Stop Global Warming Campaign* is "stimulating Tokyo's economy through anti-global warming initiatives." This shows the difficulty that the local government is facing to rationalize policies for global problems. This true for other Japanese cities such as Kitakyushu, where the concept of constructing an eco-city often includes attracting environmental industries. Without rationalizing economic benefits or direct local environmental benefits, any action based on global environmental consideration alone would be difficult to implement.

Institutional response from Tokyo Metropolitan Government

Regulatory framework: Unlike many cities in Asia whose mandates are limited for governing the urban environment, the Tokyo Metropolitan Government is empowered to govern Tokyo. This includes making rules, standards and regulations for enforcement. At the national level, The Basic Environment Law of Japan, enacted in November 1993, provides a framework for individual laws related to CO_2 emissions and air pollution, namely, the Air Pollution Control Law (June 1968), Automotive NOx and PM Law (June 1992), and Law Concerning the Promotion of the Measures to Cope with Global Warming (October, 1998).[31] In parallel with this, the Tokyo Metropolitan Government has enacted its own Basic Environmental Ordinance (July 1994) for basic environmental regulations. The TMG Master Plan for Environment (January 2002) provides basic plans to support all individual ordinances (Some of these individual ordinances were completed revised in December 2000, such as Ordinance on Environmental Preservation.)[32] The Global Warming Action Plan was thus formulated.

[28] Tokyo Metropolitan Government's Bureau of Environment has a separate Department called "Urban and Global Warming Department" (translated from Japanese by author) since 2001.
[29] For details see Japan For Sustainability Information Centre, 10 March 2003 update, http://www.japanfs.org/
[30] Despite TMG's campaign 80% said that they are unaware of TMG campaigns.
[31] Ministry of Environment, Japan, see http://www.env.go.jp/en/index.html
[32] Personal interview carried out by author at Local and Global Warming Control Department (tentative translation) of TMG in June 2003.

Numerical targets: The Tokyo Metropolitan Action Plan for Environmental Conservation sets numerical targets to reduce greenhouse gas emissions from Tokyo by 6% of 1990 levels by 2010. This means a 12% reduction from 2000 levels, or about a 20% reduction from business-as-usual emissions in 2010. While this goal is ambitious; such targets have acted as a prime mover for action towards emission mitigation.

Institutional arrangement: In order to facilitate a comprehensive response to global warming problems, TMG established a separate department[33] within the Bureau of Environment which is responsible for drawing up comprehensive plans and overseeing the implementation of integrating global warming concerns into individual sectors such as transportation, urban planning, buildings and others. This is a unique institutional arrangement seldom seen in other cities. Although this department is responsible for comprehensive planning, in reality, it does not include a number of core sectoral issues such as transportation, primarily due to the fact that its is politically risky for a city to embark on GHG emission issues when there is a urgent need to tackle growing SPM and NOx problems. Among the six key challenges witnessed after Stage I of the campaign (see below: Stop Global Warming Campaign) by TMG, the newly instituted department has been given a mandate for the first three challenges, which essentially deals with energy use in buildings and appliance efficiency. Such institutional arrangements may create a greater sectoral focus on buildings and appliances, and may not include automobiles in comprehensive global warming plans. This may cause unwarranted increases in CO_2 emissions. One possible scenario is that controlling diesel vehicles through stricter regulation to control SPM and NOx may increase gasoline vehicles. Since diesel vehicles are CO_2 friendly compared to gasoline, this substitution may accelerate CO_2 emissions. However, controlling diesel through fuel quality may not add penalties to users and may not motivate them to switch to gasoline vehicles. Thus, close co-ordination is essential to counter such problems.

Plans, policies and countermeasures: Most of the existing plans and policies of Tokyo revolve around energy efficiency improvements that target appliances, building energy use (office buildings contribute over 60% of total energy use in the commercial sector) and to some extent alternative fuel vehicles. Tokyo Green Plan (December 2000) is expected to enhance sinks to offset some of the CO_2 emissions, as well to alleviate urban warming problems in Tokyo. Under this plan, Tokyo has recently passed mandatory rooftop greening requirements for new private and public building.[34] To implement the Global Warming Action Plan and Green Building Program as stipulated by the Ordinance on Environmental Preservation, large buildings (mainly over 10,000 sq. m floor space) are required to submit environmental plans in the planning stage for public disclosure. The ordinance also requires large energy consuming businesses[35] to submit plans to reduce their energy use and make it open for

[33] Urban and Global Warming Department (tentative translation by author)
[34] For buildings constructed on land areas of over 250 m2 (public facilities) or 1,000 m2 area (private facilities), the. Tokyo Green Plan (2000) also requires the submission of rooftop greening plans for new buildings of over 10,000 m2 total floor space.
[35] For large scale developers consuming over 1,500 KL/year crude oil equivalent or over 6 million KWH/year.

public disclosure (from June 2002).[36] The Green Building Program also looks into a number of other considerations such as material use, water reuse, etc., apart from energy considerations, and a rating system has been devised as Grade 1, 2 or 3.

The "Stop Global Warming Campaign" was initiated by TMG in late 2001 to promote awareness and debates on countermeasures for global warming amongst the residents and corporate sector. Stage-I of this campaign (Feb 2002- Nov 2002) was an information campaign to accelerate discussions on very ambitious five policy proposals:[37]

- introducing obligatory reduction of CO_2 emissions from large corporations, including business and offices
- establishing CO_2 credit trading markets for promoting wind power and forest management
- requiring new buildings to use renewable energy, such as solar energy
- enforcing and expanding energy efficiency standards for automobiles
- restrictions on buying, selling, and making energy intensive products

Stage-I of the campaign, after a series of discussions, basically highlighted some of the key challenges to be addressed, making it a single package for urban and global warming abatement as a starting point for Stage-II (November 2002 onwards):

- making CO_2 cuts mandatory for business operations, including office facilities
- strengthening standards for energy efficiency for new buildings
- creating a system to fully inform consumers of information on energy efficiency
- strengthening measures to curb CO_2 emissions from road traffic
- promoting a shift to renewable energy
- promoting measures to tackle the heat island effect as part of urban planning

Figure 7.1. Appliance labelling in Tokyo

In association with other national institutions, TMG has initiated its own eco-labelling programme with the view of promoting public awareness and allows the public to choose energy efficient products (Figure 7.1). This was started in collaboration with seven prefectures and 149 store chains in mid-2002. The label shows the cost of appliances alongside the energy cost for five years and is rated A to D depending on their performance against set standards (JIS).

[36] Green Building Guideline was issued on 28 March 2002.
[37] Press release from Bureau of Environment, Tokyo Metropolitan Government, 20 February 2002.

Other potential measures to meet the above challenges that are under discussion are: (1) passing ordinances for mandatory reduction of CO_2 by large business facilities, which is likely to target 1,000 factories and offices, affecting about 10 million tonnes of CO_2 annually; (2) social and economic incentives to businesses with proactive and supplementary measures, such as emission trading; and (3) introduction of green taxes.

Some of the measures in Tokyo could be guiding principles for other cities in Japan, as well in other countries, although measures in one city cannot be copied to other cities as is. At least, the initiatives of Tokyo can be taken in a "front-runner" approach, in that many local governments in Japan may follow Tokyo, and ultimately, impacts would be larger.

7.4 Policy Trends in Seoul

Unlike Tokyo, Seoul does not have explicit policies and plans that are formulated for GHG mitigation. Seoul is carrying out basic research to clarify the status of emissions by developing detailed inventories and accessing the prospects to reduce emissions through various options. The city government is targeting an integrated approach, in which it wishes to synergize air pollution and GHG emissions. Some of the existing policies being investigated are listed below:

- provision of clean fuel in the energy sector, especially expanding the provision of district heating by 453,000 households, city gas coverage by 98.3% in 2007 and progressive introduction of clean fuel in boilers
- reduction of GHG emissions from waste by controlling waste generation through volume based fee system and appropriate waste treatment systems (restricting small incinerators)
- reduction of emissions through control of vehicle-idling, strengthening inspection systems and promoting low-polluting cars
- traffic measures, such as non-driving weekday system and others
- restoration of certain city areas and enhancement of CO_2 sink through greening

At the national level, Korea joined UNFCCC in 1993 and submitted the ratification of Kyoto Protocol to COP 8 in October 2002. After such ratification, efforts have been made to form a government-wide organization to establish policies for GHG mitigation. Such an organization is essentially an inter-ministerial committee led by the Prime Minister with several working groups ranging from negotiations on energy, environment, forestry and research and development. To date, such plans exist only at the level of the national government and have not trickled down to local governments in terms of any pre-defined obligations. In this effort, a number of voluntary agreements have been made between the national government and 15 companies for energy auditing in 1998, which reached 374 in 2001. Scattered countermeasures in the forestry and waste sector have been implemented, such as forest management and landfill gas utilisation. Such small pilots are unlikely to affect GHG emissions on a larger scale however such policies are at initial stages.

At the local pollution level, the Ministry of Environment of Korea has unveiled an ambitious plan named, "Special Measures for Seoul Metropolitan Air Quality Improvement (2003-1012).. Under this plan, PM10 and NO_2 will be reduced from 71 to 40 mg/m^3 and 37 to 22 microgram/m^3 respectively from 2001-2012 (Seong, 2004). The scheme aims to estimate environmental capacity of *pollutant volumes* and to allocate *maximum permissible emission* of air pollutants to large point sources. The objective is to control air pollutants by volume within the calculated environmental capacity. For mobile sources, this scheme focuses on significantly strengthening emission standards,[38] mandatory sale of clean vehicles by certain rates for automobile manufacturers, obligatory-buying of clean vehicles by selected public agencies, economic incentives for market penetration of clean vehicles and strengthening emission standards of vehicles in-use. Government and private sector co-operation is essential in this scheme for success. The role of the Seoul Metropolitan Government is very important because in this scheme the local government is the implementing agency, although the basic plan is being developed by the Ministry of Environment.

7.5. Policy Trends in Shanghai

Most of the interventions in Shanghai belong to the restructuring of the energy sector which would ultimately reduce CO_2 emissions. In 1999, the Shanghai Municipal Government drafted a plan for sustainable development where energy and environmental policy were addressed. According to this plan, coal consumption will be restrained in such as way that there would be a 55% reduction of coal as a primary energy source by 2010. This includes securing three GW electricity imports from the Three Gorges Dam and the nuclear plant at Qinshan, and increasing natural gas share to 10-12% in primary energy supply in 2010. Regulatory measures for prohibiting new coal-boilers in core city areas are already in place. The policy also aims to control the number of registered vehicles to 16 million in 2010 (Shanghai, 1999). Shanghai environmental policy also limits SO_2 emissions to 420 kt/year in 2010 (SEPB, 1998). Car-limiting policies have had some success; since 1998, the city has adopted the Singapore-style of auctioning registration permits for new vehicles.[39] A key question is whether Shanghai would be able to continue such private vehicle restraining policies in the future. The 10th Five-Year Plan (2000-2005) aims to stabilize coal consumption in Shanghai, and accordingly, changes in the structures of fuel consumption are expected. In particular, Shanghai will also benefit from the national programme of transferring natural gas and power from west to east. This would

[38] The plan is that by 2006 gasoline vehicles will meet ULEV level and diesel vehicles will meet EURO IV level. By 2010, standards will be strengthened by 50% compared to 2006 levels.

[39] A cap on annual registration of all new cars and trucks in 1998 was set at 50,000. See: Zhou and Sperling (2001)

compliment Shanghai's plan to establish zero-coal burning zones in the city, if distribution infrastructure could be developed in a timely manner. To complement such plans, Shanghai has implemented a number of regulatory measures such as the Shanghai Energy Efficiency Regulations, Shanghai Action Plan on Sustainable Energy Production and Consumption, Energy Saving Regulations, and others (Shi, 2004). A number of other measures are being implemented for mobile sources. Since the major thrust is on the energy sector, Shanghai can greatly benefit from international funding mechanisms, such as Clean Development Mechanisms.

7.6 Policy Trends in Beijing

The environmental policy decision-making system in China consists mainly of three organs (He, 2004). First is the Environment and Resources Protection Committee (ERPC) of the National People's Congress (NPC); this committee makes policy decisions to protect the environment, passes legislation, and supervises its enforcement. Second is the State Environmental Protection Commission (SEPC) of the State Council; this commission drafts policies, regulations, and laws for environmental protection. The third is the State Environmental Protection Agency (SEPA) of the State Council; this agency supervises and administers the environmental protection laws throughout the country. The Beijing Environmental Protection Bureau (EPB) is directly under SEPA. On 15 September 1987, the Law on Air Pollution Prevention and Control of the People's Republic of China (LAPPC) was approved by the NPC and then revised in 2000. The law required that all plants that discharge pollutants into the air must comply with the rules for pollution control. The Beijing government has enacted a series of policies and regulations for air quality protection and implemented a series of emergency measures.

In December 1998, the Beijing municipal government announced and started implementation of six stages of emergency measures to combat air pollution (BMG, 1999). These measures mainly targeted coal-fired sources, mobile sources, and dust sources. Coal-fired sources were to be controlled by the use of high-quality coal, switching coal-fired boilers to natural gas boilers, and installation of central heating systems. Vehicle emissions were to be controlled by developing the transportation system, improving traffic efficiency, tightening emission standards for new vehicles, promoting the scrapping of old vehicles, conducting inspections for in-use vehicles, retrofitting taxis with dual-fuel engines, and banning vehicles with high emissions from entering the downtown areas. In addition, industries have been required to apply advanced, lower polluting technologies, and more efficient energy and industrial practices have been adopted to reduce pollution. With these efforts, air pollutant emissions have begun to decrease. After the six phase emergency measures were implemented, SO_2 concentrations decreased to 80$\mu g/m^3$, a significant decrease rate of 33%, while PM_{10} concentrations decreased to 162$\mu g/m^3$, a decrease ratio of only 8% (Yuan et al, 2002). However, dependence on these emergency control measures only will not meet the future targets mandated by the Beijing municipal government, which require that the concentration of major pollutants should meet WHO standards before 2008 (see Beijing Olympic Action Plan, Beijing Organizing Committee for the Games of the XXIX Olympiad: http://www.beijing-2008.org, 2002). In the future, more comprehensive energy policies and end-of-pipe control strategies will be implemented. Beijing is gearing towards the 2008 Olympic Games and the municipal government is unveiling an ambitious plan to improve local pollution and to extend transportation infrastructure.

8. OPPORTUNITIES AND BARRIERS FOR POLICY INTEGRATION

Analyses of mega-cities in this report have showed that two types of policy integration are necessary at the local level for energy related issues. The first is the *integration of energy related environmental concerns into the overall urban development policies, including all sectors.* Such integration is a long-term policy issue, and the role of the national government is particularly important in Asian cities due to their governance structure. Energy could be an easy "entry point" for integrating environmental concerns into urban management (OECD, 1995), especially in those cities which are going through rapid energy re-structuring. The second is the *integration of air pollution and greenhouse gas concerns* at the local level because it is perceived that the policies aiming at greenhouse gas emissions alone are difficult to put into operation without justifying other local benefits (such as improvement of air pollution, urban heat island, energy efficiency or other economic benefits). City such as Tokyo may not need such justification in the future if the national government enforces obligatory reductions to meet Japan's 6% reduction commitment for the Kyoto Protocol. Moreover, many of the countermeasures have the potential to simultaneously contribute to local as well as global concerns and such countermeasures are likely to gain acceptability among local policy makers, the private sector and general public. This section discusses the barriers and opportunities for such integration with Tokyo as a yardstick. More emphasis here is given to the second type of integration.

8.1. Role of National Government and Local-National Cooperation

National-local cooperation is essential for effective mitigation of GHG in cities in developed countries, as well as for policy integration for air pollution and GHG in cities in developing countries. Such cooperation mechanisms have been taking place indirectly in a number of areas related to the energy sector, such as energy efficiency improvement programmes, renewable energy developments (solar, wind and fuel-cell based pilot activities in cities) and others in a number of Asian countries. For climate policy, such co-operation is at the developmental stage. As Japan is the front-runner in climate policy in Asia, major references for such cooperation in this section is attributed to Japan.

The Climate Change Policy Law of Japan enacted in October 1998 and amended in June 2002 seeks for the development of action plans to limit GHG emissions in business activities of national and local governments. Accordingly, 47 prefectures, 1,017 municipalities and 360 municipal cooperatives have formulated plans as of early 2004 (Takagi, 2004). The Ministry of Environment provided guidelines for promotion of local action, which included voluntary plans and plans to promote actions to reduce GHG emissions and enhance sinks in view of their local conditions. 39 prefectures and 43 municipalities have formulated such plans by early 2004 (Takagi, 2004). However, national-local cooperation is limited in the provision of such guidelines and regulatory frameworks, but concrete partnerships in action-oriented activities are lacking. Figure 8.1 outlines the structure of such cooperation in Japan but such system is yet not operationalised in terms of financial or information support. Apart from national-local cooperation, in front-running cities such as Tokyo, the fundamental limitations to run effective programmes to mitigate CO_2 emissions comes from the "watch and see" situation of Japanese national climate policy. In line with national policy, interventions are being made in energy efficiency and construction sectors (buildings), which are relatively easier, but in other areas not much progress has been made.

In countries other than Japan (namely China and Korea), the role of national-local cooperation is centred on research support, technical feasibility for integrated approach and promoting donor assisted projects in the cities.[40] In these countries, the role of the national government is especially important because of the lack of capacity in local governments for such policy integration, which will be discussed in next section.

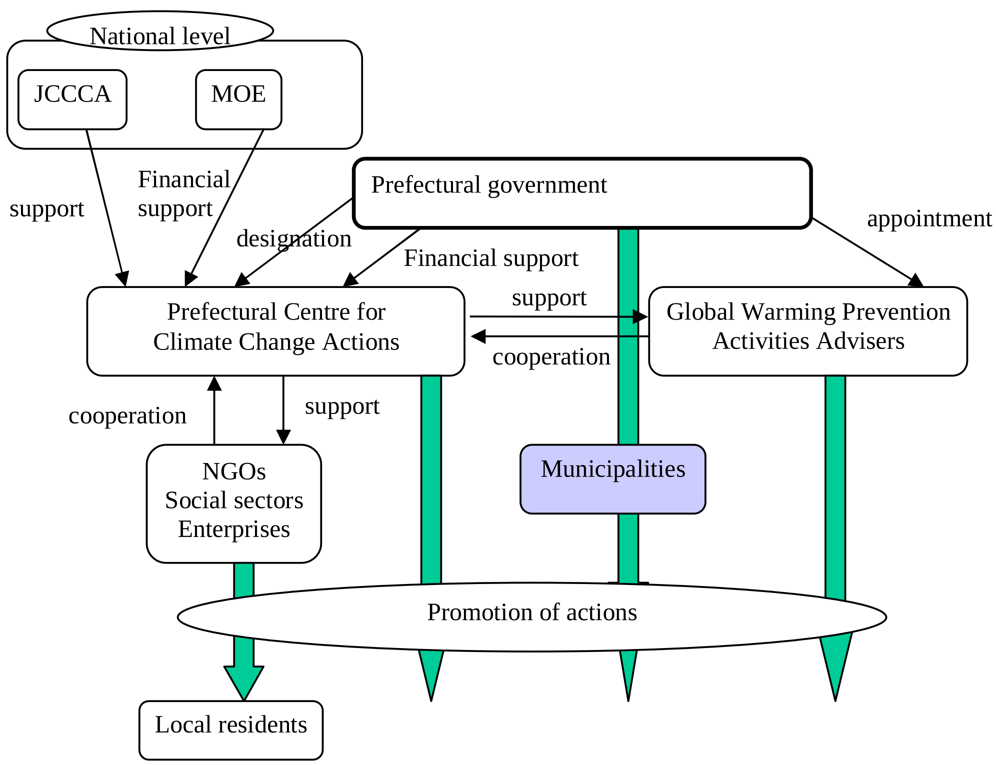

Figure 8.1. Local system to promote actions for global warming mitigation in Japan

Source: Takagi (2004)

[40] One of such example is support and coordination for Integrated Environmental Strategies (IES) Program of US-EPA by State Environmental Protection Administration of China and Ministry of Environment of Korea.

8.2 Institutional Capacity and Arrangements to Address Policy Integration

Institutional capacity and institutional arrangements of local governments in Tokyo, Seoul, Beijing and Shanghai are relatively better than the majority of other cities in Asia, despite the lack development of capacity for integrated policy.

To establish effective climate policy interventions, the institutional mechanism within the Tokyo Government needs to be strengthened. The existing set up is such that the Urban and Global Environment Division is unlikely to have significant influence on other divisions within the Bureau of Environment or other powerful sectoral bureaus, such as Taxation, Housing, Construction, and City Planning, etc. The Department of City Planning can play a more effective role in policy integration than the limited mandate of the Department of Urban and Global Warming. Institutional coordination and development of comprehensive measures is indeed a challenge. Existing programmes in Tokyo focus much on voluntary mechanisms and shy away from mandatory obligations because influencing stakeholders is a difficult task. Even in the case of “buildings,” most countermeasures are voluntary information disclosure, while the issue of addressing non-compliance is an open question. However, the *corporate culture* in Japan may force big businesses to comply, but this may not be true for medium size or smaller businesses. Mandatory obligations are being discussed in Tokyo but implementation of such obligations, in the absence of such obligations from the national government’s side, is a key challenge. Therefore, consensus building for such obligatory emission reductions by stakeholders is the first step.

The extent of benefits from the integration of policy measures for local air pollutants and GHG reduction is largely unknown due to the lack of information and detailed studies of various options in Seoul. Chinese cities are in a better position for integrated policy because of their massive energy restructuring plans for industries. Since the majority of big industries (and energy industries) in Beijing and Shanghai are state-owned, institutional capacity to force companies to comply with government policy does exist in these cities.

8.3. Exploiting Market Mechanisms

Exploiting market mechanisms is a key for Tokyo to reduce CO_2 emissions, considering the important role of corporate sectors in the city. However, establishing obligatory or trading mechanisms is not easy, especially when the national government has not initiated such a process. The Japanese national government is expected to implement strong measures after 2005. Creation of the emissions trading system, and thus credit-markets and obligatory emission reductions, may come into force after 2005 only. In this direction, exploiting such market mechanisms as early as possible is a key challenge for Tokyo. Tokyo has been quicker than the national government in some of the issues, such as introducing low sulphur fuel; such tradition can be upheld in climate affairs.

In other cities, market mechanisms may not address CO_2 directly but correct signals to the market in promoting integrated approach can be provided through various economic and regulatory instruments. In case of mobile sources, Singapore's experience of auctioning licenses for new vehicles through competitive bidding, congestion pricing through Electronic Road Pricing (or less technical method: Area Licensing System) and other fiscal measures are good examples (see APPENDIX A). Regulating parking charges, promoting public transportation and other measures such as the promotion of niche market for clean vehicles such as battery operated electric vehicles[41] or hybrid cars can reduce local air pollution and GHG simultaneously.

8.4. Prospects for Sharing Intercity Experiences

There are a number of other areas where experiences can be shared amongst cities, notably:

- district heating in Seoul and Beijing;
- reduction in waste volume and land fill gas utilisation in Seoul;
- development of mass transportation in Tokyo;
- control over registration of new vehicle in Shanghai; and
- incentives to low- and ultra-low emission vehicles in Tokyo.

The sharing of information and lessons could be bi-directional amongst developing and developed cities. From the energy efficiency point of view, district heating and cooling is an area where much gains can be made in Tokyo. In Tokyo, by mid-2001, 72 districts with an estimated area of 1,366 hectares (13.66 sq. km) were designated as District Heating and Cooling Zones; this is in operation in 63 districts.[42] Places like Marunouchi and Shinjuku have large concentrations of office blocks (In Marunouchi area, Dhakal et al (2004) estimated that density of building floor space in a 1 km grid is as high as 3.5 sq km/sq km of land area in the mid-1990s.) Thus, the potential for district heating and cooling are tremendous in Tokyo. In Seoul, in 2001, over 350,000 households were using district heating, which is expected to increase to over 430,000 households by 2007 (Jung, 2004). Similarly, other cities in East Asia, notably Beijing and Shanghai, have large shares of district heating and cooling systems. Tokyo can learn from the experiences in these cities and other cities in Europe. The box below shows the potential, barriers and lessons for the success of such systems in European cities.

[41] Depending on fuel mix of electricity generation that charge batteries
[42] Tokyo Metropolitan Government: http://www.kankyo.metro.tokyo.jp/kouhou/english2002

Box: Lessons on successful district heating and cooling systems from European cities

- The major factor for development of CHP systems is due to the municipal ownership and planning regulations, such as requirement to show feasibility of CHP.
- There is a need to ensure that the heating and electricity prices are competitive for alternative supply systems.
- There is a need to ensure supply of technical and economic reliable energy to all connected consumers under different external conditions.
- There is a need to have good local effort, resulting in a high connection rate, and again ensure good economy as invested in fully utilised and paid for
- There is a need to improve the environment, both locally and globally.
- There is a need for high connection rates, as the marginal cost of connecting more consumers are relatively low.
- There is a need to ensure stakeholder participation

Source: Urban Energy Handbook: Good Local Practices, OECD, 1995.

8.5. Strengthening CO_2 Concerns from Transportation

Weak responses in the transport sector prevail in Tokyo, especially due to existing SPM and NOx problems. Most of these emissions come from diesel vehicles which are more CO_2 friendlier than gasoline. Diesel has been eyed as one of the major options to limit CO_2 from automobiles. Regulating diesel vehicles in Tokyo (in particular, light duty trucks) to control NOx and SPM has potential to push automobile manufacturers towards introducing more gasoline vehicles and thus creating an eminent threat to CO_2 reduction policy. Active dialogue with the automobile industry is a key to climate friendly policies. Despite the fact that fuel efficiencies are improving over time and the number and utilisation rate of vehicles is relatively stagnate in Tokyo, one of the major reasons for the increase in CO_2 emissions is due to the structural shift towards larger engine-sized cars. Since the emission standards for small and large cars are different, even if individual automobiles meet the emission standards, the net emission volume increases. To counter this phenomenon, separate emission standards based on "average emission factor for automobile fleet" [43] needs to be implemented in addition to the emission standards for individual vehicles. Under such a mechanism, automobile retailers (or big buyers) would be required to sell (or buy) a good mix of vehicle sizes or hybrid vehicles, in order to keep the total volume of emissions down. Different forms of these emission standards exist in European cities and Tokyo can learn from such examples.

In case of rail networks, the majority of modern rail networks in East Asian cities are electricity-based. The fuel mix of electricity generation plays an important role in determining the volume of

[43] Introduction of Corporate Average Fuel Economy (CAFÉ)

CO_2 emissions. Expanding natural gas and the strategic location of cities in national gas pipeline networks and tapping hydro power may help Beijing and Shanghai to stay within transportation related CO_2 emission standards in the future.

Development of mass transport modes is necessary in mega-cities. Beijing is planning for such massive subway development by the 2008 Olympic Games, as described in earlier sections. The development of roads should include environmental considerations and the strengthening of public transportation is essential in mega-cities. Financial capacity is often a serious constraint for such policies however; sound public-private-partnership (PPP) in transportation services has the potential to overcome such financial limitations. New international financial mechanisms aiming at the environment are being developed. The Global Environmental Facility (GEF) provides financial support towards infrastructure projects based on “environmental additionality” criteria. Clean Development Mechanisms (CDM), which is under considerable debate and negotiation, may open a new avenue for financing infrastructure projects aiming at integrated air quality and GHG emissions mitigation in the cities.

8.6. Exploiting Existing “Niche” Opportunity and Creating Momentum for Change

Capturing “niche” opportunities is necessary for promoting integrated approach. The real effect of such individual measures may be insignificant; however such niche measures and campaigns can provide momentum for larger actions. Buses running on CNG and LPG taxis have long been in practice and the number of such vehicles runs in the thousands in cities across Asia. Other niche opportunities exist in demonstration projects and pilot experiments for clean vehicles, renewable energy technologies, biomass utilisation and waste reductions schemes. The existing role of renewable technologies is limited to pilot projects and demonstration projects, which serves to create awareness and impart environmental education. One obvious opportunity for Tokyo is to integrate renewable energy technology in building systems for energy-saving and use natural lighting as much as possible. Government policies need to provide support to promote niche opportunities, which otherwise cannot take off.

Tokyo has the potential to be a top runner in CO_2 mitigation and induce positive changes among the attitudes of local governments with regard to CO_2 emissions in Japan. Several other cities, such as Kyoto City, are planning to enact an ordinance tentatively called the “Ordinance on Global Warming Prevention” to promote effective measures against global warming. The city is planning to enforce the ordinance in fiscal year 2004.[44] Kitakyushu City, which is historically an industrial city, is active in global issues and may follow suit. Therefore, despite the fact that currently existing measures in

[44] For details see http://www.city.kyoto.jp/kankyo/ge/ (in Japanese)

Tokyo are not sufficient, if Tokyo were to realistically meet the 6% reduction target, it can act as a catalyst to induce positive changes.

8.7. Transition from Sectoral Approach to Holistic Planning

In general, weak policy responses prevail from urban planning related policies for air pollution and GHG emissions. A general observation in East Asian mega-cities reveals that:

- Metropolises are expanding. Extended metropolises are part of the problem, which has put tremendous pressure on urban planning and related management. This has further affected sprawl which is detrimental to integrated approach. This is especially true for Beijing, Bangkok, Shanghai and other cities. Containing such growth requires new approaches in urban planning, such as Growth Management and Transit Oriented Development (TOD), alongside the traditional methods of land use, zoning or building control.
- Urban environmental considerations, such as for waste, air pollution and urban heat island, are weak in traditional urban planning practices in cities. Development of the peri-urban areas due to the dynamics of socio-economic changes and the relocation of industries from the city centre has caused great concern.
- Sound urban planning practices have a strong role to play by setting a holistic systemic condition under which the city operates. Under such systemic conditions, reducing CO_2 emissions is possible by optimising the energy uses in urban transportation and households, and with the proper choice of energy supply systems.

In general, past efforts to reduce air pollution and CO_2 emissions have focused on individual sectors. The need of such a holistic approach is being realized in cities. To some extent, Tokyo has conducted such planning despite the weak responses from a few sectors. Since Seoul is developing GHG mitigation plans, this consideration is essential. Developing comprehensive urban scale plans by consolidating existing plans and by setting clear goals is necessary for Seoul; this should be accompanied by proper institutional arrangements in the municipal structure. In rapidly developing mega-cities such as Beijing and Shanghai, such provisions are most important as the window of opportunity to act is rapidly closing. Once Beijing and Shanghai are locked into urban infrastructure, remodelling the urban area would be extremely difficult.

Such comprehensive interventions can only achieved by political or institutional leadership. This requires a number of logical steps such as:

- preparation of detailed inventory and effect of selected strategies
- implementation of selected GHG emission reducing measures
- establishment of GHG emission reporting system
- development of climate action plan, follow up and monitoring

8.8. Unclear Prospects for Synergy and Constraints for Policy Integration

Unlike air pollution, which is widely studied, the opportunities and barriers for integrated approaches is largely unknown. The countermeasures that maximize air pollution benefits may not necessarily be the best countermeasures for GHG mitigation. When there are several choices for countermeasures to control the most urgent air pollutants, a carefully crafted policy might yield benefits for air pollution, as well as GHGs. However, synergy and constraints for such approaches are unclear to policy makers, despite the many studies carried out to evaluate the effects of specific countermeasures and for specific pollutants.[45] Table 8.1 shows the synergy and conflicts of a few selected countermeasures. Since policies are implemented with a package of measures with a combination of various policy instruments, the cumulative effect of such measures must be clarified so that policy makers can be guided towards better choice of measures.

Table 8.1. Potential synergy and conflict of local pollution abatement measures with GHG emissions

Local countermeasures	Synergy to global concerns	Conflicts to global concerns
Urban transportation		
CNG/propane Interventions	CNG interventions are taking place in many cities in Asia for air quality improvement such as Delhi, Beijing, Bangkok, etc. CNG or Propane vehicles emit lower NOx and PM, and at the same time are CO_2 friendlier than conventional vehicles	On the one hand, CNG reduces CO_2 emissions, but it may also outweigh CO_2 benefits by increasing un-burnt CH_4 (due to poor maintenance) in heavy duty engines such as buses and trucks. The inspection and maintenance system may have an important role in determining the level of gains in greenhouse gas emissions. Therefore, engine and fuel management technologies need to be balanced
NOx and SPM control from Diesel vehicles	High quality diesel, such as maximum sulphur of 50 PPM diesel may help reduce CO_2 emissions if additional CO_2 emissions at refineries do not offset such gains	Diesel is CO_2 friendlier than gasoline. Since diesel vehicles are major contributors for NOx and PM, stringent measures to control diesel vehicles (such as diesel cars, which are small) may result into increasing gasoline vehicles
Electric and hybrid vehicles	Electric vehicles emit no tailpipe emission including all air pollutants and CO_2. Hybrid vehicles reduce air pollutants and CO_2 significantly	Electric and hybrid vehicles have poor performance and are expensive. The CO_2 benefits from electric vehicles depend on the fuel mix of electricity generation. If major share of electricity is generated by coal, the CO_2 benefit may be negative. Only life cycle assessments can provide a clear picture
Vehicle category based emission/fuel efficiency standards	Such standards reduce local air pollutants and CO_2 emissions per vehicle-km for particular vehicle categories (type or size)	If vehicle-km per vehicle increases or if people switch to bigger engine sized vehicles, the total volume of CO_2 might increase even if such emissions/fuel efficiency standards are met. To reduce such risks of increasing both local pollutants and CO_2 emissions, additional standards based on average fuel/emission

[45] For example: For those successful measures and policies which have reduced PM10 successfully in many cities; what would their impact on greenhouse gas be?

		efficiency of fleet or Corporate Average Fuel Efficiency would be useful.
Promoting mass transport and discouraging private cars	Usually such measures reduce CO_2, as it improves energy performance and reduces gasoline which emits a large volume of CO_2. This further reduces congestion and associated CO_2 penalties from vehicles.	Operating inefficiency of mass transportation such as metro and bus systems may tend to reduce their occupancy and, if it does not divert private car passengers, may not be effective
Reformulated gasoline for reducing smog, VOC and toxic air pollutants		Compromises with fuel economy nominally 1%or 2%; therefore CO_2 might increase
Fuel quality improvements		Least effect
Inspection and maintenance systems, driving conditions and driving behaviours	May improve fuel efficiency and there by reduce CO_2	
Congestion pricing, traffic management	Reduces congestion, discourages car use and results fuel savings, however the exact impact on CO_2 depends on various factors	
Energy sector interventions		
Energy efficiency improvements (demand side management, improvement in residential and commercial buildings, industrial processes and boilers)	Contributes to reduction in CO_2 emissions	
Switch to natural gas	Contributes to reduction in CO_2 emissions	
Low sulphur coal (clean coal)	Contributes to reduction in CO_2 emissions	
Promoting renewable energy	Reduces the need for fossil fuels which are major sources of CO_2	
Waste sector interventions		
Reducing waste volume	Reduces the volume of waste to be incinerated or landfilled and thus results in lower GHG emissions	
Promoting recycling	Overall impact is not very clear and depends on a number of factors such as the type of recycled products, the amount energy consumed in making products from recycled materials and the method of disposal	
Promoting landfill/incineration	Reduces CO_2 from incineration	Increases methane which is 22 times more powerful than CO_2 for greenhouse effect
Urban planning interventions		
Controlling sprawl and promoting reasonable level of urban population density	Potentially, may reduce energy use (and CO_2) from urban transportation and households	Not very clear
Promoting urban green space	Enhance CO_2 sink	

8.9. Role of International Institutions in Policy Integration

International institutions such as UN organizations, various inter-governmental panels, international research institutions and NGOs play major roles in directing international environmental debates and action plans, such as climate policy, trans-boundary air pollution, and others. Such action plans influence international cooperation activities of bilateral and multilateral institutions which provide support to developing countries.

Greenhouse gas and air pollution are both caused by burning fossil fuel in industries, buildings and transportation. Recently, international institutions have started to take interest in the promotion of integrated approaches in industries and power plants, which can also improve energy efficiency and help in the utilisation of new financial mechanisms, such as Clean Development Mechanisms. Such measures exist on limited and pilot basis only. Although it is fairly accepted that such integrated approaches are necessary and have multiple benefits, international institutions have not operationalized explicit policies to promote integrated approaches. For mobile sources, such approaches are still at the conceptual stage. Unlike stationary sources, mobile sources are diffused in nature and deal with a wide variety of stakeholders.

For such integrated approaches to take off, international institutions should promote the incorporation of mobile sources in international financial mechanisms, such as in CDM, and set simple and correct rules in association with stationary sources. Further, creation of funding windows for promoting integrated approaches in multilateral and bilateral institutions would allow developing countries to operationalize such approaches. To lobby for such measures, consolidation of studies and research findings, promotion of policy dialogues, and advocacy and development of institutional networks would be necessary.

9. CONCLUSION: THE PATHWAYS TO SUSTAINABLE FUTURE

9.1. General Observation of Cities

The nature of energy use and greenhouse gas emissions from cities is not well understood in Asia. Limited research on sectoral energy use exists for industries and urban transportation from the viewpoint of managing air pollution, but an overall energy picture is missing. Until recently, energy management at the city level was not a priority or important topic since energy related decisions are usually made at the national level. In some cities, especially in coal dominated countries such as China, energy restructuring is indeed on the policy agenda of local governments. At the global scale, concerted efforts have been made to understand climate change by the scientific community. International frameworks such as the United National Framework Convention on Climate Change (UNFCCC) have been devised to promote the reduction of greenhouse gas emissions. Recently, due to the growing concerns regarding greenhouse gas emissions, efforts are being made to understand such phenomenon at the city level in greater detail. Consequently, city policy makers are under growing pressure to take greenhouse gas emissions, especially CO_2 emissions, into consideration while planning, although any policy measure solely aimed at CO_2 reduction is a distant possibility for cities in Asia except for selected and relatively developed cities. The role of CO_2 emissions, especially in rapidly developing mega-cities, is significantly important and integrating energy consideration into policy, either by integrating energy concerns to overall urban development or by synergising measures to reduce air pollution and CO_2 emissions, is very important. Efforts should be directed to provide support to these cities, either by generating knowledge or by building their capacity to understand the problem and to identify the possible measures to implement sound policies.

In Asia, urbanisation patterns tend to become denser leading to the evolution of compact and expanded metropolises. This has resulted into a large volume of energy utilisation in relatively smaller areas and therefore adversely affected the concentration of local air pollution. In the case of CO_2, this may open up possibilities to manage emissions effectively, utilising the compactness and promoting energy efficiency in smaller physical spaces. Based on the current and future trends of the number of mega- and medium-cities in Asia, such cities would increase drastically, and consequently, the challenges for local policy makers to manage air pollution, as well as reducing large volumes of $CO_{2,}$ would further increase.

In this process, studies on the role of energy and the determinants of energy use in cities are important; especially in mega-cities. Discussions are made here on two of the matured mega-cities in Asia, namely Tokyo and Seoul, and two of the rapidly developing mega-cities, namely Beijing and Shanghai, on scenarios of energy use and CO_2 emissions and their drivers. Policy trends in these cities were also analysed in relation to energy, air pollution and CO_2 issues and perspectives were provided on opportunities, barriers and constraints for these cities.

9.2 Clarifying the Nature of CO_2 Emissions and Drivers in Selected Cities

Driving forces

A number of factors influence energy use and resulting CO_2 emissions from cities. Of these factors, the major factors were recognized as compactness of urban settlements, urban spatial structure and urban functions, nature of transportation systems, income and lifestyle, energy efficiency of key technologies, industrial processes, building technologies, climate, and waste disposal methods. The impact of the population and demographic change on CO_2 emissions is nominal in Tokyo, Seoul, Beijing and Shanghai. Income and lifestyle changes are the major influential factors in these cities. Improvements in energy intensity (energy use per unit activity), which shows the direction of positive technological change and higher productivity of energy use, play the most important role in reducing energy use and associated CO_2 emissions. The role of fuel quality improvements and fuel switching in reducing CO_2 emissions has become important in Seoul in recent years but their effect has been surprisingly nominal in Beijing and Shanghai over last two decades. Most of the CO_2 related benefits come from energy efficiency in Beijing and Shanghai only. In the transport sector, a rapid increase in vehicle population is the major factor for CO_2 emissions. The role of mass rail networks in Tokyo is a key factor for stabilizing emissions, but increases in the number of large cars is a primary cause of the increase in emissions. In the household sector, household income and changing lifestyles are mostly responsible for the increase in emissions in cities. Interestingly, the decreasing size of household size, and consequently, the increasing number of households are primarily responsible in Seoul for increases in emissions in the household sector.

Waste treatment methods affect greenhouse gas emissions. CO_2 is emitted by incineration plants and methane is emitted by landfilling. Therefore, the choice of disposal method significantly affects greenhouse gas emissions. Unarguably, waste reduction at source is the best option. Despite huge income differences, Tokyo, Seoul, Beijing and Shanghai have smaller differences in per capita waste generation (between 1.13, 1.06, 1.107 and 1.04 kg/person/day, respectively). With weak waste management systems and less efforts to reduce waste at source, greenhouse gas emissions from Beijing and Shanghai would increase dramatically.

CO_2 emissions

Estimating CO_2 emissions is not easy for cities. The availability of data is a big challenge. However, even if data is available, major challenges arise from a number of factors; important factors include: non-matching consistent data and definition of city (political, functional, agglomeration, etc.), differences in date definition by city, different aggregation techniques used to prepare energy balance tables, lack of local emission factors, availability of aggregated emission factors only, and frequent changes in political boundaries. Due to these factors, inventory making is a difficult and time consuming task.

Commercial energy use and income are expected to have direct correlations. Consequently, the per capita energy use increases in cities where incomes have risen in last three decades. In reality, the trend of per capita energy is converging in these cities towards a common point (between 1.3 to 1.6 TOE/person). In contrast, per capita CO_2 emissions in Beijing and Shanghai are rapidly diverging from Tokyo and Seoul, which highlights the fact that existing policy interventions have relied too heavily on energy efficiency improvement, with little consideration to carbon emissions. In 1998, per capita CO_2 in Tokyo was 4.84 tons which was 1.3 times higher than Seoul; Beijing and Shanghai were respectively 1.3 and 1.6 times higher than Tokyo. The CO_2 emissions profile shows that the economic recession in Tokyo in the mid-1990s did not reduce CO_2 emissions, unlike Seoul in 1998. CO_2 emissions in Tokyo are affected more from lifestyle factors that are resistant to changes in disposable income. However, there is a difference between “economic collapse” and “economic recession,” which Seoul and Tokyo experienced. In contrast, Beijing and Shanghai transformed from “smaller economic growth” and “higher emission growth” phase in the 1980s to the “higher income” and “lower emission growth” phase in the 1990s, due to technological advancements, increases in market competitiveness, reform of inefficient state enterprises, emergence of a strong tertiary sector and massive energy efficiency improvements.

The different in the sources of CO_2 emissions is quite contrasting in these cities. Tokyo is dominated by commercial and transport sectors where the role of industry has diminished to less than 10% from 35% in 1970. On the contrary, the household and transport sectors are dominant in Seoul. Most of the emissions in Beijing and Shanghai are dominated by industry, where the role of the transport sector is smaller (about 5-6%). Despite the fact that the role of transportation is smaller, it is growing rapidly, with a rate of over 10%. Future growth is also expected to follow this trend in urban transportation with economic growth, financial market liberalization (availability of more credit mechanisms to buy car) and WTO accession (tariff barrier reduction). Since transportation related air pollution is already serious, such vehicle growth is alarming to local policy makers. On the fuel side, structural changes in the share of fuel types in CO_2 emissions have been nominal in Beijing and Shanghai over the last two decades. However, ambitious plans exist in these cities to tap clean energy from the Three River Gorge Dam Project and from the national government’s massive natural gas pipeline plan. In the case of Tokyo and Seoul, coal has been almost eliminated in recent years and electricity is playing a greater role. Oil significantly dominates the market in Seoul due to its massive district heating and cooling systems which is essentially lacking in Tokyo.

The comparison of emissions between these cities and with other OECD and major non-OECD countries based on per capita and per unit economic activity shows that Tokyo is outstanding in its performance. All the cities have failed to perform better in terms of per capita but their performance is better in terms of per unit economic activities. The better performance of Tokyo compared to other cities is attributed to a few factors, namely, compact settlements, massively developed rail based mass transportation, less automobile dependency, relatively clean energy, higher technological efficiency of equipment, better governance, and better institutional capacity.

Perspectives on indirect responsibilities of cities

In contrast to direct emissions, emissions embedded in consumption goods are often neglected in CO_2 debates. The true environmental load or "footprint" of a city, especially in case of location-nonbinding emissions such as CO_2, needs to be clarified to explore alternative urban development pathways. This essentially reduces the burden to upstream production processes and natural resources. To extend such an approach, a detailed analyses of the consumption activities of urban dwellers is necessary. However, with the lack of such studies, industrial Input-Output Table based studies can provide at least some perspective on the extent of such footprints. Such analyses show that the indirect emission of CO_2 in cities such as Tokyo and Shanghai could be over three times that of direct emissions. However, cities do not always "consume"—it also exports goods; with that argument, the CO_2 emissions for which Tokyo, Beijing and Shanghai are responsible could be about 70% of total emissions (direct and indirect). Although such estimation may not truly reflect all consumption oriented indirect emissions, is essentially provides a sound basis to show and argue that indirect emissions from mega-cities are large and policy makers should, at least, start to consider it as an issue.

Future of CO_2 and implications to air quality and options

Even under the most optimistic scenario, it is understood that CO_2 emissions from these cities will not decrease. However, the implementation of these optimistic scenarios themselves is questionable. The results from bottom-up models show that the vehicle population in Beijing and Shanghai is about one-tenth that of Tokyo, but their total fuel consumption is only about one-third to one-half that of Tokyo because of lower fuel efficiency and larger vehicle mileage travel, among others. As a result, a much smaller vehicle fleet in Beijing and Shanghai emit a larger amount of local pollutants and CO_2. In particular, light duty gasoline vehicles are expected to drastically contribute to the increase of CO_2 in the future in optimistic scenarios, and a more than twofold increase in fuel consumption from road transportation is expected in Beijing from 2000-2020. Policy measures to intervene in lifestyles and appliances will be the most important measures that would reduce the maximum volume of emissions from households and businesses in Tokyo.

Apart from CO_2 emissions, several local air pollutants in these cities are already above healthy limits. Even in the developed cities such as Tokyo, NO_X, SPM and ozone levels are high and it is already a major challenge for local policy makers to control these pollutants. In Beijing and Shanghai, TSP, PM10 and SOx levels are above WHO guidelines. Existing countermeasures in Beijing are not likely to meet WHO standards before the 2008 Olympic Games. Further increases in energy use in these cities would tremendously increase the health risks posed by local air pollutants. Such energy use would also accelerate the urban heat island effect in these cities, as energy uses play an important role in heat island phenomenon; Tokyo and Seoul are already suffering from this phenomenon significantly.

A number of options are available for these cities to tackle CO_2 emissions. These options are not new, some of which deal with energy efficiency improvements in buildings and boilers, fuel switching, improving fuel quality, delivering efficient public transportation by improving supply side infrastructure and demand side management, and the interventions in the corporate sector. The detailed accounts for each city are described in the report. Discussions are made here on broader issues.

9.3. Policy Directions and Challenges

Less awareness and less priority of local governments to global issues greatly hinders the efforts of greenhouse gas mitigation, as resources are limited and existing challenges for local environmental management are tremendous in cities. With the exception of Tokyo, all other cities do not have explicit policies to reduce greenhouse gases. Existing policy measures in Tokyo jointly tackle urban warming and greenhouse gas emission issues and intervene mostly in the building sector, voluntary information disclosure system and others, principally, in energy efficiency improvement programmes. Implicit considerations of greenhouse gas mitigation, through the implementation of local air pollution measures and energy sector restructuring, have been observed in other cities. However, air pollution improvement measures do not necessarily contribute to the reduction of greenhouse gases. Broader policy agendas, such as emissions trading and mandatory reductions in the corporate sector, do not exist in any of the cities. The market mechanisms in cities are less effectively used in the process. Consensus building is a major challenge for local policy makers to formulate plans to influence powerful stakeholders, such as the corporate sector. Institutional barriers exist in mainstreaming the concerns of greenhouse gases in the overall policy agenda even in developed cities such as Tokyo, where mandate and role of the responsible unit is limited not only due to local priority issues but also due to institutional structure.

9.4. Promoting Opportunities and Removing Barriers in Cities: Lessons from Selected East Asian Mega-cities

This section highlights major points for promoting opportunities to reduce CO_2 and removing barriers.

- A gap of 20 years persists in major infrastructure and energy-emission related indicators amongst Tokyo, Seoul and Beijing. In this, learning from the past experiences of Tokyo and Seoul would be useful to Beijing in their preparations for the Olympic Games. Sharing of experiences amongst the cities is essential. Such sharing of experiences would be bi-directional amongst developing and developed cities. Tokyo can learn from district heating and cooling programs in Seoul, while Beijing can learn from the mass transportation and energy efficiency improvement programmes of Tokyo. Volume based waste charging systems and landfill gas utilisation in Seoul would be important lessons to all the cities. Promoting forums which can facilitate information exchange, inter-city cooperation, creation of an information base, and sharing lessons and best practices is essential.
- Empowering local authorities is essential; their role is limited and jurisdiction is often narrower in environmental management in general, especially in South and South-East Asia. Building their capacity is essential for all Asian regions; so far, very limited support has been provided on greenhouse gas issues and institutional arrangements are poor.
- Improving local-national coordination mechanisms and generating concrete national support is essential for greenhouse gas mitigation measures.
- Policies and policy instruments might have been successful in intervening per unit activity such as emission efficiency of economic activities, and emission per unit vehicles travel, but they have largely failed to control the scale of activity and structural shift of environmentally adverse transportation modal choices. For example, in the transportation sector, existing standards based on emission per km alone are not sufficient; standards based on average emission of vehicles fleets for corporate sector and auto sellers is also necessary.
- Existing policies mostly focus on individual sectors in cities. Transition from a focus on such sectoral planning to urban level integrated planning is essential. Such measures create an overall urban structural setup under which sectoral planning is made. Urban planning practices have serious challenges to deal with metropolitan growth, denser population, denser infrastructure and urban activities, and a new way of planning is essential which can accommodate energy efficiency and CO_2 concerns.

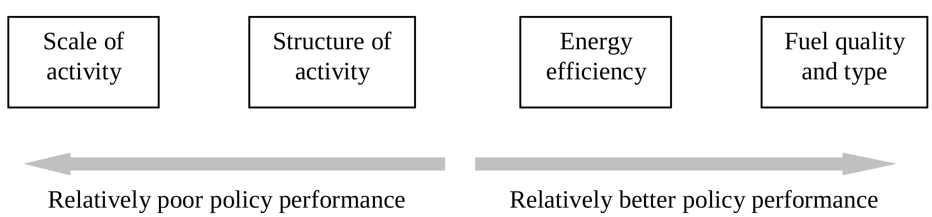

Figure 9.1. Determinants of Emissions

- Promotion of mass transportation and energy/emission efficient transportation infrastructure is essential. This can be achieved through a number of ways depending on city situations, such as promoting bus networks, restricting private cars, providing bus lanes, developing rail-based mass transportation and others. From the investment side, it could be challenging, but new financial mechanisms such as Public-Private Partnership schemes and Foreign Direct Investment can shoulder such costs with the government if the government can facilitate a good working environment from a regulatory, institutional and financial viewpoint. Asian cities, especially mega-cities, are rapidly developing and are in the process of constructing massive infrastructure. Once construction is completed, the cities will be in no position to significantly alter or change the infrastructure. Therefore, policy makers should incorporate the concept of energy efficiency and should consider of the environment during the construction of these infrastructures in order to avoid future "lock-in." It is not too late for policy makers to develop visionary policies to make energy-efficient-cities, in terms of infrastructure, although such windows are rapidly closing.

- In developed cities, formulating stakeholder consensus is a key factor in the implementation of any plausible greenhouse gas mitigation policy. If mandatory mechanisms do not work in the beginning, efforts should be made to promote voluntary mechanisms. Using market based mechanisms such as emissions trading is essential; interventions in the energy sector alone cannot deliver meaningful reductions in the long run.
- Due to priority questions, explicit greenhouse gas policies cannot be expected in the cities of developing countries at this time. Promoting integrated approaches, that means, promoting those measures which can reduce greenhouse gases without seriously compromising air pollution priorities, is essentially a first step. The synergy and conflicts between such measures have been poorly evaluated in the past. Even in those cases where it is evaluated, this has not been reflected in policy implementation due to the lack of serious consideration given to the issue. Such integrated approaches, to some extent, have garned interest in industries and power plants from the viewpoints of Clean Development Mechanisms and other financial/pollutant benefits. However, fewer efforts have been made in the evaluation of these benefits in the transportation sector. Therefore, finding barriers and opportunities at different scales of environmental governance is necessary and lobbying at the national and international level to extend support for integrated approaches is important, especially to bilateral and multilateral funding agencies and in their capacity building efforts.
- Indirect CO_2 responsibility needs to be addressed in mega-cities as they are hotbeds of consumerism, income growth and lifestyle changes. As more mega- and medium-size cities will grow in Asia, this issue will become more important in the future. At present, it may not be possible to have explicit polices however this should be addressed from other viewpoints, such as material and waste management and creation of a society with a sound material cycle (this concept is very advanced in Europe and is slowly penetrating into Japan and Korea). This contributes not only to emission reduction, but also reduces the consumption of precious natural

resources. Drastic campaigns and awareness-raising are necessary on the part of policymakers, non- governmental organizations (NGOs) and other concerned organizations, such as media.

- Although economically viable technologies are used in all mega-cities, technology has a bigger role to play in the future of all mega-cities. Promotion of alternative fuel, new transportation technology, renewable energy technology and efficient building technologies are necessary. Further, dissemination of existing high technology to developing mega-cities is essential. Technology improvement, management improvement and lifestyle changes are necessary to the realization of a sustainable future.

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APPENDIX A: URBAN TRANSPORTATION AND ENVIRONMENTAL MANAGEMENT IN SINGAPORE: LESSONS FOR OTHER CITIES

Abstract: *To combat environmental problems and congestion arising from urban transportation, end-of- -pipe interventions such as traffic management, tailpipe emission control, etc., to more-upstream measures such as urban and land use planning, etc., have been implemented in many cities around the world. Singapore provides one the rare successful examples for managing congestion and environment amid high economic growth through integrated land use, transportation and environmental planning. This paper examines this success story and their underplaying situations with due consideration to major instruments. In particular, policy instruments to restrain vehicle ownership and vehicle use by quotas, fiscal control and road pricing, and their impacts are examined in detail. Lastly, the question: "Why did it work in Singapore?" is addressed and the lessons of this success for other cities in the region and beyond are discussed.*

A. 1. Introduction

Fossil fuel energy use is a major cause of environmental emission from urban transportation. Cities around the world have tried several measures ranging from end-of-pipe interventions to more upstream measures, such as containing travel demand in many forms, by command and control to market-based approaches. Since cities often have limitations to contain growing travel demand for its possible negative implications to economic growth, focus is often placed on how to organise travel demand into a better modal structure. This requires manipulation of urban planning and land use policies together with transportation and environmental planning. Many cities and regions in the world suffer from serious vehicle pollution and traffic congestion that manifests into several social, economic and human health costs. In general, modal share of private transportation and their contribution to pollutant concentration are of serious concerns among policy makers. End-of-pipe approaches such as setting emission standards, fuel quality improvements, and vehicle technology interventions have limitations over which environment and congestion cannot

Table A1 Key dates in transportation in Singapore

Year	Activities
1968	Ministry of Communications established 30% import duty on Cars
1970	Bus service reform begins
1972	Import duty and ARF increases
1973	Singapore bus service unifies
1974	ARF raised to 55%
1975	ALS scheme initiated, ARF raised to 100%, Preferential ARF started
1978	ARF raised to 125%
1980	ARF raised to 150%
1987	MRT begins
1989	ALS extended to other vehicles
1990	Vehicle Quota System begins
1994	ALS implemented whole day
1995	Road Pricing System on expressway
1998	Electronic road pricing begins
1999	ERP extended to highways

be improved as the number of vehicles and their use increases. Such end-of-pipe measures are necessary but not sufficient for a long-term solution to the environmental and congestion problem from urban transportation in dense Asian cities.

Since its independence in the 1960s, policy makers in Singapore have been concerned about integrated urban, land-use and transportation planning (see Table A1). The major motivation for Singapore was not environmental consideration but economic prospects, which envisioned being a prominent manufacturing, commercial and trading centre by utilising its unique geographical location. Singapore has been successful in meeting unprecedented travel demand while controlling congestion and environmental pollution to the acceptable limit (within WHO and EPA-USA level) while its economy grew from SGD7.5 billion in 1965 to SGD138 billion in 2001 (at 1990 market price) (SDS, 2002). Singapore employs a mixed approach of Command And Control and Market Based Instruments to manage traffic demand and related environmental problems. This paper discusses and analyses several policies and instruments with special attention to two key instruments: congestion pricing and vehicle ownership restrictions. The analyses on underlying conditions for these instruments to work in places other than Singapore are important in order to supplement other cities' quest for congestion-less and pollution-less urban systems through these instruments. Therefore, this paper examines the success story of Singapore addressing the following questions: How successful was it? What was the underlying situation under which the city-state opted for such aggressive policies? What kind of policies and policy instruments were implemented? What were the prevailing situations that led to the successful implementation of policy instruments? Are there prospects for replicating one or more aspects of Singapore's experience elsewhere?

A.2. Challenges and Strategies for Integrated Planning

Singapore separated from Malaysia and became an independent city-state in 1965; at the time, housing shortages and unemployment were major problems in the city. Singapore was a densely packed settlement surrounded by shantytowns in the coastal area. The average density of the city's core 400 hectares exceeded 1,200 persons per hectare in 1959 (Willoughby, 2000). In 1965, nearly 70% of the Singapore population of 1.8 million was concentrated within a 5-km radius from the port of Singapore, the city centre (Humphery, 1985). In 1965, the newly elected People's Action Party prioritised housing and employment as a major government focus. The landmark Land Acquisition Act that was passed in 1966 gave the government-sweeping powers to acquire land; this was effectively land reform legislation. This resulted in an aggressive pursuit of urban planning, housing development and industrial estate development by the Urban Redevelopment Authority and Housing and Development Board (HDB) under the Ministry of National Development. Strategic location and economic liberalisation attracted huge manufacturing investment after 1965 and Singapore maintained double digit economic growth until the first oil crisis in 1973. In the late 1960s, Singapore also attracted attention from financial and commercial sector investors with no exceptions from the manufacturing sector. In the 1960s and 1970s, per capita car ownership in Singapore was much higher relative to its per capita income. In the 1960s alone, the car population doubled and motorcycles tripled, and income was constantly rising while the public transportation system was slow and unreliable. Traffic congestion in 1975 resulted in 19 km/hour average vehicular speeds during peak hours (Phang and Toh, 1997).

Realising that the growing economy needed sound long-term city planning in land scarce Singapore, a four-year State and City Planning (SCP) Project was initiated. This was a concept plan covering a 20-year period for Singapore with support from UNDP which was completed in 1971. It emphasized the need for planning the city for a population of four million rather than two million, as envisaged by earlier plans. For the transportation sector, the project significantly made important recommendations that by 1992 it would be environmentally unacceptable and physically impossible to build road infrastructure to meet prevailing private automobile growth. It suggested easing traffic congestion within the business centre, developing a rapid transit system in addition to expressways, and recognizing that buses alone would not be able to meet public travel demand by 1992 (Fwa, 2002). Following the recommendations of SCP, the Singapore government implemented a number of measures from 1972-1992. These included private vehicle ownership restriction by high import duty, additional registration fees (ARF) and a vehicle quota system, private vehicle use restrictions in city centres through an Area Licensing System (ALS), expansion of expressway systems and 67 km of rail based MRT. Public transportation was being provided in Singapore principally by three groups, a large British-owned bus company, eleven smaller Chinese-owned companies and unlicensed taxis resulting in a slow, inadequate and unreliable system. Efforts to organise such public transportation were made in 1970 by the government by forced merger into a single company in 1973 with its major market share into government hands (later floated to Singapore Stocks Exchange in 1978). These measures improved the quality of public transportation, which provided a viable choice for private motorists to switch from private cars.

Since appropriate land use and urbanisation influences travel demand, in many cases such interventions are limited by lack of government rights over built private property. In the case of Singapore, the Government's control over land rights allowed HDB to plan for housing zones in the city as well to construct high rise and affordable housing estates in those planned zones. The government scheme was successful in moving city dwellers to newly constructed public housing, well equipped with supporting commercial and recreational establishments. As a result, 86% of the population today lives in such premises (MIA, 2001). These activities followed SCP's suggestions to adopt a "Ring Concept" where high-density residential areas, industries and urban centres were to be distributed in a ring formation around the central business districts. Later, the revised plan was introduced in 1991, which replaced the ring concept to four decentralised areas in a "constellation pattern" (Lye, 2002).

Despite strong economic growth and a twenty-fold increase in office space and amount of employment, Singapore maintained its environmental and transportation system under acceptable limits. By 1995, the level of motorization was slightly over 100 cars per 1000 population, which was the general trend for cities with a one-third-income level of Singapore. The recent data suggests that the average speed during rush hour was 20-30 kph in city roads and 45-65 kph for expressways. Also, the level of major air pollutants in Singapore is well within acceptable limits of WHO and the U.S. Environmental Protection Agency (see Table 2).

Table A2 Singapore ambient air quality

Pollutant type	Average time	1982	1988	1994	1999	Standard
Carbon monoxide	8 h (roadside), ppm	1-3	1-3	1-3	1-3	9
Lead: roadside	3 months, $\mu g/m^3$	1.5	0.4	0.2	0.1	1.5
Lead: ambient	3 months, $\mu g/m^3$	0.6	0.2	0.1	0.1	1.5
Sulphur dioxide	Annual mean, $\mu g/m^3$	29	20	19	22	80
Nitrogen oxide	Annual mean, $\mu g/m^3$	18	16	29	36	100
Ozone	Max 1 h, $\mu g/m^3$	450	176	237	181	235
Ozone*	1 h concentration >235 $\mu g/m^3$, days	30	0	1	0	-
PM10	$\mu g/m^3$	-	-	48	34	50
TSP	$\mu g/m^3$	70	47	55	-	75

Source: Ang and Tan (2001) citing Pollution Control Department; Ministry of Environment, Singapore
* Ozone measurements in 1982 were conducted using the Neutral Buffered Potassium Iodide Method which was subsequently replaced by the Ultra-Violet Photometric Method

In Singapore, the Ministry of Communications and Information (MCI) had the mandate to oversee all the policies of land transportation through its departments and statutory bodies. Ministerial restructuring was carried out in 1990, 1999 and 2001, and as of November 2001, the department name was changed to the Ministry of Transport. The role of vehicle emission enforcement was transferred to the Ministry of Environment on 1 July 1999. Today, the Ministry of Transport has a mandate to look after civil aviation and air transport, maritime transportation and ports, and land transport. The Land Transport Authority (LTA), a statutory body created under the Ministry of Transport in 1995, is directly responsible for all aspects of car ownership restriction, car use-restraining policies and schemes. It is also responsible for the planning, implementation and management of all public and private land transportation and infrastructure policies. The Urban Redevelopment Authority (URA), under the Ministry of National Development is responsible for land use planning and land allocation, under which other development planning is pursued. The LTA and URA jointly manage parking space and policies, while LTA and Ministry of Environment (especially newly created National Environmental Agency, 1 July 2002) co-operate for motor vehicle emissions with the help of Traffic Police. Since the majority of land in Singapore is in the hands of the Government, the Housing Development Board (HDB) is responsible for construction and sale of housing complexes. All these agencies co-ordinate closely for integrated land use, transportation and environmental planning.

From an environmental viewpoint, the countermeasures in Singapore for air pollution reduction include cleaner vehicles with controlled emission limits, cleaner fuels and controlling traffic congestion. Interventions in fuels and vehicles are being tried with many success cases in cities around the world but interventions in traffic congestion have been proved to be a major problem where Singapore's experience is a good case of success. This paper thus focuses discussion on these efforts of controlling traffic congestion through travel demand management (TDM). This was principally achieved through four major instruments, which limits the number of private cars as well as their uses: (1) fiscal measures of car restraining (2) Vehicle Quota System (VQS) (3) Area Licensing System (ALS) which has been recently upgraded to Electronic Road Pricing (ERP) system, and (4) efficient and affordable public transportation systems.

A.3. Analyses of Major Policy Instruments

A.3.1. Restraining car ownership by fiscal measures

Fiscal measures for restraining car ownership in Singapore include import duty that is levied through the Customs and Excise Department, goods and services tax, registration fees and Additional Registration Fee (ARF) that is imposed by the Land Transport Authority when imported vehicles are registered, and road/fuel taxes. Singapore has relied upon high taxes and fees to restrain car ownership. These measures were further successful in securing large revenues to invest in land transportation infrastructure. Import duty was 30% of the open market value in 1968, which was increased to 45% after 1972 and subsequently reduced to 31% of OMV for cars, 12% for motorcycle, 7% for taxis and 31% for buses with eight or less seats. As of 4 May 2002, import duty is 20% of OMV for cars. The goods and services tax stood at 3% of CIF cost plus custom duty in 2002. The Additional Registration Fee (ARF) was originally introduced in the late 1950s but revised several times and now stands 140% of the open market value after 1980. As of 4 May 2002, it stands at 130% of OMV. In 1968, registration fees were SGD15 and increased to SGD1,000 in 1980 however after introduction of ERP in April 1998, it was reduced to SGD140. A 17.5 times increase in car registration fees (total, including ARF) was seen in the 1972-83 period; from 10% of car price before October 1972 to 175% of car price after October 1983 (Fwa, 2002). The Singapore Government has also imposed high taxes on retail fuel price. Fuel taxes vary from fuel grade. Best grade gasoline is taxed at SGD0.44 per litre (or 35% of pump price before 3% goods and sales tax). From late 1998, the tax on diesel has been lifted. The annual road tax varies from SGD70 cents to SGD175 cents per cubic cc for cars with 1000 cubic cc engine to those exceeding 3000 cubic cc engines per year (Lye, 2002). Recently, some rebate in road tax has been offered after the introduction of ERP. From September 2002, the new calculation formula for cars is given in the appendix. To lessen the implications of high registration fee on vehicle renewable/modernisation rate, Preferential ARF was launched in 1975. In this scheme, the government reduced ARF rates for registration of those new vehicles that simultaneously scrap older vehicles of same class and size. The growing economy and rise in living standards soon surpassed economic disincentives to own a car. Despite such heavy financial burdens to own cars, Singapore saw a 73% rise (average 13,000 car a year) in car population from 1977-84, followed by a brief recession and again a steep rise of an average 15,000 car a year from 1987-1990 (Fwa, 2002). Although this increase was much less than other similar nations, it was unacceptable for the Singapore Government. The Singapore Government imposed a new fiscal measure to control the volume of vehicles directly by the Vehicle Quota System to maintain a 3% annual growth rate of the vehicle population. In part, Preferential ARF helped to increase the vehicle population due to continued increase in ARF and the appreciation of the Japanese yen, which car dealers marketed with the argument of increase in "asset" if one buys a car. Indeed, in case of some classes of cars, older cars increased in value over time (Willoughby, 2000).

A.3.2.Vehicle Quota System (VQS)

VQS was announced in February 1990 with the intent to cap the number of newly registered vehicles. VQS was an easier instrument compared to ARF. ARF was a pricing instrument, and the changing level of ARF was politically sensitive. In VQS, the government just needed to fix the number of allowable vehicles, but not the price. The price is determined by the bidding market itself. In this mechanism, prospective vehicle owners should obtain a Certificate of Entitlement (COE) to allow the ownership of a vehicle valid for 10 years through open bidding. The bidding is opened twice each month and a list of bidders in descending order is arrayed. The bid quoted by the last bidder of the designated quota is called a "Quota Premium," and is levied on all successful bidders to own COE. So far, the demand of COE has exceeded the designated quota by two times or more and quota premiums for passenger cars have been in a range of 30-80% of the car selling price (Fwa, 2002; Willoughby, 2000). Table 3 lists the COE price as an illustration.

Table A3: Certificates of Entitlement (COEs) bidding of 20 November 2002

Category	Quota	Quota Premium	Total Bids Received	Number of Successful Bids	Unused Quota carried forward
Category A (Cars 1600cc and below and taxis)	1,334	$29,008	1,942	1,328	6
Category B (Cars 1601cc and above)	663	$28,001	879	597	66
Category D (Motorcycles)	835	$1	676	676	159
Category C (Goods vehicles and buses)	576	$13,789	736	567	9
Category E (Open)	1,095	$28,005	1,445	1,094	1

A, B and D are non-transferable categories
C and E are transferable category
Source: http://www.onemotoring.com.sg/main/default.asp (Accessed on 25 November 2002)

To allow less wealthy consumers to own cars, different sub-categories were established in the beginning. This included weekend cars, small cars, medium cars and taxis, big cars, luxury cars, etc. This gave additional complexities and consequently such sub-categorization was reduced in 1999. For cars, two categories mainly exist: below 1600 cc and equal or above 1600 cc. Public and school buses, diplomatic vehicles, ambulances and emergency vehicles are all excluded from the scheme. Beyond 10 years of COE, one should either de-register or acquire COE at the price of a three month moving average quota premium of that category. Since then, many efforts were made to discourage speculation and other distortions but the basic rule remained the same (Phang, Wong and Chia, 1996; Toh and Phang, 1997; Chu and Goh, 1997). For example, at the time of introduction, COE was transferable, which soon gave rise to a speculative market. In the first two months, 20% of COEs changed ownership. Subsequently the government made COEs non-transferable with the exception of open and goods categories in October 1991. In the face of such strict measures that were basically controlling demand rather than need, the government implemented other relief measures such as the Week-End Car (WEC) Scheme. The WEC scheme allowed rebates in ARF, import duty, quota premium and road taxes and allowed WEC-use only during off-peak hours. For urgent uses, five day-use licenses were granted at the time of payment of annual road taxes at the cost of SGD20 a day. In essence, WEC schemes were manual road pricing, although of a very primitive form.

A.3.3. Area Licensing System (ALS)

ALS is a road pricing mechanism where each car is charged for their contribution to congestion in the central business districts (CBD). This measure reduces the use of cars in CBD when import duty, ARF and other measures such as road or fuel tax cannot influence the use of cars once they are on the street. Singapore's ALS Scheme was based on a "cordon pricing" system and was introduced in 1975. The cordoned CBD area of 5.59 Square km (600 hectares), referred as the "Restricted Zone (RZ)," was isolated from rest of the city by constructing a 22-entry point (Toh, 1977). In the scheme, the license to enter into restricted zone during morning peak hours (7.30 to 9.30) was required to be taken at the cost of SGD3 (later changed to SGD4) a day (SGD60 per month, later changed to SGD80) in advance. The system was paper based that was verified by the observers at the entry posts. Non-complying vehicles needed to pay a fine posted to their homes through letters. The restricted zone, time and price of ALS licenses were changed several times to accommodate CBD expansion, traffic and economic conditions. Initially, taxis and cars with more than three passengers, excluding the driver, and buses were exempted from buying entry licenses; later (since 1989), they were not exempted. At the same time, public parking charges in restricted zones were raised and additional surcharges were levied on private parking operators to discourage car use.

ALS was highly successful in curbing traffic congestion in morning peak hours. By the fourth week of ALS, traffic flow during peak hours had fallen by 45.3%, the number of cars dropped by

76.2%, and the percentage of commuters travelling by public transportation rose from 35.9% to 43.9% (Toh, 1977, Yap 1986). The average speed increased from 18 to 35 kph (Willioughby, 2000). The traffic reduction by 45.3% was higher than the targeted 25-30%. However, this also increased traffic pressure just before or after restricted hours and to immediate-outside areas of the restricted zone that served as an "escape corridor." Traffic management measures were implemented in those escape corridors to relieve pressure. The anticipated "mirror effect" of less traffic during evening peak hours did not happen. In order make optimal use of road space and smooth operation, several adjustments in restricted time and uses were made in later years through careful monitoring. After 27 years of ALS implementation, the inbound traffic volume of CBD in morning peak hours was still less than it used to be before ALS implementation (Fwa, 2002). Apart from congestion, the major advantage of ALS was on energy saving and air pollution reduction. Fwa and Ang (1996)'s conservative estimate of energy savings with and without ALS, based on 1990 flow and traffic speed data, suggested 1.043 GJ per day. The shift from clean vehicles to clean transportation system relieved over dependence on end-of-pipe measures for air pollution in CBD.

One of the major questions in ALS is whether pricing was correct given externalities to society due to congestion and environment. In 1990, a study by the Public Works Department in Singapore revealed that the average speed during morning peak hours in restricted zones was higher than during non-peak periods (McCarthy and Tay, 1993). The existing price of the access license was calculated at about 50% more than the optimal price. However, in the absence of time and spatially varying pricing mechanisms, any such price would not be optimal. The new measures that replaced manual ALS, Electronic Road Pricing (ERP) with improved technology may pave the way for such pricing mechanism.

A.3.4. Electronic Road Pricing (ERP)

ERP was implemented in September 1998 replacing the Area Licensing System (ALS). The basic idea of ERP is similar to ALS, but ERP is technologically sound, so that time and spatially varying charges is possible, reflecting the true cost of vehicle use in central business districts. In this system, all 33 ALS gantries are replaced with ERP gantry for 720 ha of core area, and vehicles to enter into restricted zone are fitted with In-vehicle Units (IU). IU is fitted in the lower right hand corner of windscreen in the four-wheeled vehicle and in the handle bar of motorcycle. IU unit reads stored-value cash card from which charges are deducted automatically as soon as vehicle enters into restricted zone through ERP gantry. This is done by short wave radio frequency link between ERP gantry and In-vehicle Units. For violators, photographs of non-complying vehicle's license plates are taken automatically for further action.

From the institutional side, four of the departments of the Land Transport Authority are involved in governing ERP. The traffic management department is responsible for setting up rules and guidelines; the computer information department maintains the hardware and software, the regulation department deals with enforcement of rules and regulation and violations, and vehicle engineering department.

At the moment pre-determined ERP charges vary each half-hour during the day, from SGD2.50 during peak hours to 50 cents during off-peak hours depending on road sections. Charges are different for motorcycles, cars, good vehicles, taxis and buses, etc.; different IU units are installed in each category of vehicles. The fundamental question is what amount of charge is appropriate. Theoretically speaking, real time pricing reflecting the cost of congestion, level of congestion and relative contribution of each vehicle category to congestion is an ideal mechanism that can internalise the externality of congestion. In reality, it is not easy to enforce such pricing, although it is not impossible through ERP. At the moment, charges do not fluctuate depending on the traffic conditions in Singapore. ERP charges are subject to review every three months to suit changing traffic conditions. These charges are basically tied to prevailing speeds with the aim of maintaining traffic speeds of 45-65 kph on expressways and 20-30 kph on arterial roads (Willoughby, 2000). The successful implementation of ERP has facilitated the reduction of taxes and other charges and increased the allowable vehicle quota. The cost of IU units was less than SGD300 and for new vehicles with IU units, rebates are offered for road taxes as much as SGD200. Frequent adjustments, such as special reduced ERP prices during school holidays when traffic is reduced, are possible and are being carried out.

A.4. Why Did it Work in Singapore?

Travel Demand Measures (TDM) have seen only limited success in many parts of the world, while supply side measures (such as building road infrastructure, etc.) are being actively pursued in most countries. Supply side measures are never sufficient and put greater burden on the environment because more infrastructure usually means more vehicles on the street. From a global sustainability perspective, TDM measures facilitate energy and resources conservation at the "downstream" as well as the "upstream." The fundamental question therefore remains, why did such measures work in Singapore?

Integrated planning of a city is the keyword in Singapore's success. All the measures are a part of a comprehensive strategy and are coordinated very closely to provide a comprehensive solution; without such strategies, a single measure alone would not have worked. The right to travel is a basic human right; however, government policies can provide various options to travellers to choose reasonable modes of travel. Such perspectives in policies are essential and will be acceptable to residents. When the Electronic Road Pricing Mechanism was implemented in Singapore, commuters had choices to (1) pay charges and drive smoothly, (2) change the time of travel to pay lower charges, (3) use alternative roads, (4) use public transport, and (5) use other schemes, such as park-and-ride

(Menon, 2002). The success of Singapore is also coupled with favourable economic, social and urban conditions. Small land and population size allowed flexibility of planning in Singapore. Being a city-state, a single tier government exists in Singapore, which eliminates all the complexities arising from layers of authority, and a mismatch between local and national priorities. The economy of Singapore relies heavily on foreign investment and on transactions related to international trade, commerce and finance for which efficient transport and communication is essential. The need to fulfil this condition for economic reasons has contributed to transport and environment. Unlike other countries where economic growth is sensitive to environmental countermeasures, improvements in environment and transport complimented economic growth in Singapore. Strong government, stable and strong regulation and institutional frameworks for enforcement are other reasons why it worked in Singapore. From a jurisdiction point of view, the roles and responsibilities of authorities responsible for urban/land use planning, land transport and environment were clearly demarcated. The land reform initiated in 1967 allowed the government to acquire a majority of land and subsequent development of housing estates in the city periphery, and facilitated infrastructure for sound land use planning. The Housing and Development Board, which was set up in 1960 by the British Colonial Government, provided housing to 9% of the population in 1960, however, the sweeping powers under the Land Acquisition Act allowed the government to acquire private land for public housing or other development activities. As a result, 85% of the population today live at HDB housing complexes. Another reason for Singapore's success is the periodic adjustment of policies through feedback from public and other stakeholders and learning by doing, including transparency in policy formulation; policies are never perfect. For example, charges in ERP are subject to review every three months; charge structures and times of ALS changes several times depending on traffic and economic conditions.

One of the keys to these successes is infrastructure investment. Demand side management was supplemented by constructing additional road infrastructure, good maintenance of roads, improving co-ordinated traffic lighting systems, expressways and rail based MRT. The taxes and fees imposed on vehicles generated huge financial resources not only to invest on demand and supply side management, but also to reduce less desirable taxes. Willoughby (2000) estimated that the annual revenue from road transportation was at least three to four times that of road expenditure.

There are some technology-factors that also played important roles in Singapore. ERP for example, depends on sophisticated technology that allows time of day pricing which reflects traffic conditions. Its primitive version, ALS, however was non-technology measure. A computerized traffic controlling system was already in place by 1986 in central business districts (Lee, 1986). This was replaced with a more advanced automated traffic signalling system called GLIDE (Green Link Determining System). GLIDE was a traffic adaptive signal control monitored centrally to adjust changing traffic conditions (Lee, 1990). Efforts are being made now to create a Global Positioning System based coordinated public taxi calling system, which dispatches taxis automatically from the nearest location although individual taxi operators are already using such system. These high-technology measures provided support to non-technology measures of car ownership and use restrictions. However, some researchers have claimed that the high-technology measure's overall effectiveness can be questionable (Fwa, 2002).

Lastly, Singapore is a migrant society where people move to Singapore from many countries. From a societal point of view, this probably facilitated Singapore in implementing policies because the migrants were economic migrants in most cases and their opposition and barriers in the form of organised resisting force to government policies was minimal.

A.5. Concluding Remarks: Significance of Singapore's Experience to Other Cities

The big question is therefore what are the lessons of Singapore's experience to other cities, discounting the localised favourable conditions of Singapore?

Being a city as well as nation, ease of policy implementation exists in Singapore. It is possible to control the flow of goods and services in and out of the city, as it is an "island city". As mentioned earlier, the root of integrated land use and transportation planning goes back to the Land Acquisition Act of the 1960s, which allowed the government to acquire land and made land reservations for city planning. Clearly, in dense cities in Asia, government control over land does not exist with the exception of a few centrally administered countries. Calls for land reform have set limits and placed constraints on the public, and it has remained an area that is not addressed by policy makers in many countries, due to the sensitiveness of the issue. In densely built cities, some changes in land-use may be possible by providing incentives to de-populate central areas; however their effectiveness could be nominal.

Vehicle quota systems in other countries need serious planning and would not be as simple as in Singapore. Collaboration of national government and local authorities is greatly needed. Controlling quotas only at the national level might produce "hot spots" due to over concentration of vehicles in a few cities. The national government can exercise control over total vehicle import quotas and allocate registration quotas to local governments based on their traffic conditions. Some form of restrictions over transit vehicles in the form of local road use charging systems could compliment such policies. Hong Kong, in particular has long adopted strong vehicle ownership control measures through fiscal measures.

In general, a strong legislative and institutional framework is prerequisite. Electronic Road Pricing may seem a little bit too ambitious at the moment in cities in developing countries but other measures such as ALS and VQS need neither high technology nor are operationally complicated. ALS, for example is a simple measure that is easy to enforce and most suitable for dense city core areas in mega- and medium-scale cities to curtail emissions and congestion during peak hours. Local governments under the Self-Governance Act, which are in force in many cities, can carry out such provisions. Together with parking regulations, such charging systems do not interfere with the national government, and revenue generated from ALS can be used to improve roads, signal systems and to relieve pressure on escape routes around the cordoned area by the city authority. This can further relieve financial burdens for maintaining road infrastructure. ALS, in particular, has generated much interest around the world. Many cities have prepared schemes to implement such cordon pricing in central city areas. Three Norwegian cities, Bergen, Trondheim and Oslo, initiated such a scheme in 1980 covering wider areas than Singapore. High technology options, especially ERP and Intelligent Transport Systems (ITS) have attracted attention in developed countries; Canada, Norway, and the U.S. are already carrying out initial applications, while Chile, Netherlands and the U.K. are expected to do so (Willoughby, 2000) in the near future. London has recently started a system similar to that of ALS since late 2002 with five pound charges to enter the core area. In nearby cities, especially Bangkok, Kuala Lumpur and Manila, vehicle ownership and use restrictions were proposed several times. In Manila, such restrictions were proposed in 1977 (Freeman and Fox, 1977), however citing insufficiency in enforcement mechanisms, such ideas were later dropped (Kirby et al., 1986). Similarly, proposals were made several times in Kuala Lumpur and Bangkok for car restrictions in central areas since the late 1970s, but have enjoyed little success.

In most other cities in Asia, cities do not have clear functional boundaries and often have too many interactions outside of the cities; this poses difficulties in making effective policies. In many cities, the transportation sector provides employment to low-income groups through cheap travel modes such as manual tricycles (Bangladesh, India), three wheelers (many cities in South and Southeast Asia and China), jeepney (Philippines) and others. Policies need to provide viable alternatives. The root causes of policy failure in cities of developing countries are inappropriate and inadequate policies, lack of integrated policies, lack of institutional capacity to enforce existing policies, problems of jurisdiction of authorities (institutional arrangement) and lack of co-ordination, and political interests of governing parties. These are all examples of poor governance, which are often associated with lack of financial resources. Selling travel demand measures to the public is not easy because it directly affects the travel of each city dweller. Such measures cannot be acceptable or popular unless it is a part of the overall strategy and is a good public campaign, regardless of economic and social conditions of a city. At the same time, acceptable alternatives need to be provided. Development of a sound public transportation system is key to replicate Singapore's other successful measures.

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APPENDIX B: ROLE OF GOVERNMENT, PRIVATE SECTOR AND CIVIC SOCIETY IN PROMOTING BATTERY OPERATED ELECTRIC THREE-WHEELERS IN KATHMANDU, NEPAL

B.1. Introduction and Background

Kathmandu Valley, which also includes the capital city of Nepal, is situated at a 1,320-meter altitude from sea level and is surrounded by mountains. The topographic condition of the city is unfavourable to rising air pollution, which effectively blocks wind flows and thus enhances air pollution and photochemical smog. The air pollution in the valley is increasing at alarming rate; the concentration of pollutants, especially particulate matters is well above health guidelines set by WHO. This has led to a loss of atmospheric visibility and increase in asthma and respiratory related heath problems in the last decade. The implication of air pollution is not only limited to health issues, it has also created a threat to the tourism industry, which is one of the major economic activities in the valley. Motor vehicles are identified as the major source of air pollution in the Valley, mostly as a result of old and poorly maintained vehicles, low quality and adulterated fuel, prevalence of two-wheelers and two-stroke engine vehicles, increasing congestion, and inadequate and ill-serviced road infrastructure.

Box B1: Vital statistics of Kathmandu Valley

Area: 550 Sq. km (valley floor)
Altitude: 1350 metres above sea level
Road Length: 535 km (2002)
Registered vehicle population: 171,678
Vehicle composition: Car/jeep 23.7%, bus/truck 5.2%, 3 wheelers 2.9%, 2 wheelers 65. 3%, rest others (2001)
Pollutant concentration: 24-h average PM_{10} concentrations are 225,135 and 126 $\mu g/m^3$ in core, sub-core and remote parts of the valley, respectively, with the highest value of 495 $\mu g/m^3$. TSP concentrations are 376, 214 and 137 $\mu g/m^3$ in core, sub-core and remote parts of the city
Size of electric vehicle market: Rs. 500 million

Sources:

- Department of Transport Management
- Ambient air quality monitoring of Kathmandu Valley. Final Report of ADB-TA-2847-NEP Project prepared by Nepal Environmental Services for Asian Development Bank, 1999, Kathmandu.
- Electric Vehicle Association of Nepal

The diesel operated Indian-made three-wheelers, introduced in the valley in late 1980s and early 1990s, were visibly producing a cloud of black smoke and other air pollutants in the valley. Although, the new registration of such three-wheelers had been banned since 1992, their use was prohibited on streets only from 1995. The combined effort of government, private sector and civil society (mainly NGOs and advocacy groups) produced synergy effect to promote and expand battery operated electric three-wheelers on a commercial basis in the valley to fulfil the vacuum created by the expulsion of diesel three-wheelers. This successful introduction of zero-emission (from tail pipe consideration) electric three-wheelers on commercial basis is noted as a successful practice in many international forum by USAID[46] and UN Sustainable Development;[47] the IPCC Special Report on Technology Transfer features it on its cover page. Although, end-of-the-pipe solution for the pollutant emissions in the niche sector is not a solution to overall air quality problems, this experience provides useful information and a case of successful interaction of government, private sector and civil society in improving urban air quality by controlling vehicular emissions and promoting clean vehicles. The experience is also of interest to other cities in the region, which harbours gasoline and diesel three-wheelers as one of the major stakeholders in the public transportation system. Without facilitation at the beginning, it would be impossible for these clean vehicles to move into any market; the successfulness of this practice is viewed from that perspective in this paper. It has established a new industry, invited private sector investment, created employment opportunities, and promoted the first experimentation of women drivers in Nepal's public transport sector.

Figure B1. A typical battery operated three-wheeler in Kathmandu Valley (Courtesy: Clean Energy Nepal (CEN), Kathmandu, Nepal)

In this paper, we have analysed why the introduction of electric three-wheelers was successful in Kathmandu since electric vehicles have severe techno-economic limitations in other places. We also analysed the prevailing situation and the roles played by the government, private sector and advocacy groups. The role of various command-and-control and market based economic instruments are also illustrated. Lastly, the factors for their replicability are discussed and relevance of this experience to other cities in the region is explored.

B.2. The Success Story

B.2.1. Serious air pollution and smoke blenching three-wheelers

Gasoline operated three-wheelers were introduced in Kathmandu Valley as a cheap taxi alternative in the last few decades. Many cities in the Indian sub-continent embraced those three-wheelers since foreign built cars were expensive and three-wheelers served as cheap public taxies serving short distance commuting routes. These three-wheelers could carry three persons, including a driver, and are powered by two-stroke engines. Kathmandu saw a sudden surge of diesel-operated three-wheelers from 1989-92, which were larger and could ferry ten passengers in its narrow

[46] http://www.info.usaid.gov/countries/np/success/success2.htm

chassis.[48] The vehicles plied the streets, emitting thick black smoke and creating a lot of noise; at the time, there were no environmental standards for emissions from motor vehicles in the valley. Due to public out-cry over these polluting three-wheelers, the government banned further registration of new three-wheelers in 1992. Despite growing public awareness over air quality and pressures from NGOs and other civic groups, a ban on these vehicles in the streets could not be carried out in early days due to a number of local specific economic and political difficulties. Policy makers failed to create any incentive mechanisms for restrictions on three-wheelers.

In a series of programmes to improve the environment, the government set emission standards for in-use vehicles in 1994 (65 HSU for diesel vehicles and 3% CO by volume to gasoline vehicles[49]), formed the Ministry of Environment in 1995, and passed Environmental Protection Act 2056 in 1997. Despite the announcement for phasing out non-complying vehicles within two years in late 1998 (Budget Speech 2055/56) and formulation of a phasing out programme by the Ministry of Environment, Department of Transport Management, and local municipal governments in consultation with the private sector and NGO groups in early 1999, this could not be implemented. An anti-diesel three-wheeler movement peaked in early 1999 with the participation of NGOs, the tourism sector, cine-artists associations, local clubs and the public. This movement led to street protests and road blockades of three-wheelers. Finally, in the 1999 budget (2056/57), the government provided an alternative to owners of diesel three-wheelers for their replacement in the form of a 75% custom holiday on the import of twelve to fourteen passenger public transportation vehicles. Consequently, diesel three-wheelers were banned in the valley from July 1999.

B.2.2. Demonstration of techno-economic feasibility

Interest in converting diesel to electric three-wheelers was generated as early as 1992 in the valley. In 1993, at the request of the Kathmandu Metropolitan Corporation, a U.S.-based NGO called Global Resources Institute, with support from the United States Agency for International Development (USAID) and the U.S.-Asia Environmental Partnership Program, started a pilot project to design and convert diesel three-wheelers to electric three-wheelers. By 1995, a total of eight electric three-wheelers were designed and pilot-tested on one of the major routes in the valley for six months, carrying over 200,000 passengers and travelling more than 175,000 km.[50] This was essentially a demonstration program for battery operated three-wheelers, which showed that such vehicles are economically feasible in the local context. This demonstration project, apart from

[47] Success Stories Vol 4/2000, http://www.un.org/esa/sustdev/success/PCBCP-5.htm
[48] Built by Scooters India Ltd. with payload of 1000 kg powered by 10 HP four-stroke one cylinder diesel engine
[49] This standard was later loosened. For two-wheelers, 4.5% CO was set in early 1998.
[50] Peter Moulton and Marilyn Cohen (1998), Promoting Electric Vehicles in the Developing World, Paper presented at International Electric Vehicles Conference, Coata Rica, November 1998.

designing vehicles, also created awareness and acceptance by the government, private sector and public.

B.2.3. Favourable government policy 1991-2000

> Box B2: Key dates
>
> - 1991 November: Ban on new registration of three-wheelers
> - 1993: Techno-economic feasibility demonstration of electric three-wheelers by Global Resources Institute
> - 1994 August: Announcement of in-use vehicle emission standards
> - 1996 July: Reduced import custom tariff and sales tax on electric vehicle parts
> - 1999 July: Ban on in-use diesel three-wheelers
> - 2001 September: Number of electric three-wheelers over 600

From 1995 onwards, the government has provided direct and indirect facilitation to the EV industry as a consistent policy. The National Transport Policy-2001 [51] further consolidates the policy of promoting electric transportation system in the country. The indirect facilitation mainly consisted of a ban on diesel three-wheelers that created a market vacuum exploited by electric three-wheelers. Direct facilitation included fiscal benefits in the form of reduced import custom tariffs and waivers on annual vehicle registration fees (annual registration fees were about 4,500 Rupees/year in 2001). The 1996 budget[52] reduced custom duties on parts and accessories for electric three-wheelers to 1% and completely waived sales tax.[53] Such policy has been continued in succeeding years, thus greatly reducing the price of those vehicles and encouraging many private groups to invest in EV industry. From the transportation management side, the government had provided a favourable route allocation to electric three-wheelers by wiping out competition from other three-wheelers in early days, though this was later scrapped. These benefits to the private sector helped to develop the electric vehicle industry in the valley. From the fuel side, the state-owned Nepal Electricity Authority provided electricity at low tariff rates for battery charging. Since the majority of electricity in Nepal comes from run-off-river hydro power plants, the charging of batteries could use the surplus and unutilised energy during off-peak periods (night-time charging) with reduced tariffs; electric vehicles were indeed a new market for the electric utility. Thus far, price differences for normal and off-peak charging do not exist, despite the fact that such prospects exist.

The EV sector also enjoys benefits that are offered to manufacturing industries that deal with energy efficiency, energy conservation and pollution abatement as announced by the Industrial Enterprises Act 2049 (Article 15e). Under this act, they are entitled up to 50% discount from taxable income for a period of seven years.

[51] National Transport Policy 2058. Available from Ministry of Labour and Transport, Kathmandu, Nepal.
[52] Year 2053/54 budget presented to Parliament.
[53] For diesel three-wheelers, import duty (and sales tax) was 60%; this was 160% for four wheelers. For batteries and electronic components it was 20-40%. The same budget set a 5% duty (and sales tax) on components of electric vehicles other than three-wheelers; 10% for all complete electric vehicles.

Table B1: Comparison of electric tariff rates, 2002 December

	Fixed power cost	Running energy cost
Electric three-wheelers	Rs 200/kw (Rs 8000 for 40 kw)	Rs 4.30/kwh
Industry	Not available	Rs 5.10/kwh
Household	Not available	Rs 6.8/kwh

1 US$ is about 78 Rs in 2002.

For promotion of electric vehicles, four government bodies have played important roles. These include the Ministry of Environment, Department of Transportation Management, Ministry of Finance and Valley Traffic Police. The role of the Kathmandu Metropolitan Corporation was limited to push the government and bring stakeholders together, since it did not have jurisdiction over this area.

B.2.4. Emergence of a new industry

Box 3: Performance of batteries

Type: Trojan, US125 and Excite USA
Cost: Rs 60,000 per pack (12 batteries each of 6 volts)
Average driving distance per charge: 65 km
Energy per charge: 15-18 Kwh
Average cycle life: 450
Average life: 18 months (improvement from earlier 9-10 months)

The demonstration project demonstrated that battery operated three wheelers are techno-economically feasible in the valley. This caught the attention of the private sector with regard to investing in this industry. Since then, the role of the private sector has been the main impetus for expansion of electric vehicles. Seven converted electric three-wheelers in the demonstration project were bought by a private company, which expanded the fleet size further to 15 vehicles; these vehicles were put into operation in more routes in the valley. Investment of about 500 million Rupees[54] has already been made in EV industry in the valley[55]. By 2002, over 600 electric three-wheelers were manufactured, sold and operated by the private sector in the valley. They ply on 16 routes in the valley today and also employ over 70 women drivers.

The EV industry in the valley principally consists of three major groups; vehicle manufacturers, vehicle owners and charging station operators. Currently, there are about five major manufacturers,[56] 38 battery charging centres, and many owners.[57] Each charging centre owns about 5-10 vehicles, and individuals own the remainder.

Some success has also been made in adaptation to local technology as an alternative to expensive imported technology, especially in chargers; this has enabled the reduction of costs to some extent. Energy sources for EVs, i.e. battery, are one of the major factors in EV. The cost and performance of batteries are often barriers to a full-scale diffusion of electric vehicles in any transportation system. In the valley, electric three-wheelers today are commuting along short and fixed routes of 120 km on a

[54] On average, an electric three-wheeler costs Rs. 540,000. A charging station investment is about Rs. 1.5 Mn
[55] Personal communication made at Electric Vehicle Association of Nepal
[56] The major EV manufacturers are Nepal Electric Vehicle Industry (NEVI) and Electric Vehicle Company (EVCO) that has share of about 40% each in local EV market.

daily basis, changing batteries once a day. The average route length of about 10-13 km serves well for the capacity of electric three-wheelers. Three types of batteries are used in electric three-wheelers in the valley: Trojan, US125 and Excite USA. Since the cost of the battery is of a serious concern, a mechanism of battery leasing has been devised by the EV industry; as a result, today, 99% of the batteries are acquired from the lease system. In this mechanism, a 50% down payment is made in the beginning and remaining payments can be made on instalment basis over several months with 7% interest. This had started an additional expansion of industry.

The Electric Vehicle Association of Nepal is an umbrella organisation of the EV industry. This association integrates the charging station operators' association, manufacturers' association and owners' association and lobbies for the EV industry with the government, media and public at large.

B.2.5. Efforts of NGOs and of civic society

The role of advocacy and civil groups was significant in opposing diesel three-wheelers and facilitating the introduction of electric three-wheelers in the valley. These civic groups organised a number of activities that created public awareness on air pollution, the role of polluting vehicles and need for clean vehicles. They also created a forum to stimulate discussions among the private sector, public and the government for technical and policy debates, and lobbied for electric vehicles. The major NGOs and civic groups involved in these issues included Martin Chautari, Winrock International-Nepal Office, Leaders Nepal, Abhiyan Group (cine-artists' group), Pro-public and The Explore Nepal (tourism sector's group). A number of other organisations, groups and local clubs also took part in protests against diesel three-wheelers. At the peak of protests, groups such as Abhiyan and local clubs boycotted and physically blocked the operation of diesel three-wheelers on streets, demonstration and mass rallies were organised, FM Radio talk programs were held, and lawsuits were filed in court against the diesel three-wheelers. The role of media was favourable to those issues which disseminated air pollution concerns from diesel three-wheelers and motor vehicles to the public. All these activities put tremendous pressure on the government to act.

B.3. Replicability and Significance to Other Cities

B.3.1. Local conditions

Before discussing the replicability and significance of Kathmandu's experience to other cities, it is important to discuss the local conditions under which these electric three-wheelers were successful. The phasing out of diesel three-wheelers and introduction of electric three-wheelers were made amid

[57] About 450 owners

a state of chaotic air pollution, where public support could be easily garnered for such actions. The geographic situation, traffic pattern, travel demand, and energy availability affected the choice and feasibility of electric vehicles in the urban transportation system. These barriers mainly emerged from the limitation of battery technology. However, the area of Kathmandu Valley is about 550 square kilometres and the majority of the vehicles ply inside a circle about 15-20 kilometres in diameter. The top speed of the traffic in the city does not go beyond 30-35 km/hour, while the average speed is as low as 10-12 km/hour. Under such conditions, top speed and driving distance did not become a serious constraint for electric three-wheelers. Further, when these vehicles run on fixed routes, battery changing could easily be carried out once or twice a day. Nepal also has great potential for hydroelectric power. Most of these hydro-plants are run-off-river types, where electricity would be "spilled away" if not utilised during surplus or off-peak times. Therefore, a low tariff rate for off-peak charging of batteries was possible; in that case, the country could save a huge amount of foreign currency (for trade deficit country like Nepal) and financial resources spent on foreign oil, if a significant number of electric vehicles ply on the street. Although, such off-peak charging mechanisms and time-of-day tariffs were not created in 1995-2000, such possibilities helped to create a favourable response from public and policy makers to a great extent. The interest of foreign donors was also one of the important local factors in the case of electric three-wheelers in the valley. The role of two donor communities, USAID (US ODA agency) and DANIDA (Danish ODA agency) was very instrumental; USAID/US-AEP supported demonstration programmes and DANIDA provided support at later stages. Since donors are influential in many governmental policies, such donor interest helped to create a favourable response from the policy makers.

B.3.2. Significance to other cities

Three-wheelers make up a significant part of urban transportation system in cities in South Asia,[58] mainly India, Pakistan, Sri Lanka and Bangladesh. In other cities such as Bangkok, *tuk-tuks* are popular for short distance commuting. Three-wheelers are also popular in Chinese cities. However, governments in South Asia are struggling to phase out three-wheelers, which run mostly by two-stroke gasoline engines and are significantly responsible for worsening air pollution. In many cases, cheaper modes of transportation, such as three-wheelers, are closely linked to low-income groups of the society and inter-twined with urban poverty issues. This makes even more difficult to ban or replace those vehicles without providing some form of alternative to the owners. In most cases, those vehicles are being pushed out from cities rather than being phased out. Bangladesh announced a ban on three-wheelers with two-stroke engines in Dhaka City from 1 September 2002, affecting nearly

[58] South Asia refers to Nepal, India, Sri Lanka, Pakistan, Bhutan, Maldives, Bangladesh (Indian sub-continent)

12,500 such vehicles.[59] The government in Bangladesh has permitted 5,000 four-stroke CNG three-wheelers to ply the street to void the gaps in travel demand due to such ban.[60] Possibilities for replacing Kathmandu's experience in Dhaka are being examined by the Bangladesh Centre for Advanced Studies (BCAS)'s South-South-North Project.[61]

Table B2: Three-wheelers in South Asia

Country	Two-stroke	Four-stroke
Nepal 1999	-	5,900 (including two stroke)
Bangladesh 1999	68,000	7,600
India 1997	1,180,000	210,000
Pakistan 1999	91,000	-
Sri Lanka 1997	59,000	-

Source: Masami Kojima, Carter Brandon, Jitendra Shah, Improving Urban Air Quality in South Asia by Reducing Emissions from Two-Stroke Engine Vehicles, The World Bank, December 2000, Washington DC.
- refers *data not available*

Learning from the success from its demonstration programme of converting diesel three-wheelers to electric in Kathmandu, USAID is providing assistance to India in a programme called "India Zero Emission Transportation Program (IZET)" in 1999-2003. The objective of this programme is to reduce health impacts from vehicular emissions and is essentially a demonstration program in Delhi, Agra and Pune where 1,000 electric-three wheelers will be designed, tested, and assembled. Under this programme, seven three-wheelers were field tested in the city of Agra for one year. With this success, two private companies (Bajaj Auto Limited of India and New Generation Motors of the U.S.) are entering into a joint venture to produce 1,000 electric three-wheelers in India. USAID will provide USD3.9 million of the USD9.3 million programme; the remainder will be borne by private sectors[62].

Kathmandu's experience is a good case for exploring the role of electric three-wheelers in cities, where a significant number of gasoline or diesel three-wheelers exist and where three-wheelers are responsible for significant air pollution. However, introducing electric vehicles should not only limited to designing and testing vehicles; this should be supplemented by facilitating public awareness and acceptance, creating laws and regulations, government policies and incentive mechanisms for removing initial market barriers, and inviting private investment on a commercial basis. Synergy of the roles played by government, private sector and advocacy groups can facilitate the successful introduction of such vehicles. It should be mentioned that three-wheelers are low occupancy public transport modes and a large-scale penetration of these vehicles may lead to a slow down of other forms of transport through congestion and other externalities. They are best suited for short commutes

[59] Bangladesh Centre for Advanced Studies web-page http://www.bcas.net/ accessed on December 25, 2002.
[60] Bangladesh has large natural gas reserves and an extensive network of gas pipelines in Dhaka.
[61] Recent BCAS News http://www.bcas.net/ assessed on 3 January 2003 at
[62] For complete project see web-page of US Department of Energy, Office of Policy and International Affairs, http://www.pi.energy.gov/library/EWSLindia-izet.pdf

and fuller integration with other high occupancy public vehicles through well-designed transportation planning is essential.

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APPENDIX C: SUCCESS OF CONTROLLING SOx EMISSIONS IN KITAKYUSHU, JAPAN

C.1. Introduction

Kitakyushu City was one of the most polluted cities in Japan during the 1960s and early 1970s due to industry related pollution, such as high sulphur oxide concentrations and dust fall. Since then, drastic measures have been taken by the city to improve its air quality. As a result, Kitakyushu City was able to enjoy high economic growth, as well as improvement in air quality in later years. Recognising the achievement of Kitakyushu, the city was awarded the Global 500 Award by UNEP in 1990.

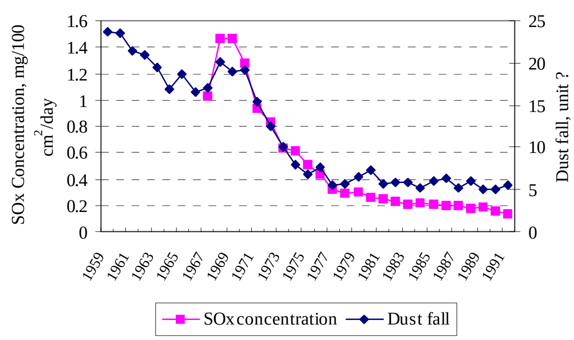


Figure C1. SOx concentration and dust fall

Source: Masaharu Inoue, Kitakyushu City Environment Bureau, presented at Kitakyushu Initiative 1st Network Meeting, 20-21 November, 2001. Kitakyushu, Japan.

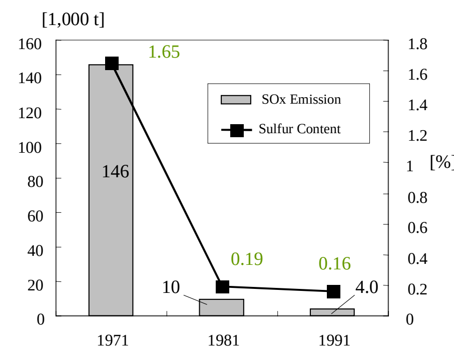


Figure C2. SOx emission and average sulphur content of fuels

In the 1960s, Kitakyushu was one of the most industrialized cities in Japan, which was dominated by heavy industries including paper and pulp, steel and petro-chemicals. This required consumption of large quantities of energy, whose primary source was coal. Higher sulphur content of coal, inefficient use of energy, inefficient industrial production process, and non-utilisation of end-of-pipe technologies to curb sulphur oxides were major problems. With pressure from residents, Kitakyushu forged a partnership with industries to improve air quality through various means. The process involved strengthening local regulations, encouraging voluntary measures by industries, promoting technology, improving quality of fuel, providing incentives to small- and medium-scale industries, strengthening monitoring systems and enhancing institutional capacity of the local government.

C.2. Processes and Policies

The motivation for the local government to act to improve SOx and dust, in particular, goes back to women's protest movements that started with the slogan, "We want our blue sky back," in the mid 1960s. Such campaigns increased awareness among people who were silent for many years regarding the negative aspects of environmental pollution. Despite pressure from polluting enterprises, these women groups petitioned and challenged the local government with their own studies on air quality. In other cities in Japan, such as Kawasaki and Osaka, resident groups had a number of confrontations with polluting enterprises and the local government. Anti-pollution movements had lot of political repercussion in those cities. The motivation for local political leaders to carry out anti-pollution measures had some political consideration as well because of the leftist political party's active environmental agenda and ongoing public awareness and protests for environmental improvement. This provided motivation to polluting enterprises to seriously cut emissions. The situation led to voluntary agreements (March 1972 and January 1977) between residents, polluting enterprises (48 companies, 57 factories) and the local government to reduce emissions and implement pollution control measures.

Air pollution countermeasures by the city government can be divided into the following themes:

- Strengthening of local regulations
- Enhancing institutional capacity
- Fuel quality improvement
- Fuel substitution
- Technical guidance and technology enhancement in the manufacturing process
- Change in industrial structure
- Factory relocation from residential areas
- Financial mechanisms: subsidy measures

C.2.1. Strengthening of local regulations

Apart from the anti-pollution law of the national government (Environmental Quality Standard, Emission Standard, Area-wide Total Pollution Load Control, and Automobile Exhaust Emission Regulation), Kitakyushu City itself formulated stricter laws, regulations and inspection systems. This included: (1) new plant modification order, improvement order, and stricter inspection to smoke and soot treatment facilities, (2) continuous pollution monitoring, and (3) emergency measures (1969-74). The emergency measures demanded the systematic reduction of SOx emissions by 20%, 30% and 50% from industries during the implementation period. Local regulations also included time and quantity reductions. For time regulations, a weather information system was developed for smog warnings and for special weather events that would aggravate pollution concentration. Once smog warnings were issued, individual industries were required to follow the assigned quantity reduction for the designated time period. The K-Value[63] regulation, in which the emission quantity was regulated by the height of the exhaust port, was set at 1.75 for Kitakyushu, which was the second most strict in Japan.

C.2.2. Enhancing institutional capacity

In order to support countermeasures, the institutional capacity of the environmental section, in terms of the number of qualified staff members, monitoring system and equipment were enhanced. The table below shows the number of administrative and research staff members since the early 1960s.

Year	Status	Administrative	Research
1963	Subsection	4	-
1965	Section	8	9
1870	Division	22	17
1971	Bureau	25	21
1977	Bureau	75	45

Source: Masaharu Inoue, Kitakyushu City Environment Bureau, presented at Kitakyushu Initiative 1st Network Meeting, 20-21 November, 2001. Kitakyushu, Japan.

Similarly, authority for decision making for regulations and standards and smog warnings was shifted from Fukuoka Prefecture to Kitakyushu City in 1970. This transfer of authority to the local body provided opportunities for the city to act quickly and also a sense of ownership among the city council, administration, enterprises and the residents. Following this, the Kitakyushu Air Pollution Prevention Joint Council was established, consisting of representatives from the national government, Fukuoka Prefecture and key polluting enterprises. This council played a key role in implementing a wide range of countermeasures. Decentralisation of the responsibilities within Kitakyushu City was also a key institutional measure.

Apart from the local government, enterprises falling under certain criteria were mandated to have pollution control managers whose job was to manage technical and managerial matters related to pollutants. Such managers were required to pass the national qualifying examination.

C.2.3. Fuel substitution and fuel quality improvement

One key component of the countermeasures was the type and quality of fuel. The city government had encouraged enterprises to shift from coal based energy systems to liquid fuel and then gradually, to natural gas. The figure below shows the consumption of fuels in Kitakyushu. Therefore, the sulphur content per unit of energy consumption was drastically drastically. The process first involved fuel

[63] In K-value regulation, allowable emission in Nm3/hr = K * 10-3 * He2, where, He is effective stack height in

switching from coal to crude oil (sulphur 1%) in 1960s. This was followed by a switch to low sulphur content crude oil (0.15%) and light oil, then to LPG, LDG and finally to LNG.

C.2.4. Technology in manufacturing process and end-of-pipe

Efficient manufacturing processes can produce large amounts of energy savings in manufacturing establishments. The following technology enhancements were carried out:

- Process conversion to efficient processes such as in cement kilns
- Raw material switch such as ferric sulphide to sulphur in sulphuric acid manufacturing plants
- Desulphurization of furnaces
- Phasing out of small and mid-size boilers and introducing large scale boilers
- Introduction of better equipment
- Recycling of waste energy
- Increased height of chimney stacks
- End-of-pipe technology, in particular, FGD (Fluidizes gas desulphurisation) installations

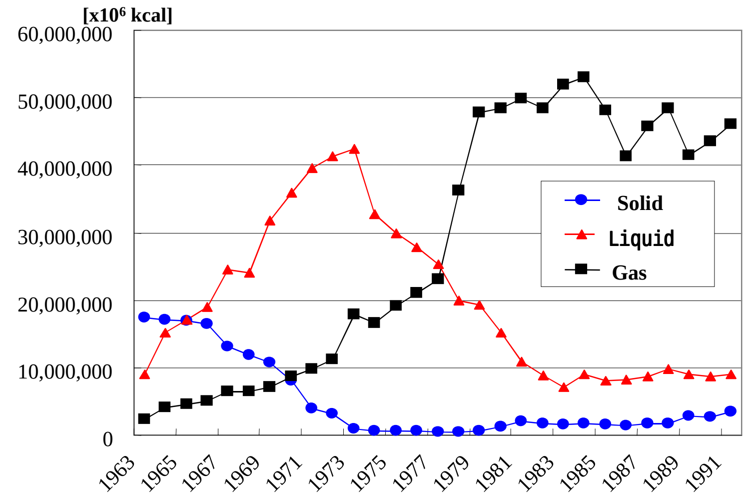
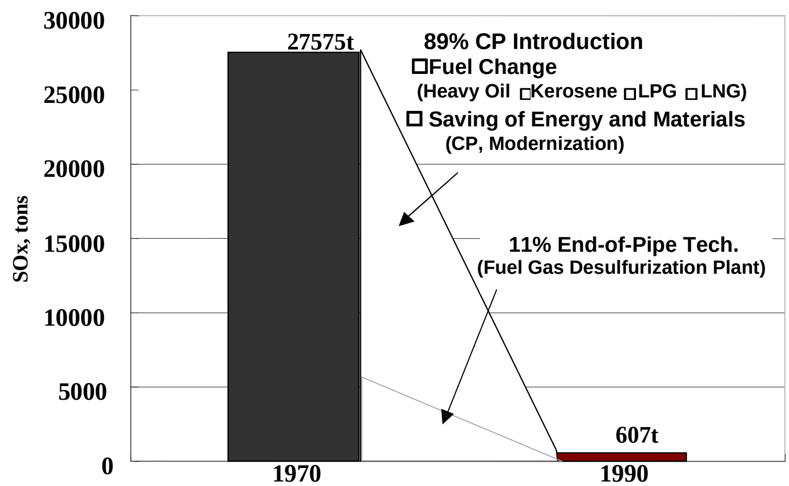


Figure C3. Energy consumption in Kitakyushu City



Imai, S. Undated, Features of Pollution Control in Japan, Tokyo: Japan International Corporation Agency

Figure C4. Reduction of SOx emission by various means

Source: Masaharu Inoue, Kitakyushu City Environment Bureau, presented at Kitakyushu Initiative 1st Network Meeting, 20-21 November, 2001. Kitakyushu, Japan.

meters, K=1.75 for Kitakyushu.

Introduction of Clean Production (CP) measures was successful in reducing energy and emissions by large amount. The figure below shows the contribution of CP in SOx reduction.

Know-how and technical support to polluting enterprises by the local government was one of the important factors. Local government employees, experts and relevant persons on many occasions carried out pollution diagnosis and provided needed technical guidance to manufacturing establishments. This helped in identifying the appropriate improvement measures. At the same time, such processes enhanced the understanding and trust between the government and the enterprises.

C.2.5. Factory relocation from residential areas

For effective control and to reduce the exposure of high SOx concentration to residents, several factories were relocated from residential areas to an industrial area near the coastal zones. In the Okidai area, approximately 100 factories were relocated to three industrial zones. Other relocated industries were steel and chemical. At the same time, in densely industrialized areas, residents were persuaded to be relocated to less polluted areas, such as the Shiroyama area where more than 650 households were relocated.

C.2.6. Financial mechanisms and subsidy measures

All the activities explained above were not possible without financial facilitation to the enterprises by the local government, particularly in the case of small- and medium-scale businesses. Financial mechanisms consisted of two parts: (1) public capital financing system and (2) tax incentives. The core of control measures were technological enhancements and fuel switching. So the capital needed for technical countermeasures to be carried out to meet volunteer agreements and requirements for regulations were provided at low interest rates. The pay back period (7-20 years) depended on the type of company.

Tax system benefits were introduced to reduce the burden of expenses necessary for the maintenance and management of pollution control equipment and activities for national, as well as local, taxes. This included tax exemptions and reductions on fixed assets related to pollution control facilities and equipment, and the extension of applied terms for repayment.

The table below shows local governmental financing for air pollution countermeasures of small- and medium-scale companies.

Table C1. Local government support to small and medium scale companies

1968-95	Number of Cases	Million US$
Air pollution	57	4.8
Odour	19	1.0
Noise	161	15.0

Water pollution	45	3.0
Others	11	0.6

Source: Communication at Kitakyushu City

C.2.7. Future considerations in planning process

Consideration for future development was included in the planning process in subsequent years in Kitakyushu by the local government. This includes planning based on future anticipated industrial facilities, scientific analysis of the relationship between source and pollution distribution, support from wind tunnel test/computer simulations, and prediction models.

C.2.8. Enforcement

Without enforcement of the regulations and standards, real success cannot be achieved. The inspection systems developed by the local government were: spot inspections, tele-metering and routine inspections. Violators were first given warnings and allowed to make needed modifications in two stages and, if this proved unsuccessful, led to fines and imprisonment.

C.3. Lesson Learned

- Public awareness and resulting political will is important for environmental problems
- Comprehensive planning based on scientific approaches can produce better results
- Anti-pollution measures should be implemented taking stakeholders into confidence

C.4. Replicability

SOx emissions control in the industrial city setting is Kitakyushu's distinctive feature. Most of the achievements in reducing SOx emissions were made by implementing technical measures, mainly, process modification and fuel quality coupled with effective enforcement and monitoring. The case is interesting to rapidly industrializing cities, such as cities in China and others in Asia. In the case of China, some of the conditions may be similar, such as a rapidly growing economy, availability of large city revenue, and coal based economy, which is in transition to liquid and gaseous fuels. Kitakyushu has made significant achievement in Clean Production (CP) techniques, and its experience on how to implement CP measures taking industry into confidence might be useful to cities in South-East and North Asia. However, technology, time and approaches have changed in recent years and, in reality, only a few aspects of the successful experience in one city can be transferred to another due to local conditions.