Asian Mega-Cities

Tokyo • Seoul • Beijing • Shanghai

Urban Energy Use and Greenhouse Gas Emissions in Asian Mega-Cities

POLICIES FOR A SUSTAINABLE FUTURE

IGES
Urban Environmental Management Project
Institute for Global Environmental Strategies

IHDP - Industrial Transformation

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Author's Note

This report is one of the outcomes of a research project entitled "Urban Policy Integration of Energy-Related Environmental Issues in Selected Asian Mega-Cities," which was undertaken from April 2001 to March 2004 by the Urban Environmental Management Project (under the leadership of Professor Hidefumi Imura) of the Institute for Global Environmental Strategies (IGES) with support from a number of researchers from Korea, Japan and China. A number of outcomes, namely, a comprehensive database on four cities, articles for academic journals, conference papers and publications in various newsletters and magazines have already been published. IGES, a strategic policy-oriented research institute, regards outreach, multi-stakeholder dialogues and capacity-building activities as integral parts of its research activities. Accordingly, researchers involved in this project have disseminated research outcomes to city policy makers, national governments and international institutions through various forums of policy dialogue, including those 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. Since its audience includes experts as well as non-experts, it is written in a manner that is easy to read.

During the course of this project, three international conferences were organised in Kitakyushu, Japan; the East West Center, Hawaii; and Kanagawa, Japan. Together, they strengthened international linkages and expertise and facilitated the collection of information.

Shobhakar Dhakal
Urban Environmental Management Project

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List of Abbreviations

ALS	Area licensing system
APN	Asia Pacific network
ARF	Additional registration fees
BCAS	Bangladesh Centre for Advanced Studies
CAI-Asia	Clean Air Initiative for Asian Cities
CBD	Central business districts
CDM	Clean development mechanisms
CHS	Cooling and heating systems
CIF	Cost-insurance-freight
CNG	Compressed natural gas
CO_2	Carbon dioxide
COE	Certificate of Entitlement
COP3	Third Conference of the Parties
CP	Clean production
DANIDA	Danish International Development Assistance
EKC	Environmental Kuznet Curve
ERP	Electronic road pricing system
ERPR	Environment and Resources Protection Committee
EURO IV	European Union emission standard IV
EV	Electric vehicle
FGD	Fluidised gas desulphurisation
GEF	Global environmental facility
GHG	Greenhouse gas
GLIDE	Green Link Determining System
GPS	Global Positioning System

GRP	Gross regional product
HDB	Housing Development Board
ICLEI	International Council for Local Environmental Initiatives
IGES	Institute for Global Environmental Strategies
IHDP	International Human Dimensions Programme
IHDPI	International Human Dimensions Programme
IIED	International Institute for Environment and Development
I-O	Input-output
IPCC	Intergovernmental Panel on Climate Changes
IT	Industrial transformation
ITS	Intelligent transport systems
IU	In-vehicle units
IZET	India Zero Emission Transportation Program
LNG	Liquid natural gas
LPG	Liquefied petroleum gas
LTA	Land Transport Authority
MCI	Ministry of Communications and Information
MRT	Mass rail transport
MSW	Municipal solid waste
MTCE	Million ton of coal equivalent
NGO	Non-government organisation
NO_X	Nitrogen oxides
ODA	Overseas development agency
OECD	Oganisation for Economic Cooperation and Development
OMV	Open market value
PPP	Parity in purchasing power
PM	Particulate matter
PM_{10}	Particulate matters of less than 10 microns
RZ	Restricted zone
SCP	State and City Planning Project
SG$	Singapore Dollar
SEPA	State Environmental Protection Agency, China
SME	Small and medium size enterprises
SO_x	Sulphur oxides
SPM	Suspended particulate matters

START	global change SysTems for Analyses, Research and Training
TMG	Tokyo Metropolitan Government
TOE	Tonne of oil equivalent
TOD	Transit-oriented development
TSP	Total suspended particles
ULEV	Ultra low emission vehicles
UNFCCC	United National Framework Convention on Climate Change
USAID	United States Agency for International Development
URA	Urban Redevelopment Authority
US-AEP	United State-Asia Environmental Partnership
USAID	United States Agency for International Development
VQS	Vehicle quota system
WHO	World Health Organisation

Executive Summary

The nature of energy use in and GHG emissions from cities is not well understood in Asia. Although a number of research projects on sectoral energy use for industries and urban transportation have been conducted from the viewpoint of managing air pollution, an overall energy and CO_2 picture is missing. In recent years, however, city policy makers have gradually felt growing pressure to take GHG emissions into consideration while planning and formulating policy. That any city in Asia but the most advanced will adopt a policy measure solely aimed at CO_2 reduction is unlikely. Even so, if global emissions are to be reduced, CO_2 emissions from rapidly developing mega-cities, due to their rate of growth and of emissions volume are crucial importance. The discussions in this report centre primarily on two mature mega-cities in Asia, Tokyo and Seoul, as well as on two rapidly developing mega-cities, Beijing and Shanghai.

Characterising the Driving Forces

A number of factors influence energy use in and the resulting CO_2 emissions from cities. The major ones include the compactness of urban settlements, urban spatial structure, urban functions, the nature of transportation systems, income and lifestyle, the energy efficiency of key technologies, industrial processes, building technologies, climate, and waste disposal methods. Income and lifestyle changes are particularly significant in Tokyo, Seoul, Beijing and Shanghai. Improvements in energy intensity due to positive technological change and higher productivity of energy have played an important role in reducing energy use and associated CO_2 emissions. The improvement of fuel quality and fuel switching have helped reduce CO_2 emissions in Seoul in recent years but had a surprisingly nominal effect in Beijing and Shanghai over the last two decades. Most CO_2-related benefits in Beijing and Shanghai come from energy efficiency alone. In the transport sector, a rapid increase in the size of vehicle populations is a major cause of increasing CO_2 emissions. The reliance on mass rail networks in Tokyo has helped stabilise emissions, but increases in the number of large cars has countered that effect. Despite huge income differences, Tokyo, Seoul, Beijing and Shanghai the differences in per capita waste generation (1.13, 1.06, 1.11 and 1.04 kg/person/day, respectively) are small. With weak waste management systems and little effort to reduce waste at the source, GHG emissions from Beijing and Shanghai could increase dramatically in the future.

CO_2 Emissions in Tokyo, Seoul, Beijing and Shanghai—Past and Future

The trend of per capita energy use is converging towards a common value (between 1.3 to 1.6 TOE/person) in these cities, but per capita CO_2 emissions in Beijing and Shanghai are rapidly surpassing those in Tokyo and Seoul. This trend highlights the fact that existing policy interventions in China have relied too heavily on increasing energy efficiency and have paid scant consideration to carbon emissions. In 1998, per capita CO_2 in Tokyo was 4.84 tonnes, 1.3 times higher than it was in Seoul; Beijing and Shanghai were 1.3 and 1.6 times higher than Tokyo respectively. The CO_2 emissions profile shows that the economic recession in Tokyo in the mid-1990s did not reduce CO_2 emissions, whereas Seoul did register a decline in 1998. The discrepancy can be accounted for in that CO_2 emissions in Tokyo are affected more by lifestyle factors resistant to changes in disposable income than is the case in Seoul. The historical transition of emission shows that Beijing and Shanghai transformed from a slow-economic-high-emission growth phase in the 1980s to a fast-economic-low-emission growth phase in the 1990s. This transition has been attributed to technological advancements, increases in market competitiveness, reform of inefficient state enterprises, emergence of a strong tertiary sector and substantial energy efficiency improvements.

The sources of CO_2 emissions differ in these cities. Tokyo's emissions are dominated by commercial and transport sectors and industry's contribution has decreased to less than 10% from 35% in 1970. In Seoul, the household and transport sectors dominate. Most emissions in Beijing and Shanghai, in contrast, are dominated by industry, and the role of the transport sector, though at 10% it is growing rapidly, is currently just 5 to 6%. We expect growth to continue to be high as urban transportation gets a boost from economic growth, financial markets are liberalised (making available the availability of more credit mechanisms to buy a car) and WTO accession is secured (resulting in reduction of tariffs on imported vehicles).

Over the last two decades, the effects of fuel mixing on CO_2 emissions have been nominal in Beijing and Shanghai. Ambitious plans to tap clean energy from the Three River Gorge dam and from the national government's massive natural gas pipeline plan do, however, exist. In Tokyo and Seoul, coal has been almost eliminated in recent years and electricity plays a greater role than it used to. Oil dominates Seoul due to its massive district heating and cooling systems, but is not used much in Tokyo.

A comparison of each city's emissions per capita and per unit economic activity reveals that Tokyo is performing the best. Various factors including compact settlements, well-developed rail-based mass transportation, low dependence on automobiles, relatively clean energy, high technological efficiency, good governance, climatic factors and strong institutional capacity account for its superiority.

Even in the most optimistic scenario, CO_2 emissions from these cities will not decrease. The results from our bottom-up models show that while the number of vehicles in Beijing and Shanghai is about one-tenth that in Tokyo, their total fuel consumption is only about one-third to one-half that of Tokyo because of lower fuel efficiency, larger vehicles, and greater mileage, among other factors. Far fewer vehicles emit a much larger amount of local pollutants and CO_2 in Beijing and Shanghai. The increasing numbers of light-duty gasoline vehicles are, in particular, expected to drastically increase CO_2 emissions. Indeed, in Beijing, a more than two-fold increase in fuel consumption by road transportation is expected for the period from 2000 to 2020. In Tokyo, policy interventions in lifestyles and appliance use will be the most important measures in reducing the volume of emissions from the households and businesses which are its predominant source.

While direct emissions are discussed explicitly, emissions embedded in consumption goods are often neglected in CO_2 debates. The true environmental load or "footprint" of a city, especially in the case of non-location-binding emissions such as CO_2, needs to be clarified before alternative urban development pathways are explored. This requires detailed analyses of the consumption activities of urban dwellers; if they are lacking, industrial I-O table-based studies can provide some sense of the size of environmental footprints. I-O based analyses suggest that the volume of indirect emission of CO_2 in cities such as Tokyo and Shanghai could be over three times that of direct emissions. Since cities do not only consume goods but also export them, the CO_2 emissions for which Tokyo, Beijing and Shanghai can be considered "responsible," calculated by subtracting the embedded CO_2 in exported goods, from the embedded CO_2 in imported goods, are about 70% of total emissions (direct and indirect). Although these estimations may not truly reflect all consumption-oriented indirect emissions, they do provide a sound basis to argue that indirect emissions from mega-cities are large and that policy makers should at least regard indirect emissions as an issue worthy of their attention.

Policy Directions and Challenges

Because local governments lack awareness and are confronted with more urgent local issues, they give little priority to global issues. Another problem is that while resources are limited existing challenges for local environmental management are greater. With the exception of Tokyo, no city has an explicit policy of reducing GHG. Existing policy measures in Tokyo jointly tackle urban warming and GHG emission issues; it includes intervention in the building sector, a voluntary information disclosure system and energy efficiency improvement programmes. Shanghai, Beijing and Seoul consider GHG mitigation implicitly in their implementation of local air pollution measures and energy sector restructuring, but air pollution improvement measures, do not necessarily contribute to the reduction of GHG. Broader policy agendas, such as emissions trading and mandatory reductions in the corporate sector, do not exist in any of the cities, nor are market mechanisms effectively used. Building consensus is a major challenge for local policy makers, who seek to formulate plans which can influence powerful stakeholders such as the corporate sector. Even in developed cities such as Tokyo, institutional barriers against mainstreaming GHG concerns exist and the mandate and role of the responsible unit are limited not only due to the dominance of local priorities but also due to the structure of institutions.

The first step for cities in Asia towards achieving a low CO_2-emission future is to carry out sound energy management at the city level and to implement synergistic policies which reduce local and global concerns but do not seriously compromise local environmental priorities. The needs in this direction are outlined below:

- Improving the scientific information base for understanding and finding solutions to reducing CO_2.
- Improving institutional capacities and arrangements for addressing policy integration along two dimensions: integrating energy policies into overall urban development and developing synergistic policies for local environmental problems and GHG emissions.
- Promoting research on the opportunities for and constraints on policy integration and its impacts.
- Reorienting sectoral planning towards holistic, urban-level planning.
- Enhancing national and local cooperation in mitigating emissions.
- Creating forums for sharing experiences.
- Exploiting market mechanisms.
- Tackling CO_2 emissions from rapidly expanding urban transportation.
- Increasing the role of international institutions in promoting policy integration.

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 (GHG) concentrations in the atmosphere at levels that prevent dangerous human-induced interference with the climate system. It urges parties to protect the climate system in accordance with their common but differentiated responsibilities. In December 1997, the Third Conference of the Parties (COP3) adopted the Kyoto Protocol, which includes legally binding commitments for developed countries to reduce their GHG emissions an average of about 5% by the target years of 2008 to 2012.

Within Asia, the most significant increase of energy consumption and GHG emissions is expected to take place in cities, especially mega-cities, whose rapidly expanding populations enjoy higher living standards and material affluence than do people in rural areas and smaller cities. The increasing demand for passenger mobility and freight transport is expected to be met by increasing the number of automobiles, whose use will exacerbate traffic congestion and air and noise pollution as well as increase energy consumption and CO_2 emissions. The carbon sink within mega-cities, primarily urban greenery, will not be able to absorb all the CO_2 emitted. The problems mega-cities face today will be those of smaller cities in the future and their actions can be a model for other cities. Studies of mega-cities can provide a good basis for countries to consider comprehensive action strategies which promote sustainable development by employing efficient use of energy and other resources in order to reduce environmental load. It is likely, however, that emission reduction strategies will differ from city to city and that no single universal strategy will work in all situations.

Cities in rapidly industrialising regions of Asia face many tasks related to economic development and environmental protection. They tend to prioritise immediate, local issues as urgent and to regard global warming as a long-term and distant issue. Since the nature of energy use in and GHG emissions from cities is not well understood in Asia, urban managers are largely unaware of the multiple benefits of energy management and CO_2 reduction. There has been limited research on managing energy use in industrial and urban transportation sectors to control air pollution, but an overall energy/emission picture is missing. Energy management was not considered important at the city level until recently because most energy-related decisions are made at the national level. In some cities, though, especially in coal-dominated countries such as China, energy restructuring has become a key policy agenda of local governments. Due to growing concern about GHG, efforts are being made to understand energy use at the city level in greater detail and to take GHG emissions into consideration while planning. With the exception of a very advanced city, it is unlikely that cities will implement policy measures aimed solely at reducing CO_2 emissions in the near future. Still, it is important to integrate energy considerations into policies, either by integrating energy concerns with overall urban development or by synergising measures to reduce air pollution and CO_2 emissions. Efforts should be directed toward supporting cities either by increasing knowledge or by building their capacity to understand the problem and identify possible measures for implementation. The prerequisite for systematic action is an analysis of the CO_2 emission budgets of cities and of the driving forces behind energy use and associated policy analyses.

In this context, the objectives of this report are as follows:

- to clarify the energy use in and CO_2 emissions from selected cities in Asia and to present perspectives on future challenges at the city level;
- to show the extent of indirect CO_2 emissions and to trace cities CO_2 footprints;
- to study the major driving factors;
- to trace major sectoral challenges;
- to identify policy directions and policy challenges in cities; and
- to discuss major opportunities for and barriers to implementing integrated policies in cities.

The four mega-cities evaluated in detail in this report are Tokyo, Seoul, Beijing and Shanghai. Analyses of these cities have been used to generate wider perspectives on cities in Asia.

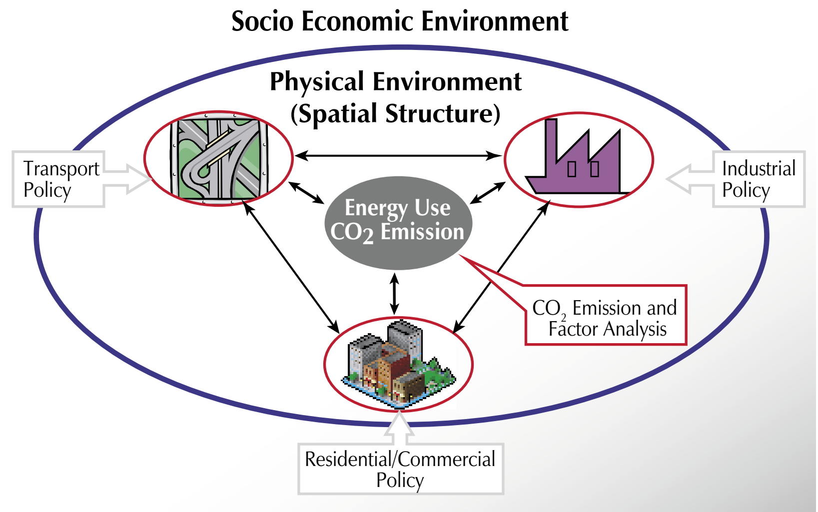
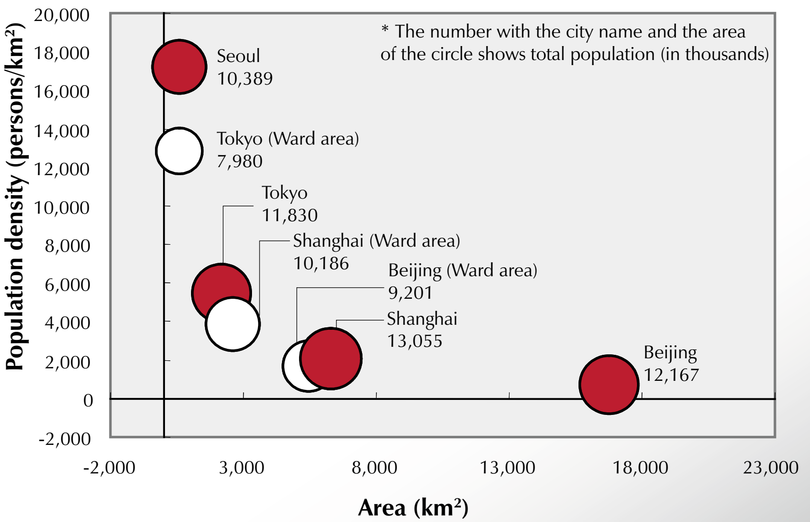


Figure 1.1 **Analyses framework**

Table 1.1 Mega-cities investigated

City	Remarks
Tokyo	The most developed mega-city in Asia, Tokyo, has a modern urban infrastructure, a well-organised mass transport system, and a number of new energy-saving technologies for buildings and appliances. Residents' 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 a larger energy demand for heating in the wintertime.
Beijing	The capital of China, Beijing is undergoing rapid transformation, with a growing population, many new buildings, and increasing automobile traffic. Preliminary analysis has shown that both Beijing and Seoul are following Tokyo in sectors like transport but with a phase-lag.
Shanghai	The richest mega-city in China, Shanghai is undergoing a rapid transformation. New business facilities, increasing automobile traffic and a profusion of affluent lifestyles characterise it.

These cities share the characteristics of having a high population density and being the most important cities in their respective countries. They differ in terms of a number of factors, such as level of income and development, form of governance, and institutional capacity. A number of methods, such as political and functional boundaries and urban agglomerations, can be used to define a city. Figure 1.2 shows the population density and area of these cities assumed by this report. Figure 1.2 shows the boundaries of Tokyo-to (Tokyo Metropolitan Government administered area), Seoul City, Beijing and Shanghai. Beijing and Shanghai are far larger than Tokyo and Seoul although the boundaries of the core ward areas (the built-up areas at the centre of ward areas) of Beijing and Shanghai are comparable to the areas of Tokyo and Seoul.



Source: Internal database compiled from statistical yearbooks of cities

Figure 1.2: Area and population density of case study cities

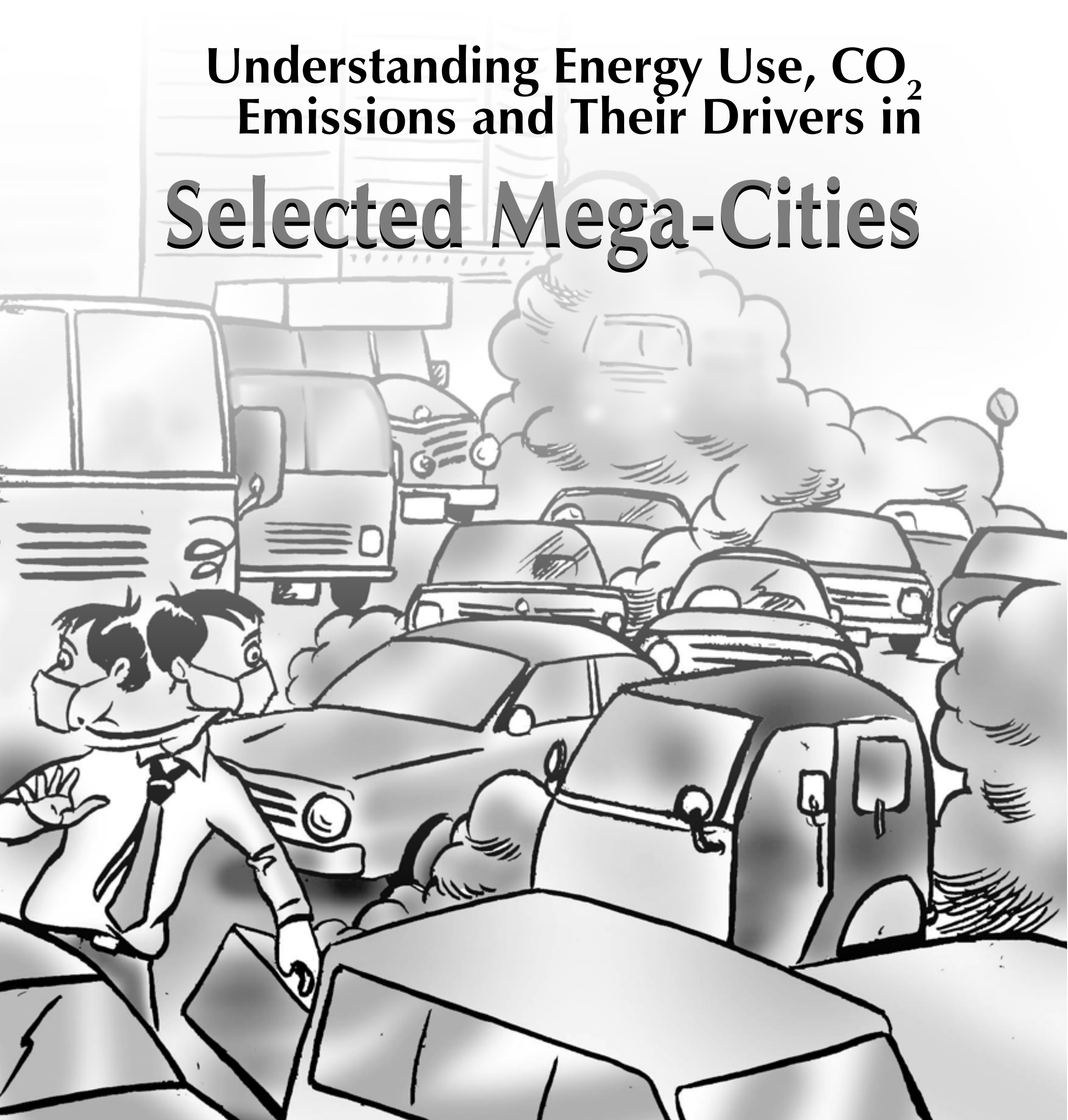
This report also compiles and analyses the results of the research carried out by the author collaborators under the framework set by the author in a bid to provide a comprehensive picture of cities. The collaborators' outcomes are clearly mentioned in the relevant sections of the report.

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

section **A**

Understanding Energy Use, CO_2 Emissions and Their Drivers in

Selected Mega-Cities



2 Energy, Cities, and Sustainable Development

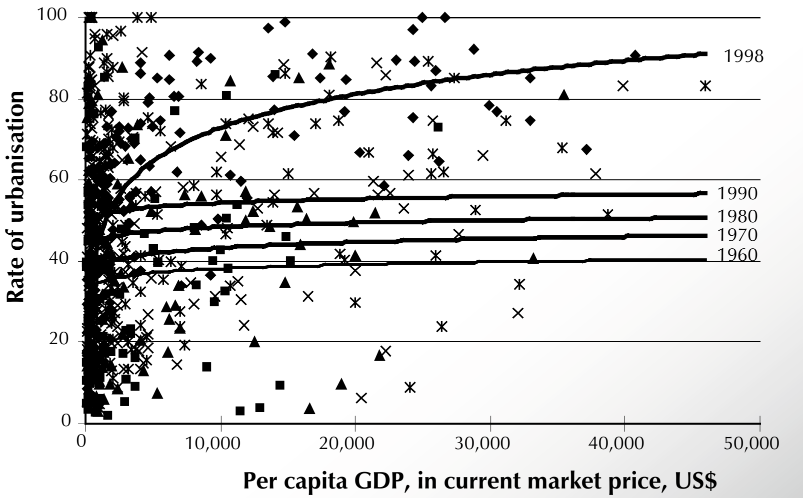
Sustainability and sustainable development have different definitions, yet all link them closely to energy use, emissions and urbanisation. This section traces and highlights those relationships and proposes a policy framework. In particular, this section aims to answer questions such as the following: How are cities and sustainability linked? What determines urban energy use? What is the relationship between energy and emissions and economic growth in cities? What is the role of urban policies?

2.1 Urbanisation and the 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 industrialised countries lives in urbanised areas (UN, 2002). Although a smaller proportion of the populations of developing countries lives in cities, cities are still driving forces for development and centres for power and cultural and societal transformation.

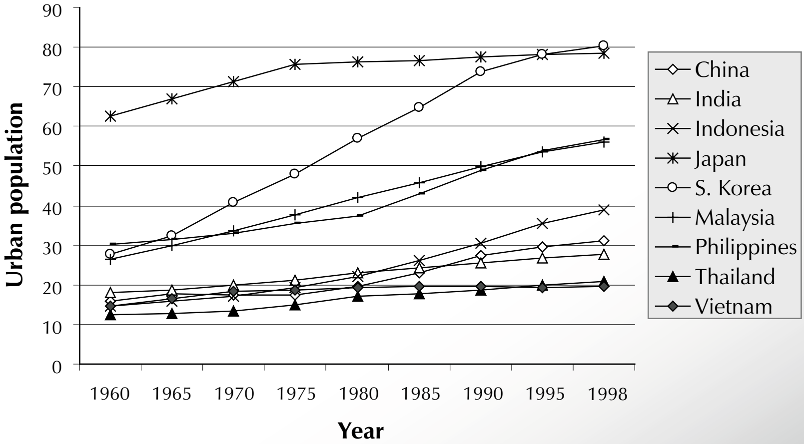
The number of people living in urban areas is increasing rapidly around the world. In recent decades, such rates have accelerated. In 1950, 30% of the world population lived in urban areas; that figure had increased to 47% in 2000 and is expected to increase to 60% by the year 2030. From 2000 to 2030,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

Cities contribute towards promoting global sustainability as we as impede progress towards sustainability. Since cities are centres of high living standards, they consume large amounts of material goods, which leads to the over-utilisation of limited natural resources, including energy



Source: *World Bank Indicators CD-ROM 2001*

Figure 2.1 World urbanisation trend



Source: *World Bank Indicators CD-ROM 2001*

Figure 2.2 **Urban populations in selected Asian countries**

resources, and to the emission of large volumes of GHG. At the same time, people living in cities set the direction of future development and can promote the movement towards sustainable development. Cities are engines of economic growth that provide space for innovation, knowledge, technology and employment. High population density and massive consumption opens several options for using compactness as a means to effectively utilise natural resources and practice 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 on sustainability. Cities and sustainability bring two major environmental issues to the forefront for policy makers. The first is the intensive consumption of energy and materials which affects natural systems and ultimately areas and people outside the boundaries of cities and even future generations. The second is the exposure of a large and concentrated urban population to worsening air, water and solid waste pollution and to considerable vulnerability related to global climatic changes.

2.2 Determinants of Energy Use in Cities

Energy plays a vital role in sustaining the metabolism of cities. Energy has no conflict with urbanisation; in fact, due to their compact population and infrastructure, cities open up avenues for the efficient utilisation of energy. Compact cities need complex energy management systems, whose provision challenges policy makers. Asian cities, in contrast to European and North American cities, tend to get denser and denser and expand. Because North American cities are low density and sprawled over large areas they require large amounts of energy to run their transportation and distribution systems and their public transportation is cost ineffective. Energy use concerns are not related only to availability or use, but also to implications after their use. Energy produces local air pollutants and GHG as waste; if their concentrations reach unacceptable levels, there are serious local and global implications for human health and natural ecosystems. Efficient utilisation of energy is the key to conserving depleting energy resources, as well as to reducing the levels of air pollutants such as NO_x, SO_x, hydrocarbons, CO, particulate matters, CO_2, and so on. Several key factors determine the extent and nature of energy use in cities:

Compactness of urban settlements

The compactness of urban settlements influences the demand for energy for transportation and for other areas such as district heating and cooling using co-generation systems. Urban sprawl, in which low-density suburbs depend on lengthy distribution systems, undermines efficient energy use.

Urban spatial structure and urban functions

Urban spatial structure and urban functions affect energy use as they influence the demand for mobility of urban dwellers. Mixed land use (residential and industrial, or residential and commercial, etc.) results in different energy use than does segregated land use. Urban zoning policies and industrial relocation from city centres to peri-urban areas in Asian cities significantly influence travel demand and energy use. Similarly, the energy use patterns in commercial cities are different from those in industrial cities.

Nature of transportation system

Transportation systems are very important as mobility is a key aspect of urban life. Historically, cities have moved from non-motorised to rail-based and then gradually to automobile-dominated transportation. The energy implications of transport depend on a number of factors: the availability of a built-in infrastructure for rail and road networks, mass transportation systems, the share of public and private travel demand, the role of alternative fuel vehicles, and the share of small-occupancy vehicles such as two-wheelers (used in India, China, Thailand, Indonesia, etc.) among others. Increasingly, cars dominate transportation due to rising incomes, increased social status through car ownership, and inefficient public transportation systems. This trend threatens energy security and results in increased local air pollution and GHG emission.

Income level and lifestyle

Since cities are engines of economic growth, it is often difficult for policy makers, especially those in rapidly industrialising cities, to constrain increasing energy use. Past research on the relationship between income and energy use at the national scale has clearly demonstrated that there is a strong correlation between per capita commercial energy consumption and gross domestic product. It is generally accepted that per capita energy use increases with income (though from some point it may actually decrease). High income is associated with better lifestyles and more consumption, which affect energy use in and beyond the borders of cities. Consumption-oriented lifestyles are associated with the greater utilisation of natural resources as well as with the greater energy use needed to produce these materials (and hence, with more GHG emissions). This relationship is important in the sustainability debate as global sustainability seeks to provide welfare and equity along all scales (spatial and temporal).

Energy efficiencies of key technologies

Energy efficiency is defined as the energy needed to produce a unit of service. Since demand is for services, not for energy, energy efficiency can directly improve or worsen energy use. Technologies whose efficiency dominates cities include automobile fuel and household and commercial appliances used for lighting, heating, cooling, and cooking. Improving of energy efficiency is a function both of the technology itself and of patterns of utilisation.

Industrial processes

The energy efficiency of production processes and boilers (industrial energy use) affects energy use, too, but it is not discussed in detail in this paper. Cities in Asia are rapidly relocating their primary industries either to peri-urban areas or to areas outside city borders, leaving cities increasingly dominated by the tertiary sector. Small and medium-sized enterprises (SMEs), however, remain prevalent in many Asian cities and pose a big challenge for policy makers. The role of local policy makers in this area is limited in South and Southeast Asia.

Building technologies and floor space use

Building-related technologies such as air conditioners, district heating and cooling systems, insulation systems and other building energy management systems have significant effect on energy use. Services such as lighting and space heating/cooling depend directly on floor space, whose use depends on a number of factors such as real estate market prices, business culture and socio-cultural factors.

Waste management

Big cities, especially mega-cities, are producing an increasing volume of solid waste, a fact making its management increasingly complex. Policy makers resort to either incinerators or landfills although both options emit GHG. Incineration uses energy and emits CO_2, while landfills emit methane, whose effect on GHG is 22 times higher than that of CO_2.

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 energy for energy than do cities with temperate climates. Some cities in Asia, such as Tokyo and Seoul, also suffer from urban heat island (this is a phenomenon in which the core urban temperature is a few degrees higher than that in the suburbs; this creates hot-spots in cities), where concentrated urban energy use is a major factors, responsible for exacerbating urban warming. This sometimes triggers a vicious cycle in summer, where increasing the use of cooling devices contributes towards increasing the heat island effect. Heat islands 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 The Income-Energy-Environment Conundrum

As cities are dynamic systems, it is important to understand trends in energy use and emissions 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, in correspondence with increasing levels of economic development, the following three levels of urban environmental problems: (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). It does not say anything about the evolution of these issues over time or with income growth. Bai and Imura (2001) hypothesise and demonstrate that selected cities have proceeded through stages: (1) poverty, (2) industrial pollution (3) consumption and (4) sustainable eco-city. Their model provides a picture of how selected highly industrialised cities evolved in the past, but a careful examination of factors other than income which might have contributed to this environmental transition is needed, particularly in the case of less highly industrialised 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, 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 among 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 support 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.

Peter Marcotullio (see Marcotullio *et al.*, 2003; Marcotullio, 2003; and Marcotullio and Lee, 2003) and Gordon McGranahan (see McGranahan *et al.*, 2001) provide alternatives to the evolutionary stage model. McGranahan *et al.* (2001) presents a simple 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. Marcotullio presents a model of urban environmental transition in which urban environmental issues are compressed over time and space with a shift in scale (local to global), timing (immediate to delayed), impact, and character (health-threatening to ecosystem-threatening) rather than with the simple formation of stages.

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. Boulder: University Press of Colorado.*

The income growth of Asian cities has been tremendous and had usually exceeded their national averages (Table 2.1 and 2.2). The Environmental Kuznet Curve (EKC) theory suggests that a rise in income leads to an increase of environmental adversity but, that after some point, it results in a decrease in environmental adversity; the result is an inverted U-shaped curve. Many studies conducted in the past have tested the validity of the EKC under different sets of environmental adversities and concluded it is reasonably valid for industrial air pollution, particularly SO_2 emissions. The EKC may be valid at the national level, but its applicability to cities is questionable. First, cities do not have well-defined boundaries and their interactions with other places are both very intense and poorly documented. Obtaining reliable data to check the validity of the EKC and setting boundaries for the city are significant problems. Second, there is a growing trend to relocate major industries away from densely populated areas; what remains in a city are commercial activities, service industries and other activities that put a greater emphasis on mobility, infrastructure development and households than industrial activities do. Major sources of air pollution in many cities include urban transportation and industries, which are in turn associated with low-income groups and urban poverty. In sum, establishing an EKC relationship between income and environmental adversity at the urban level—if it is indeed valid—is difficult.

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

The urban environmental problems that result 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 where policies are not well formulated to address problems. Thus, cities with similar income levels vary widely in terms of the environmental problems they experience: a well-managed city with a medium or low income may be better off than a richer city with poor urban environmental management. The lesson is that good policies and good urban environmental governance can perform miracles irrespective of economic levels.

In performing the dual tasks of economic development and environmental protection, cities tend to give policy priority to immediate, local issues and to regard issues such as global warming as long-term, distant threats when, in fact, municipal policies that reduce energy consumption bring multiple benefits to a community. They help solve the problems of air pollution and traffic congestion and tackle global problems such as the emission of GHG, in particular CO_2. There are many technological and non-technological management options through which the environmental implications of energy use can be minimised without seriously compromising economic growth. For example, the disassociation of environmental problems and economic growth in Japan in the 1970s and 1980s was largely the result of implementing environmental regulations with end-of-pipe and process enhancements (Sawa, 1997). Each city has to address its own distinctive features; the role of policy makers is to explore alternative policies and implement them successfully.

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

Energy management has traditionally not been a priority for municipal policy makers as 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 either from energy availability or from the impact of energy use on the environment, namely air pollution. In the case of energy management, there is often no policy framework. A comprehensive policy framework for urban environmental management is also lacking in general, and environmental policy response is often fragmented into different sectors and actors without proper coordination.

The need to empower local governments to manage their cities is well understood by national governments and processes for empowering local governments have been underway for several decades. Still, the major role of municipal governments in Asia is often limited to solid waste[1]. In many countries, especially those in South Asia and Southeast Asia, water/wastewater and air pollution management is the responsibility of the national government. Economically more developed Northeast Asia is one step ahead: local governments assume authority for more aspects of governance. In China, for example, the decentralisation of environmental affairs is well institutionalised, and environmental protection bureau in each city are responsible for environmental affairs. According to the framework established by the State Environmental Protection Administration (SEPA), these bureaus work under municipal governments in coordination with the Provincial Environmental Protection Bureau. Four cities, Beijing, Shanghai, Chongqing and Tianjin, have provincial authority and work directly with SEPA. In India, city-level environmental bureau do not exist. The role of large municipal governments such as Mumbai is limited to solid waste and, to some extent, wastewater management. Mumbai exercises some authority over air pollution but only through traffic management. The Central Pollution Control Board[2] of India exercises much pollution control through state pollution control boards, while most industrial pollution control falls under the responsibility of state industrial development corporations. Like the four aforementioned cities in China, the capital of India, New Delhi, is categorised as a state and the Delhi Pollution Control Board exercises the same authority as do the other states of India. In Thailand, the Bangkok Metropolitan Administration exercises limited control over air pollution management such as management of traffic, managing one air quality monitoring station, and checking of in-use vehicle emission 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.

Close cooperation among municipal governments and national agencies is mandatory if a sound policy framework and policy implementation mechanisms are to be developed. In addition to the government, other stakeholders in policy making and policy implementation process must be

1. In some cities, waste water management falls under the municipal government (for example in India). A city's role depends on its size and on its economic and/or political status.

2. These are semi-autonomous bodies with representation by different stakeholders. The Ministry of Forests and Environment is the line ministry.

involved. A top-down process alone may not work. Typically, the private sector and civic society (NGOs, the 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. The involvement of stakeholder in centrally planned countries such as China and Vietnam is low and the government is very strong. In Northeast Asia, in general, despite strong governments, some consideration to stakeholders, especially corporate stakeholders, is given. Increasingly, policy makers are realising the need to involve different stakeholders in policy making and implementation processes.

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

Choices of policy instruments, which include regulatory, economic and institutional arrangements, are important in implementing energy-environment management policies. Regulatory instruments (command-and-control) prevailed in the past and are still dominant today. Several cities have tried using economic instruments including pricing regulations, incentives, and taxes and subsidies applicable to various sectors to manage specific problems. Singapore's use of economic instruments to control vehicle ownership and use has caught the attention of the world. Some city-level efforts to promote voluntary mechanisms such as appliance labelling and information disclosure on the energy performance of buildings are being made in Tokyo.

A comprehensive urban energy policy framework seeks a balanced consideration of short- 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 direct energy use and CO_2 emissions as well as for indirect energy use and CO_2 emissions embedded in electricity use in respective sectors. Cities, especially mega-cities, are centres for consumerism, but the production of the goods and services demanded usually takes place outside a city's boundaries. It is there that CO_2 is emitted. Since a city's emission footprint extends beyond its boundaries, it should be responsible for these emissions. In order to obtain a clear picture of the responsibilities of cities, accounting for indirect energy use is necessary. Policies aiming at indirect emissions are at present unimaginable for most municipal policy makers in Asia. In Japanese cities, however, such policies are being implemented through the government 's general policy to create a "sound material cycle society." Although explicit policies at the local level are not expected at this time, it is important to raise the awareness of policy makers about this issue.

The causal framework for energy-environment management is (1) identifying the options available in the short-term; (2) intervening in the appropriate determinants; (3) finding the right ways to intervene (4) finding appropriate tools for intervention and creating consensus; and (5) carrying out monitoring and providing feedback.

<table>
<tr><th>Section in which to intervene (excluding industry</th><th>Physical indicators</th><th>Ways to intervene</th><th>Tools with which to intervene</th><th>Future scenario</th><th>Consensus of stakeholders</th></tr>
<tr><td>Urban planning</td><td>Population density
Urban functions
Urban land use
Building</td><td rowspan="5">1. Technology options
2. Management options

(Based on the nature of each determinant)</td><td rowspan="5">1. Economic tools
2. Regulatory tools
3. Institutional arrangements
4. Voluntary mechanisms

(Based on an evaluation of the number of tools applicable to each sector, determinant or way)</td><td rowspan="5">1. How might such determinants change in the future?
2. What kind of technologies and management principles might evolve in the future?</td><td rowspan="5">1. Who are the stakeholders?

(National government, local government, private sector, civil society)

2. What kind of combinations of determinants, ways and tools would be most suitable given the roles of various stakeholders?</td></tr>
<tr><td>Urban transport</td><td>Travel activity
Travel modes
Energy intensity
Fuel quality and choice</td></tr>
<tr><td>Households</td><td>Number of households
Floor space use
Appliance utilisation
Energy efficiencies
Fuel choice
Building</td></tr>
<tr><td>Business</td><td>Office floor space
Appliance utilisation
Energy efficiencies
Fuel choices
Buildings</td></tr>
<tr><td>Waste</td><td>Waste volume
Incineration
Landfill
Energy recovery</td></tr>
</table>

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

3 Factors Driving Energy Consumption and Emission

3.1 Introduction

Earlier sections in this report outlined some of the physical determinants of energy use and emissions in a comprehensive policy framework. These were mostly sectoral in nature. At the macro-level, the major driving forces behind energy consumption and CO_2 emissions in rapidly industrialising cities are related to lifestyles and to behavioural and socio-economic aspects of urban life. A sound understanding of these factors is essential for proactive/anticipatory as well as end-of-pipe/curative policies. In rapidly industrialising cities such as Tokyo in the 1970s and 1980s, Seoul in the 1990s, and Beijing and Shanghai in last two decades, the behaviour of driving factors has changed drastically. Some of the driving factors are as follows:

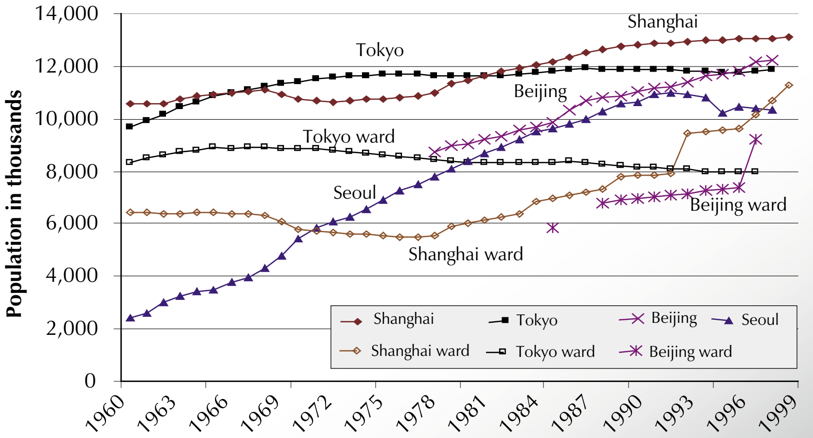
- urban demographic changes;
- patterns of urbanisation and land use;
- income growth;
- structure of economic activities;
- lifestyle and social transformations;
- material dynamics and consumption patterns;
- climate and urban geography.

This section describes the salient features of the changes in these physical determinants that Tokyo, Seoul, Beijing and Shanghai have experienced in the last few decades. It also examines the driving factors in several sectors, namely residential, business, urban transport and waste.

3.2 Demographic Changes

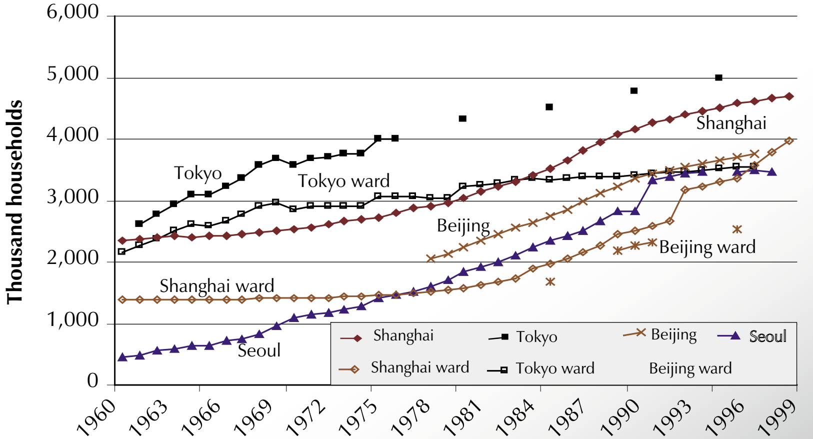
Urban demographic trends, especially day and night-time populations and the size and number of households, affect the scale of energy use. Tokyo's population has stabilised since the early 1970s; in fact, the population of the 23 wards constituting downtown Tokyo is decreasing. Seoul experienced unprecedented population growth before 1990, but soon afterwards the population started decreasing. Beijing's and Shanghai's populations have been growing, especially since 1980, but less rapidly than other similar cities in Southeast Asia. Much of this growth is attributable to migrant populations, as the one-child policy is strictly enforced in Chinese cities. Changes in the political boundaries of Beijing have often resulted in drastic population changes. The number of households is increasing in all four cities, primarily due to the rapidly decreasing size of the average household. The population of Shanghai is greater than that of Tokyo, but has fewer households. The number of households could be a more important determinant of energy use than population.

Another important aspect of demographic change is the difference in the day and nighttiime populations. Tokyo attracts a significant number of commuters, who are not counted in the resident population. One-third of the total workforce commutes from surrounding cities and prefectures utilising its well-developed surface rail and subways. The ratio of the daytime to nighttime population increased from 1.15 in 1975 to 1.25 in 1999 in Tokyo and stabilised only after 1990. In the 23 wards the ratio reaches as high as 1.41 (TMG, 2000). In contrast, the ratio in Seoul is 1.04 and is insignificant in Beijing and Shanghai (Yoon and Araki, 2002).



Source: Internal database compiled from statistical yearbooks of cities

Figure 3.1 Population trends, in thousands



Source: Internal database compiled from statistical yearbooks of cities

Figure 3.2 Household populations, in thousands

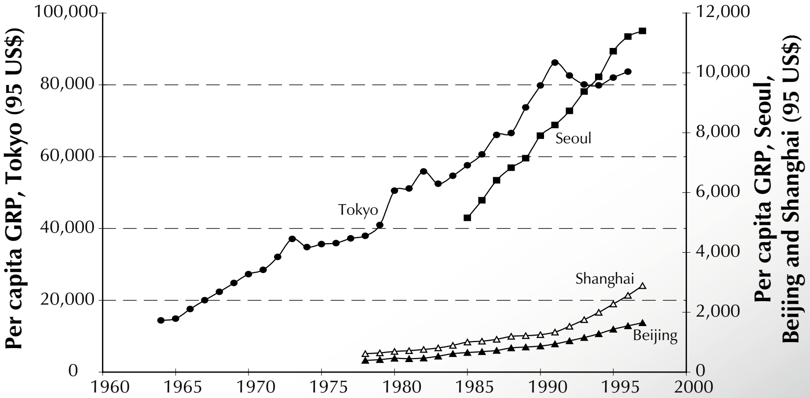
3.3 Patterns of Urbanisation and Land Use

Urban population density, the structure of urban functions (the concentration of certain type of activities), urban geography and land-use patterns (mixed land use vs. zoning) are important determinants of energy use and emission. For example, a compact city may have a lower per capita energy consumption due to its compact infrastructure and lower per capita building floor space, both traits which reduce energy use. This relationship may not always hold true, however, as a number of other factors affect energy use. In Japan, the per capita energy consumption in dense urban areas is lower than that in non-urban areas (Ichinose *et al.*, 1993). Developed countries exhibit a similar relationship. In contrast, developing countries such as China and Thailand report the opposite trend: city residents use more energy (Ichinose *et al.*, 1993). Since the income gap between urban and rural areas is small in developed countries, density has a clear influence on per capita energy use. In developing countries, in contrast, the effect of the huge income gap surpasses that of density for commercial energy uses (non-commercial uses are not considered in many studies) and the effect of density is often not seen. In later sections, we will show that the energy and CO_2 performances (in terms of a cumulative index of economy and per capita energy/emission) of Tokyo and Seoul is better than those of Beijing and Shanghai partly because of the density effect. This density effect is especially significant in the central business districts of cities. Because large cities in China such as Beijing have a combination of urban and rural settlements (the definition of a city is based on political boundaries), it is difficult to generalise the implication of urban density for the political definition of a city.

The traditional urban structure of Tokyo is core central. In the long run, it plans to adopt a multi-core urban form that might have significant implications for energy use. It is also characterised by mixed land use, a system which is usually better for energy. In Beijing and Shanghai, urban zoning for industrial and other activities has become common practice in the last few decades. The exact implications of relocating industries from residential areas to designated industrial zones on energy use are difficult to quantify, but such measures have resulted in reductions in 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; and beyond the fifth ring road are suburban and rural areas. These suburban areas are expected to grow substantially as many new housing complexes are being constructed in and around the fifth ring road. Beijing is already developing 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 the provision of infrastructure remains energy inefficient. In the Seoul metropolitan area, the most recent urban expansions have taken place around Koyang, Paju, Kimpo, Inchon, Ansan, Sihwa, Sungnam, Anyang and Suwon (Yoon and Lee, 2002).

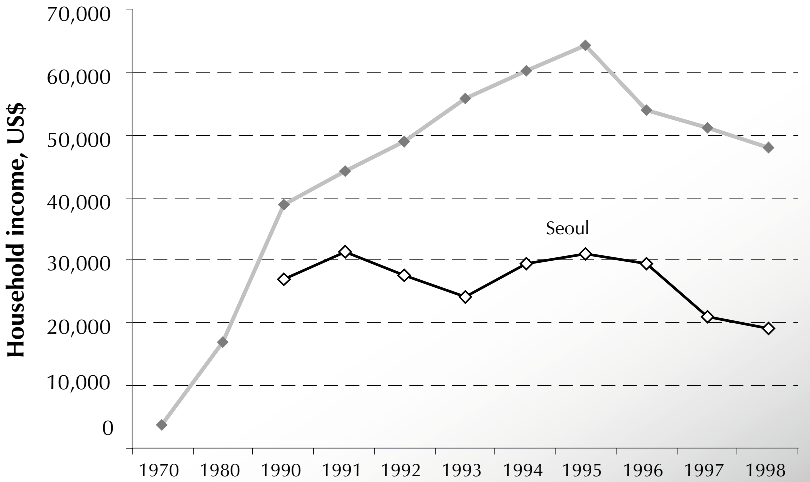
3.4 Income Growth, and Lifestyle Changes

Rapid industrialisation in Northeast Asian cities has resulted in high economic growth. Tokyo experienced sustained economic growth from the early 1960s until it went into recession in the early 1990s. The financial collapse of South Korea in 1997 had obvious implications for Seoul, but Seoul has since regained growth rates. Double-digit growth in Beijing and Shanghai has continued since 1990. Economic growth in cities has led to an increase in disposable income, which in term affects the lifestyles of residents: they can afford to consume more material goods, follow fashions and pursue leisure activities and thus they use more energy. Upsurges in the use of electric appliances in households and businesses are described in the next section. Figure 3.3 shows trends in per capita gross regional/city product (GRP) in the four cities over the last few decades. Figure 3.4 shows the household income for Tokyo and Seoul.



Source: Internal database compiled from statistical yearbooks

Figure 3.3 Trends in per capita gross regional product for four cities

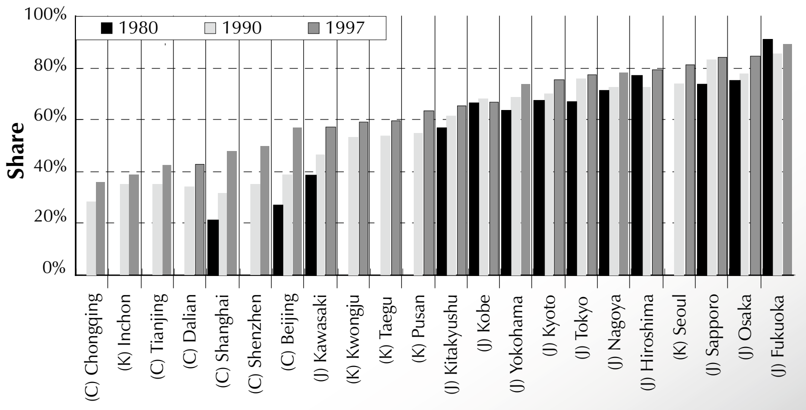


Source: Internal database compiled from statistical yearbooks

Figure 3.4 Net disposable income in Tokyo and Seoul

3.5 Structure of Economic Activities

A gradual shift from primary industries to tertiary and commercial activities has been observed in cities. Growing populations, high population density, noise and environmental problems related to primary industries are forcing industries to relocate from city centres to city outskirts and peri-urban areas. At the same time tertiary sector activities are becoming more prevalent in cities and the value added from the tertiary sector has increased consistently. The share of the tertiary sector in the total value added has risen in Tokyo from 67% in 1980 to 78% in 1997. Similar trends in other cities are shown in Figure 3.5. While Tokyo and Seoul are commercial cities, Beijing and Shanghai are industrial. As a result, the industrial sector is expected to play a major role in any measures implemented to reduce energy use and emissions in Beijing and Shanghai but not in Tokyo or Seoul.



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.

Figure 3.5 Share of value added by the tertiary sector in selected cities

3.6 Household and Business Sectors

A number of factors, particularly the scale and intensity of cooking, lighting, use of electrical appliances and heating/cooling devices, influence energy use in a household. Lifestyles and technology are key issues that any measures to reduce energy use by households need to address. Building floor space per household, which is one a major determinant, has not increased significantly in Tokyo in the last two decades: the average ranged from 50 to 60 km^2 per household from 1980 to 2000. Increases in floor space per household in the other three cites have also been nominal. However, this rate has been drastically increasing in rural areas of Beijing and Shanghai (Matsumoto *et al.*, 2003). The use and diffusion rate of household appliance differs from city to city. Tokyo is saturated in terms of key household appliances[3], which Beijing and Shanghai are rapidly catching up with Seoul and Tokyo in the use and diffusion of appliances[4]. The automation of offices and the increasing use of electrical and electronic equipment, especially computers, is one of the major determinants of energy use in Tokyo. In some of the four cities, central heating systems based on boilers are common. The fuel type and efficiency and nature of the boilers used in central heating and cooling systems are important factors in the energy use of household and business sectors in Seoul, Beijing and Shanghai. In Tokyo central heating systems are not commonly used. The type of fuel used varies from city to city. Seoul relies on oil-based central heating and cooling systems, while coal is still a major source for residential boilers in Beijing and Shanghai. In recent years, there have been rapid changes in the fuel structure in households. Many have switched from coal to oil or oil to natural gas. In Tokyo, the energy efficiency of key appliances has reached from saturation; further improvement will be difficult. Another factor which influences energy use in households and in the commercial sector is building insulation. In Seoul, Beijing, and Shanghai, building insulation, especially that in residential houses, is much poorer than it is in Europe and North America and is responsible for major energy losses. Table 3.1 compares some of the technological efficiencies of Shanghai with those of OECD countries.

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.

4 The diffusion rate of refrigerators in urban Beijing and Shanghai was 100% in 2000. Air conditioner diffusion in urban Beijing and Shanghai in 2000 was 60% and 80%, respectively. The diffusion rates for TVs and microwavres is over 100% in all four cities.

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

	Unit	Shanghai	OECD countries
Coal-based electricity production	(GJ el/GJ fuel)	0.38	0.40–0.44
Primary steel production	GJ/tonne	20–25	18–20
Oil refining	GJ/GJ	0.03	0.03–0.07
Coal-fired industrial boilers 410 t 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

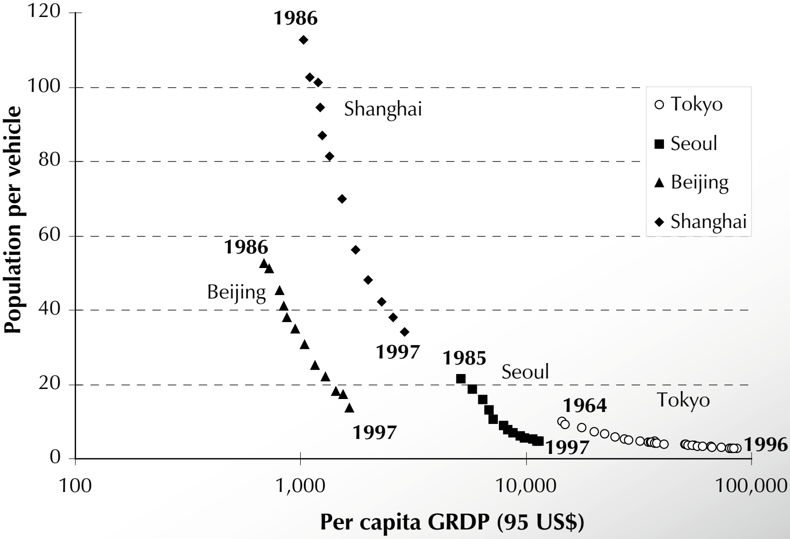
Source: Dolf Gielen and Chen Changhong (2001). The CO_2 emission reduction benefits of Chinese energy policies and environmental policies: A case study for Shanghai, period 1995-2020, Ecological Economics vol. 39 (2001) pp. 257-270.

3.7 Urban Transportation

3.7.1 Speed and Scale of Motorisation

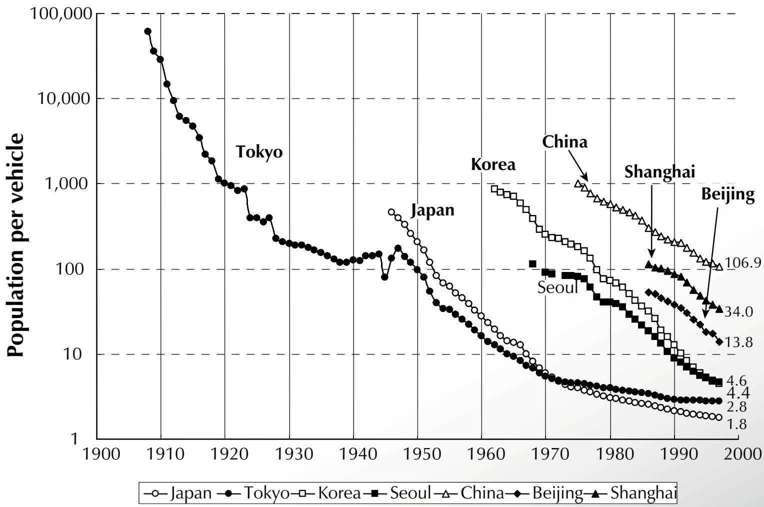
In the transport sector, the growing number of private cars is a key determinant of energy use and CO_2 emissions. Motorisation in Tokyo started in the early 1950s, and vehicle ownership rose rapidly in the 1970s. Since then, ownership rates have not increased rapidly. In fact, growth in ownership has stagnated in Tokyo ward areas due to saturation and in wider Tokyo has been nominal since the recession of the Japanese economy in the late 1980s. In Seoul, rapid motorisation began 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 motorisation but is rapidly caching up, and the gap that existed between Beijing and Shanghai has narrowed in recent years. Seoul reached a higher level of motorisation at a lower income stage (per capita economic output) than Tokyo did. The case of Beijing is serious: while its income is constantly rising, its inability to shift to rail-based mass transportation might put it into a situation like that Bangkok faced in the mid-1990s. Shanghai seems to be following Seoul in its per capita vehicle trend. Tokyo, Seoul and Beijing seem to have a 20-year time difference for the same level of motorisation; Tokyo in the 1950s, Seoul in the 1970s, and Beijing in the 1990s have the same level of motorisation (people per passenger vehicle), as shown in Figure 3.6. It also highlights the differences in patterns of vehicle ownership in cities of different countries in contrast with those at the national level. For example, the vehicle ownership rate (per person) in Beijing and Shanghai is much higher than China national average, while Seoul rate is almost the same as Korea. Japan national average trailed behind Tokyo until 1970, after which Tokyo rate of vehicle ownership dropped below the national average (see Figure 3.7). Interestingly, the point (around 4.5 people per vehicle) at which the gap between city and national vehicle ownership is zero seems to coincide in both Japan and Korea. It will be interesting to see whether this is true in other cities and if there are any patterns.

Trends in the use of private vehicles (cars) and public vehicles (buses and trucks) are major determinants of energy use and emissions from



Source: Internal database compiled from statistical yearbooks

Figure 3.6 Speed of motorisation in Tokyo, Seoul, Beijing and Shanghai



Source: Internal database compiled from statistical yearbooks

Figure 3.7 **Scale of motorisation: population per vehicle in Tokyo, Seoul, Beijing and Shanghai**

urban transportation. Figure 3.8 shows these trends. Cars, in particular, are significant because of their large number and their strong correlation with income growth. Growth in the number of cars in the dense ward areas of Tokyo has stagnated, while the number of cars in the Tokyo metropolitan area is moderately increasing. The absolute number and the growth in the number of cars in Beijing and Shanghai was, in the past, much less than it was in Tokyo. Beijing has always had more cars than Shanghai and since 1990 the number of vehicles in Beijing has increased rapidly. The numbers of buses and trucks are falling in Tokyo and more rapidly in its ward areas, probably due to the stagnation of urban populations in ward areas and the greater reliance on surface railways for long-distance commuting and subways for passenger transportation. In Seoul, however, the numbers of buses and trucks continue to increase (partly due to its having relatively small populations of long-distance commuters and few subway stops). The numbers of buses and trucks continue to increase in Beijing and Shanghai; in particular, the number of light-duty trucks in Beijing is increasing so rapidly that policy makers concerned about the environment are expected

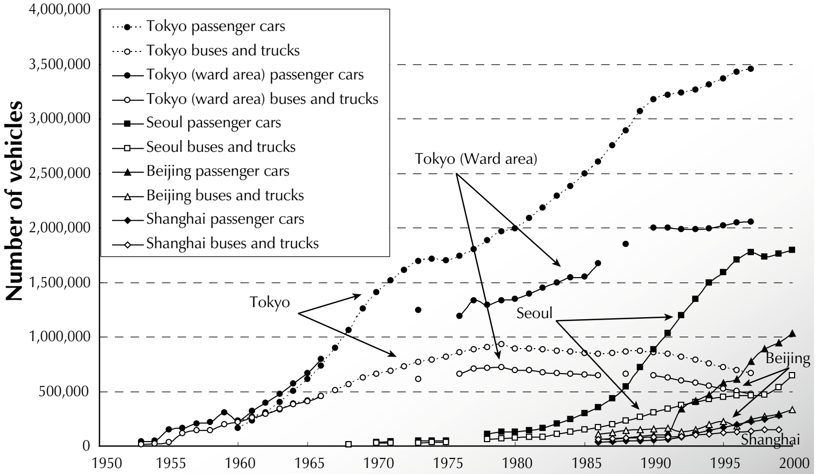


Figure 3.8 Trends in the number of cars, buses and trucks in Tokyo, Seoul, Beijing and Shanghai

to apply stringent controls soon. The growth in the number of taxis in Beijing and Shanghai is tremendous: numbers increased from 9,000 to 653,000 in Beijing and from 500 to 224,000 in Shanghai from 1980 to 1997[5].

3.7.2 Road and Railroad Infrastructure

Roads play an important role in any urban transportation system: an adequate network is essential to guarantee the smooth flow of traffic. Comparisons of road systems show that Tokyo has the largest per capita road area, 12 m^2. Figure 3.9 compares the per capita road area and the vehicles population per km of road length in the four cities. Beijing and Shanghai have significantly lower per capita road areas as well as the highest numbers of vehicle per km of road. The infrastructure needed to accommodate even such a moderate level of vehicle ownership is inadequate in Beijing. From 1979 to 1999, the road length in Beijing nearly doubled, while the number of vehicles increased seventeen-fold (He, 2004). Road area in Shanghai rapidly increased after 1990. The Tokyo metropolitan region has a well-developed and well-connected subway

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

and surface rail system of 2,143 km. These rail networks were constructed well before motorisation had begun and thus did not face fierce competition from motorisation. The current state of the subway network is shown in Table 3.2. A closer look at the subway traffic and infrastructure reveals the following points:

- Before 1990, the rate of subway expansion (the length of subway lines) and rate of increase in subway passengers (the 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.

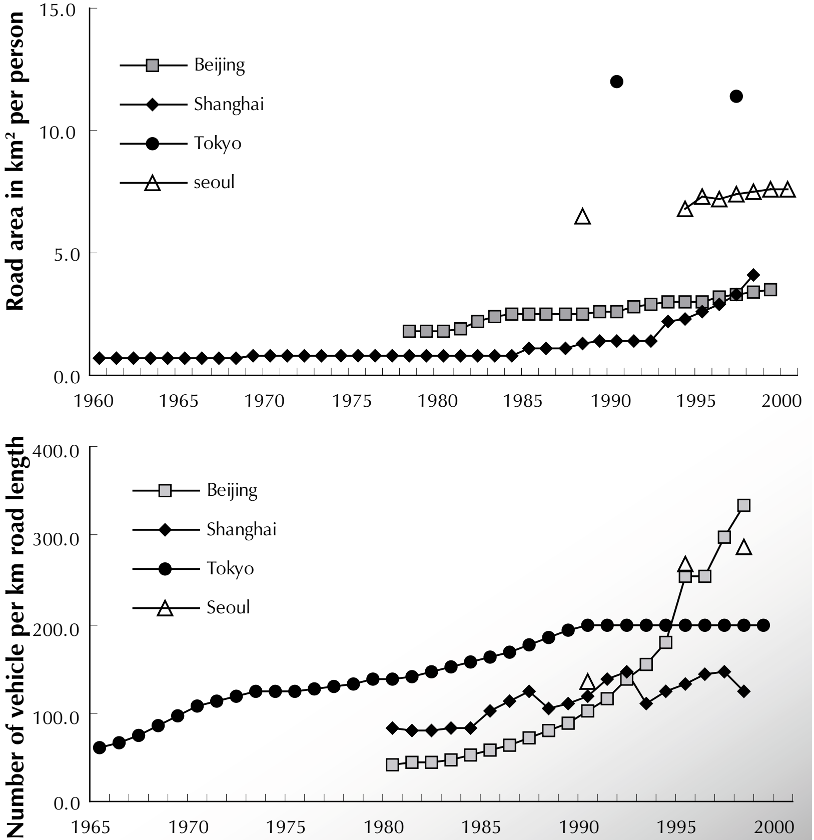


Figure 3.9 Comparison of road infrastructure

- The length of subway lines in Seoul is almost equal to that in 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 in Beijing stalled from the mid 1980s to the early 1990s although the utilisation rate of the existing subway increased during this period. The stalling of both the construction of additional lines and the expansion of existing lines gave rise to rapid motorisation. Since the late 1990s, urban railway construction has been progressing; Beijing hopes to fulfil its goal of 254 km by the 2008 Olympic Games. From the current three lines, Beijing plans to construct ten more lines by 2008.

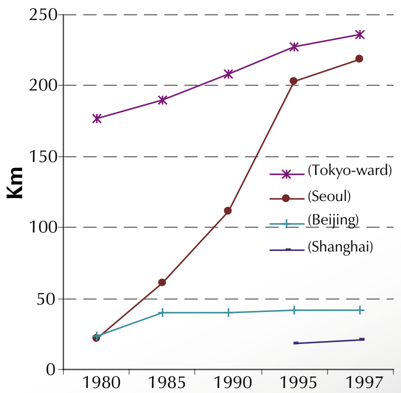
Table 3.2 Urban railway information in selected cities (2000)

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

Source: He (2004).

3.7.3 Transport Mode

Figure 3.11 shows the share of various modes of travel used in cities (in passenger times). The figure shows that the structure of travel modes in Tokyo and Seoul (except buses and subways in Seoul) has not changed in recent decades, whereas in Beijing and Shanghai it has. In contrast to the other three cities, travel by subway and taxi is very high in Tokyo and by private cars very low. In Seoul, the expansion of



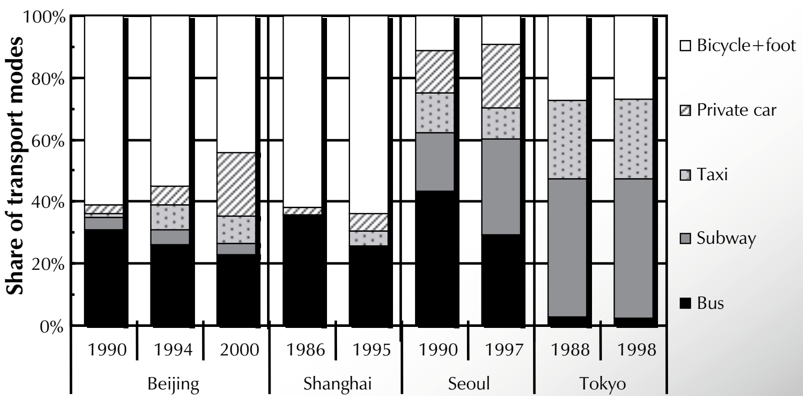
Source: Internal database compiled from statistical yearbooks and other sources

Figure 3.10
Subway lengths in selected cities

the subway has considerably reduced travel by bus. Travel by non-motorised modes (walking and bicycles) and by buses is rapidly decreasing in Beijing, while 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; travel by taxis has also increased significantly (He, 2004). Shanghai has also witnessed a rapid increase in private car travel despite stringent control; the increase, however, is less than it is in Beijing.

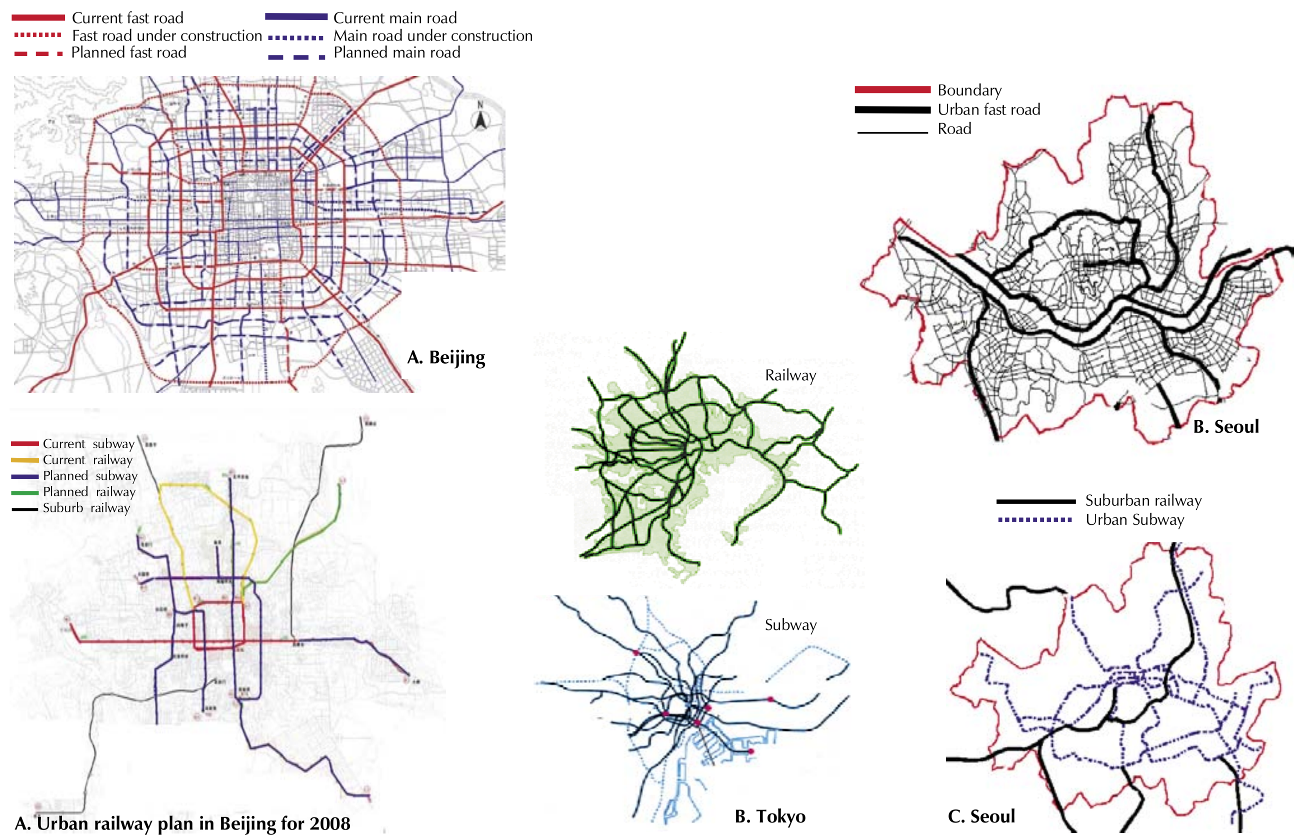
- In Tokyo, rail accounts for about 45% of total passenger transportation (1998).
- In Seoul, roads account for about 70% of passenger transportation (1997).
- In Beijing and Shanghai, roads account for over 95% of passenger transportation, including non-motorised modes (2000).
- In Beijing and Shanghai,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

While there is an increase in the volume of total travel, the share of travel by buses has decreased in Beijing, as demonstrated in Figure 3.11. The actual number of buses, however, is increasing. From 1990 to 1998, the number of buses increased by 87%, but passenger traffic increased by only 22% (He, 2004). This shows that the comfort of bus travel is much greater



Source: He (2004)

Figure 3.11 Variations in transport modes in four cities



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

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

than it was in the past, but at the same time, it highlights the inability of the public transport to attract passengers due to low service quality (lack of punctuality, distance of bus stations, etc.). The drastic increase in taxi travel suggests that a considerable number of passengers are looking for better service from and greater efficiency in public transportation.

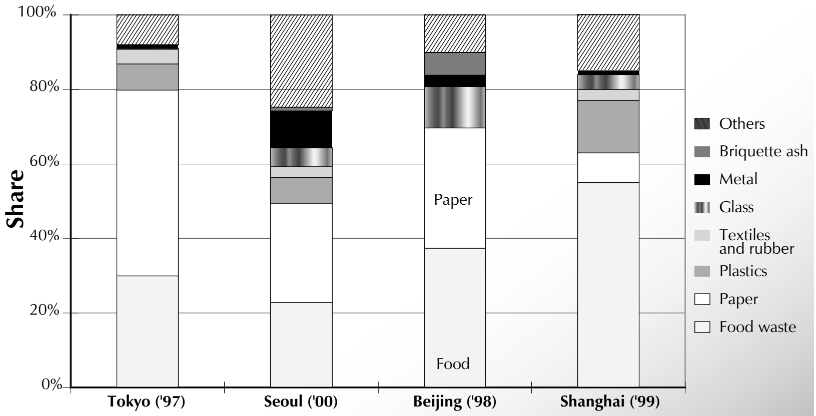
3.8 Waste Management[6]

Due to the increasing volume of waste, municipal waste management is becoming an ever more serious challenge for urban policy makers. Whether waste is recycled or incinerated, it requires energy, and the resulting emissions are not insignificant. That incineration and landfill usage have various advantages and disadvantages from a waste management perspective is a given; less obvious is the fact that each method has a different effect on the type and amount of GHG emissions. The disposal of waste in landfills results in the production of methane, a gas 22 times more harmful than CO_2 in terms of its contribution to greenhouse effect. Incinerators, in contrast, use energy to burn waste and produce CO_2 from that energy use as well as from the waste that is burnt. Choosing a method is not motivated solely by a consideration of GHG emissions: incinerators, unlike landfills, allow for energy or heat recovery. If this heat or energy is used to produce power, $CO_{2,}$ which otherwise would have been released into the atmosphere and thereby gone to waste, can be recycled.

The composition and volume of municipal solid waste (MSW) have a significant effect on the method of treatment and therefore on GHG emission. 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. The volume has been decreasing in Tokyo since 1989 and in Seoul from 1992[7], while it is rapidly increasing in Beijing and Shanghai. Figure 3.13 shows the share of various types of waste treatment in the four cities.

6 Based on a report written by Dr. Eui Young Yoon for the project. See Yoon and Jo (2003a) and Yoon and Jo (2003b).

7 Data on Seoul shows that there was a drastic reduction in the volume of waste in 1992. The huge data discrepancy was due to the fact that until 1991 data was based on the volume collected by garbage trucks, whereas after 1992, it was based on weight. Since 1992, MSW has continued to decrease.

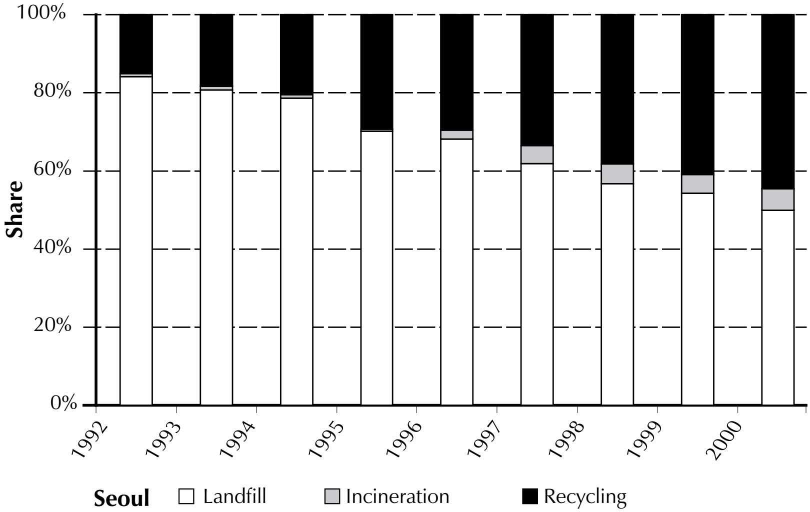


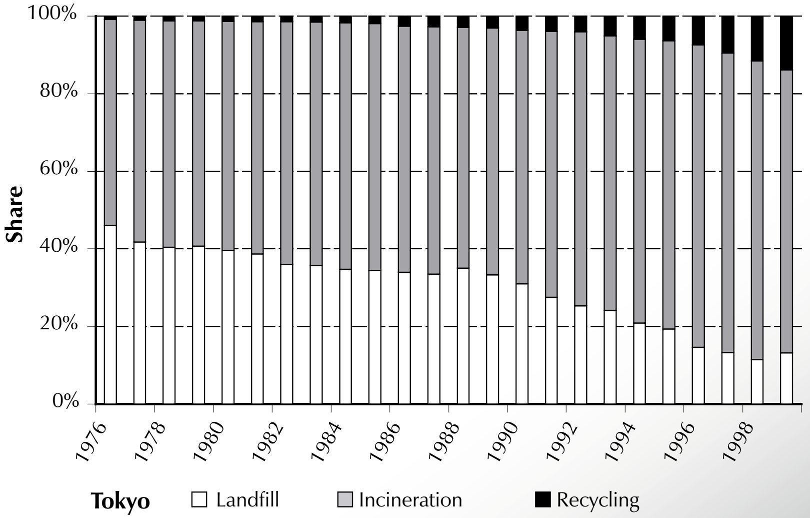
Source: Internal database compiled from city statistics

Figure 3.13 Waste composition in cities

The proportions of waste recycled (after separation), buried in landfills and incinerated are important from the standpoint of energy and emission. Incineration has increased in Tokyo over time; today over 85% of waste is incinerated in 18 incinerators. In Seoul, most waste is placed in landfills. As of 1999, Beijing had six landfill sites, two composting facilities and one incineration facility. Most of its waste goes to landfills. In Shanghai, there are only two landfill sites. Little attention is given to waste in Beijing or Shanghai although the current rates of economic growth and waste generation suggest that these cities will face serious waste problems soon.

Source reduction is the most effective method for reducing GHG emissions (ICLEI, 1999). Table 3.3 shows that recycling is the next best option, while using landfills and incineration (without heat recovery) produces more GHG.





Source: Internal database compiled from city statistics

Figure 3.14 Method of treatment of municipal solid waste in Seoul (top) and Tokyo (bottom)

Table 3.3 Net GHG emission from source reduction and municipal solid waste management options (Emission counted from a waste generation reference point in MTCE/tonne)

Material	Source reduction	Recycling	Composting	Combustion	Landfill
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). GHG emission from the management of selected materials in municipal solid waste. P. Es-12.

3.9 Climatic Factor

Lastly, one of the most important factors in determining energy use in and CO_2 emissions from each city is the prevailing climate. Heating and cooling services consume a major share of energy. In the winter, per capita heating energy needs in Beijing surpass those in Tokyo due to its cold climate but the hot and humid summers of Tokyo drastically increase energy consumption due to the use of air conditioners.

4 Energy Use and CO_2 Emissions in Cities and Future Challenges

4.1 Introduction

Although many analyses of energy use and CO_2 emissions on a national scale have been published, at the city scale there are very few such analysis. City-scale studies that cover urban sectors comprehensively are still in the stage of methodological development. Such analyses typically focus on urban energy CO_2 inventories of specific cities, most of which are outside of 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 and energy-related CO_2 emissions in four Asian cities; it includes past trends and future scenarios. The focus is on CO_2 emissions from energy use rather than on energy use itself. This section also quantifies and analyses the role of selected driving factors in both total and sectoral (transportation, household, and business) CO_2 emissions. As mentioned above, the role of indirect emissions could be significant in cities as cities consume large qualities of material goods. Although a consumption-oriented analysis would have been more powerful, because of the limitations of existing studies this report relies on the outcomes of the I-O, table-based approach. The aim of this section is to clarify the current picture and future scenario of CO_2 emissions. It also discusses future local environmental challenges for cities which will result because the driving factors behind CO_2 emissions will exacerbate air pollution and urban warming.

4.2 Challenges for Achieving Exactness and Comparing Data

Estimates of CO_2 emissions are usually seriously limited because of the difficulty in obtaining city-scale data. One reason for this limitation is that major policy decisions on energy-related issues are made at the national level. Another handicap is the difference between the political and functional boundaries of a city. To circumvent these problems, most studies focus on selected sectors, usually transportation and building. This section, in contrast, examines comprehensive city-scale CO_2 emissions for selected East Asian cities that have seen unprecedented industrialisation in the last few decades.

The lack of quantitative and qualitative information at the city level poses a problem even though the four cities discussed in this report have the best data available in the Asian context. Obstacles to a comparative analysis include the incomparability of information, problems in defining data, and differences in the methods used to organise information and data. Urban-scale analyses of Asian cities share the following generic problems:

- Some information is available for the political boundaries of a city, while other information is available at a different scale (such as for a metropolitan region).
- Some cities, especially those in China, use unique definitions of terms and methods of aggregation into sub-sectors and sectors which do not follow definitions used internationally by the International Energy Agency or other multilateral institutions.
- The classification of various driving forces behind energy use and emissions, such as the structure of energy balance tables, vehicle categories, indicators for travel demand, the structure of regional I-O tables, etc., differs from city to city.
- Since a city is politically defined, it may have both rural and urban populations inside it. This is especially the case for Beijing and Shanghai. The mixture renders it difficult to explain analyses.
- Although emission factors are crucial for calculating estimates of energy emission, many are either unavailable (thus compelling the use of IPCC factors) or are too aggregated for use.

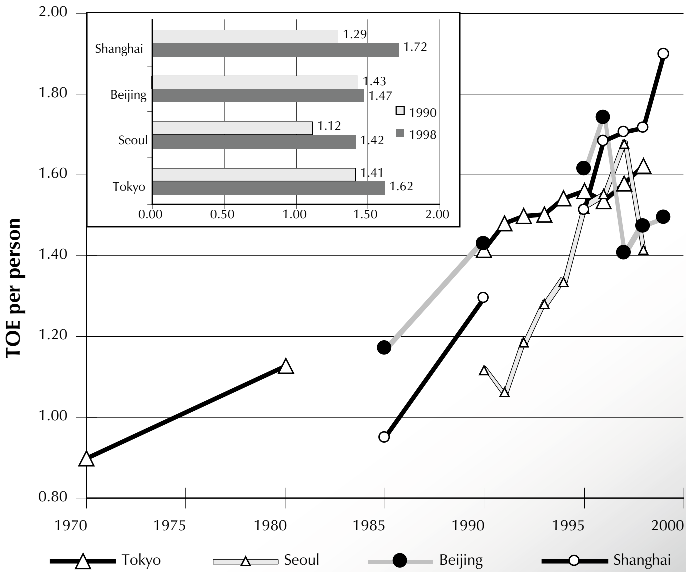
- Information gaps are so large in the majority of Asian cities that many ICLEI-sponsored estimates of energy and CO_2 emissions measure only corporate emissions from municipality services rather than emissions from the municipality as a whole.
- Comparing cities is a difficult task. The choice of indicators, such as total emissions vs. per capita emissions or emissions per capita vs. emissions per unit of economic activity, raises controversy as each indicator has different implications.
- The role of many Asian municipal governments within their political boundaries is undermined by the lack of management capacity and absence of proper decentralisation of governance. In addition, urban sprawl and expansion beyond original boundaries is common, but municipal governments do not govern those areas. As a result, analyses conducted within a city's political boundaries do not yield a complete picture of energy use or emissions. There are dual problems: in some cases municipal government governs a small section of the city (Dhaka, Bangladesh, is an example) while in others it covers areas which are too big and include surrounding rural (an example is Beijing).
- Since energy use and emission problems in one city are often interlinked with the problems of neighbouring cities, policies based on information from a single city often have limited impact.
- The political boundaries of cities often change, as is the case in Beijing. These changes make it difficult to compare information and data over time.

It is clear from this list of limitations that the scientific as well as the policy research community needs to create a consistent city-level information base and to make local policy makers aware of the need for sound analyses of options and measures. Despite these generic problems, the availability of information about Tokyo, Seoul, Beijing and Shanghai within their political boundaries is reasonably good. Even the two developing cities, Beijing and Shanghai, have a solid base because although they are cities they exercise the authority of a province. Most of the analysis in this report predates 1998 as that is the period for which data is readily available.

4.3 Energy Scenario in Cities

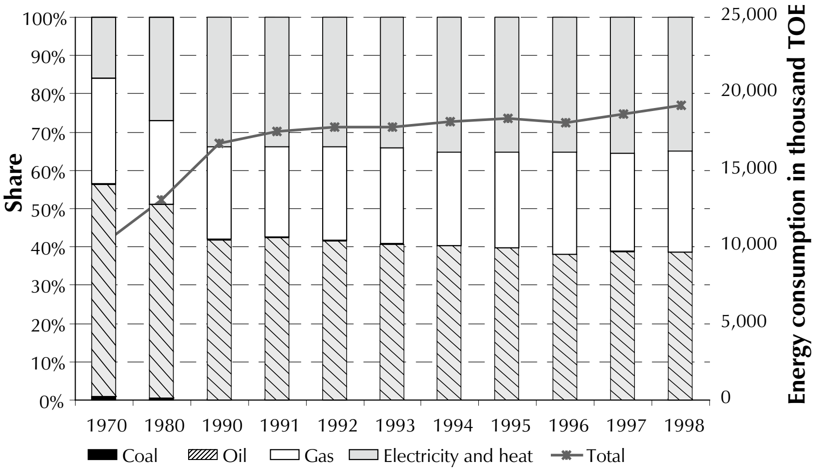
Energy consumption in Tokyo, Seoul, Beijing and Shanghai is, in general, increasing; exceptions are Beijing in 1997 and Seoul after the Asian financial crisis. Beijing seems to have followed the national trend, which is reported to be a decline in energy consumption and CO_2 emissions since 1996. This claim, however, is the subject of an ongoing controversy; it has often been suggested that the reduction in China is due to accounting problems. In Beijing, total energy consumption increased by 15% from 1998 to 2002 (Wu, 2004).

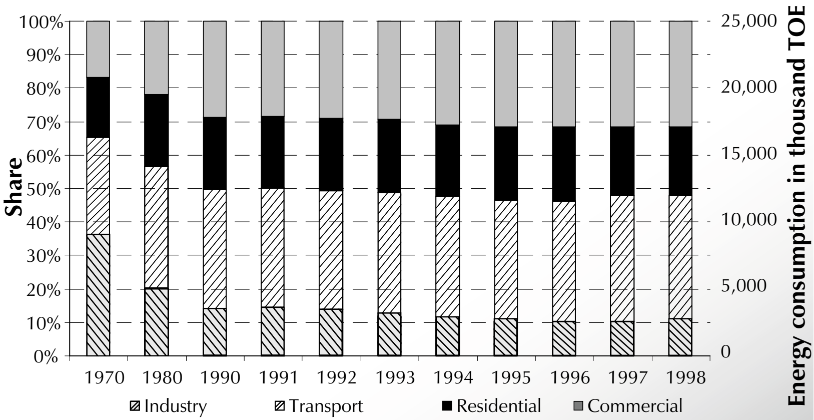
Figure 4.1 shows that the per capita energy consumption of all four cities is consistently increasing and that it has been converging towards a common point in recent years. This means that energy use in developing cities such as Beijing and Shanghai is rapidly approaching and even surpassing that in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



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

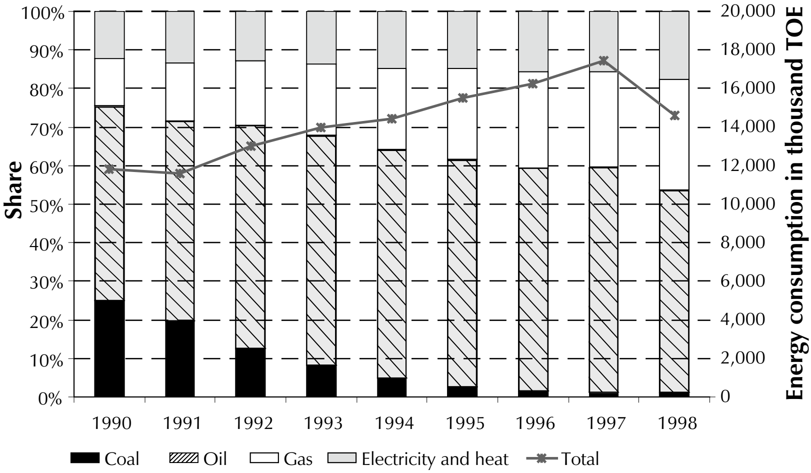
Figure 4.1 Per capita energy consumption

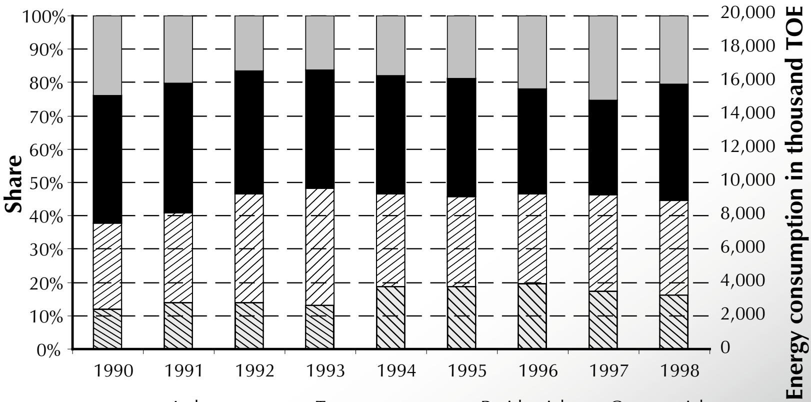




Source: Internal database compiled from energy statistics of cities

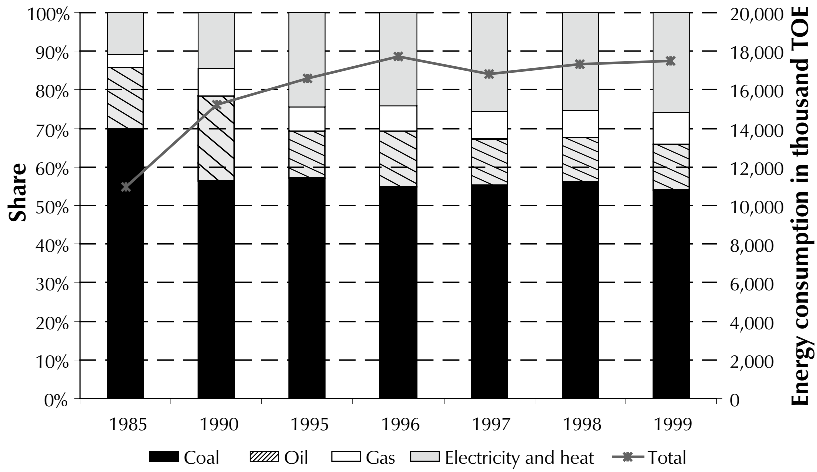
Figure 4.2A **Energy consumption in Tokyo**

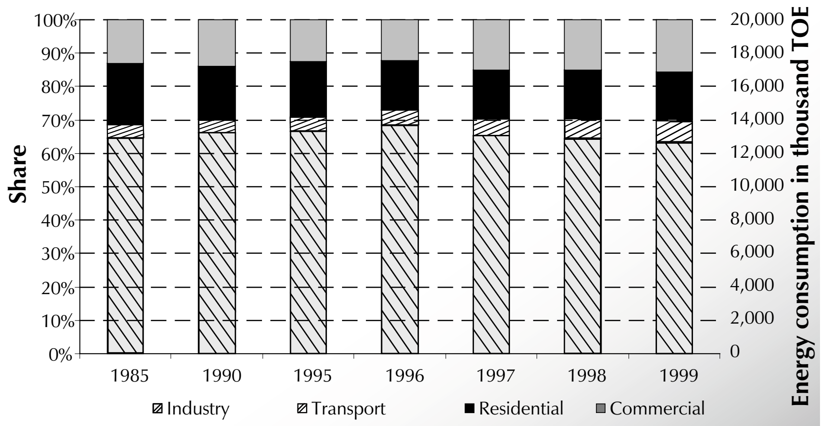




Source: Internal database compiled from energy statistics of cities

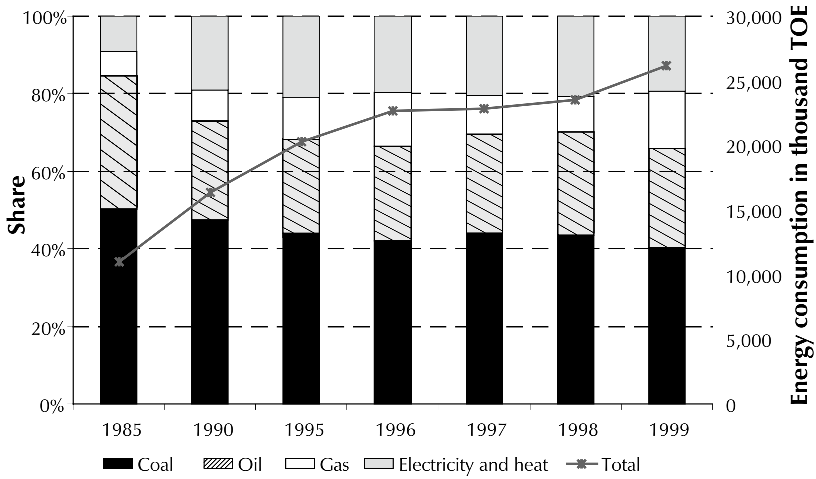
Figure 4.2B Energy consumption in Seoul

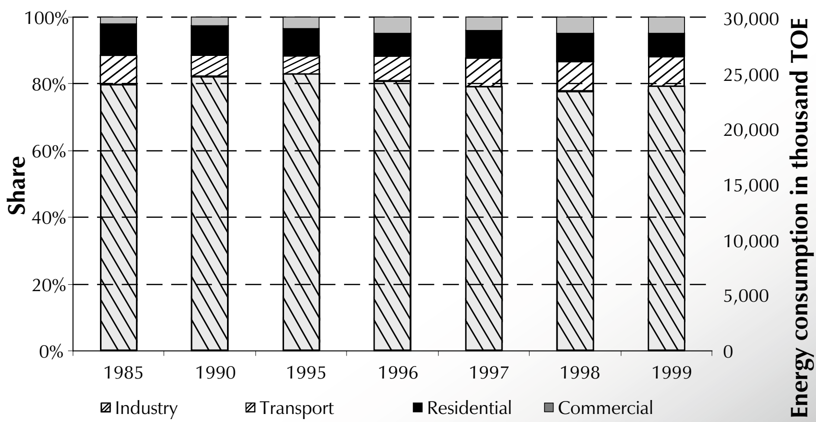




Source: Internal database compiled from energy statistics of cities

Figure 4.2C Energy consumption in Beijing





Source: Internal database compiled from energy statistics of cities

Figure 4.2D Energy consumption in Shanghai

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

Seoul is distinct in its heavy reliance on oil; in recent years, coal has been replaced by gas and electricity. Residential households consume the majority of energy in Seoul; transportation is the second biggest user. Provisions for district heating are rapidly expanding. In 2001, over 350,000 households used district heating; this figure is expected to increase to over 430,000 households by 2007 (Jung, 2004).

The structure of energy use in Beijing and Shanghai did not change significantly in the period from 1985 to 1998. The major characteristics of the energy profile in these cities are (1) the share of electricity usage is increasing somewhat, (2) coal dominates energy use, and (3) the share of the transport sector ranges from 5 to 10%. Primary industry is shrinking in Beijing and Shanghai and significant economic growth now stems from the tertiary sector. This change has balanced the energy profile to some extent so that increasing economic growth has not resulted in huge growth in per capita energy consumption. In Beijing, for example, the share of coal consumption by secondary industries in total consumption has grown, a fact consistent with the economic growth of secondary industries. After Beijing replaced small coal-fired boilers with gas-fired boilers in residential sectors, coal consumption in this sector dropped from 4.0 million tonnes in 1995 to 2.8 million tonnes in 1999[8]. The use of natural gas has risen dramatically in Beijing and Shanghai in recent

8. Beijing Statistical Yearbook 2000, Beijing Statistical Bureau: Chinese Statistical Press, 2000.

years but still accounts for a very small share of total energy usage. In Shanghai's energy structure, the share of coal in total consumption dropped about 7% from 1995 to 2000; it was replaced largely by oil. In sum, rapid changes in the energy structures of Beijing and Shanghai have taken place only lately, after 1998.

4.4 Patterns of CO_2 Emissions in Cities[9]

The patterns of CO_2 emissions from energy use in the four selected cities are like those of energy consumption although choosing alternative fuels results in differences (see Figures 4.2 and 4.3). Tokyo emits 1.5 times more CO_2 from energy use than Seoul does, while Beijing and Shanghai respectively emitted 1.4 and almost 2 times more than Tokyo in 1998. Emissions from Tokyo have increased more than two times in the last three decades, with an annual average growth rate of about 2% between 1970 and 1998. During that same period, the annual average growth rate of the economy (GRP) was 6.87%. Between 1990 and 1998, 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%.

Economic growth is one of the major determinants of emission levels. The economic recession in Tokyo did not reduce the volume of emissions because emissions in Tokyo are strongly related to lifestyle (automobiles and transportation), office automation and building systems. In Seoul, on the other hand, the economic collapse has had a major impact on emissions. The growth of emissions in Beijing and Shanghai decreased in recent years despite rapid economic growth due to ongoing fuel switching, rises in productivity, improvements in energy efficiency and changes in the economic structure; the decrease in Shanghai was particularly notable.

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 declined steadily from 30% to 10%;

9. The numerical estimates for CO_2 emissions given in Sections 4.4, 4.5 and 4.6 were carried out in collaboration with Dr. Shinji Kaneko.

the absolute volume of emissions from industry has also decreased. This is due to the relatively small scale of industrial activities in Tokyo; it is principally a commercial city and the tertiary sector has gradually dominated the industrial sector. The share of tertiary industries in the total industrial value added increased from 67% in 1980 to 77% in 1998.[10] Oil and electricity (CO_2 emissions are based on an average electricity generation mix) are responsible for the majority of CO_2 emissions.

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%)	

The definitions of high and low growth are subjective; for the purpose of comparison, over 5% was considered as high in this table.

In Seoul, transportation and residential households not only consume the most energy but are also are responsible for the highest emissions. The residential sector's share and volume has, however, decreased in recent years. The economic collapse in Korea seems to have contributed

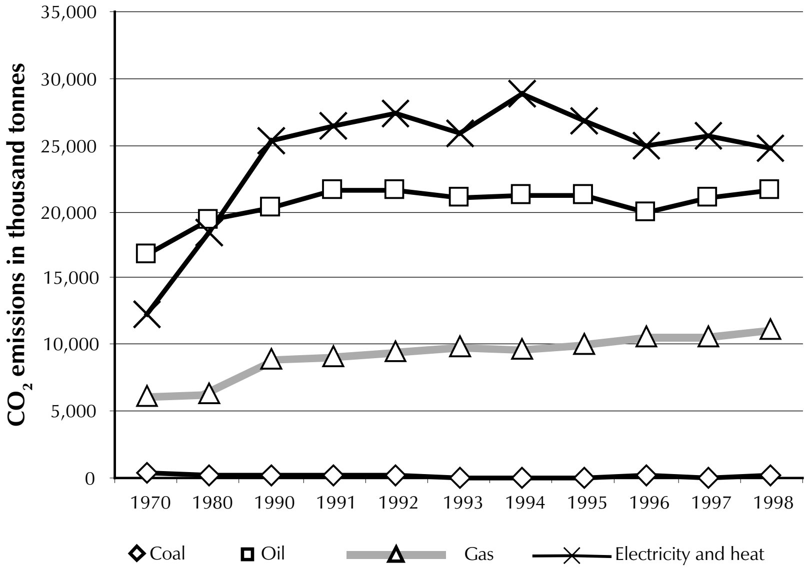
10. TMG : Tokyo Statistical Yearbook, Annually published (1970-2001) by Tokyo Metropolitan Government, Tokyo, Japan.

greater to the reduction of emissions from businesses and transportation than from other sectors. The small contributions of the industrial sector to total emissions can be partly explained by the dominance of the tertiary sector. The share of the tertiary sector in industrial valued added 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 because its use dominates in the building and transport sectors. Unlike in Tokyo, in Seoul most large buildings use oil-based centralised heating systems. The rising share of emissions from gas and electricity has replaced the share of coal (which dropped from 35% to 3% in the period from 1990 to 1998) while the share of oil has not changed considerably.

Emissions in Beijing and Shanghai are dominated by industrial activities, whose shares in 1999 were as high as 80% in Shanghai and 65% in Beijing. The share of transport was about 5 to 6% in 1999. The structure of emissions in these cities 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. The increasing use of gas has raised its share in total emissions in recent years, but coal is still the major cause of emissions since most electricity is coal-generated. Shanghai is distinct from Beijing in its emission structure by fuel types in that it has a larger share of emissions from oil and gas.

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

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%).



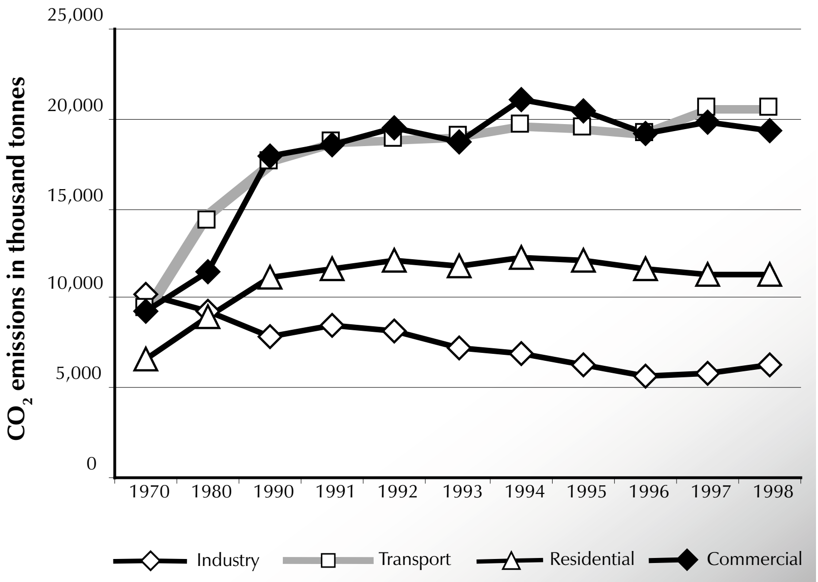
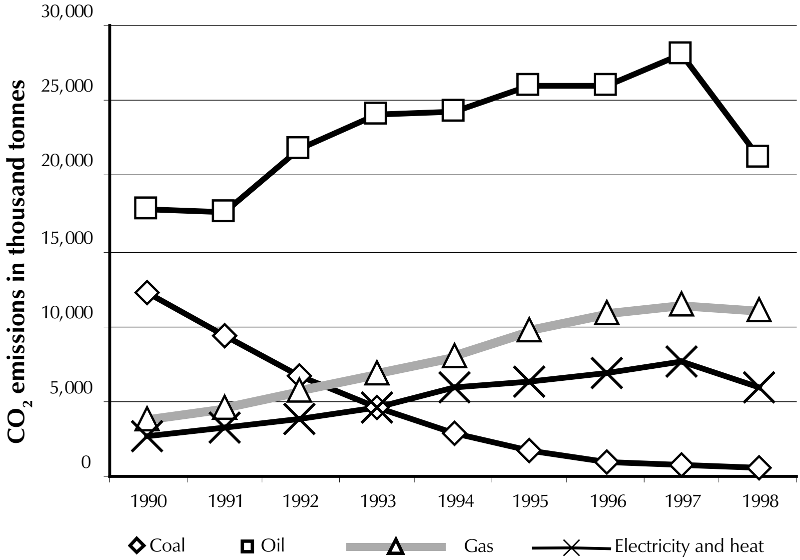


Figure 4.3A CO_2 emission from energy use in Tokyo



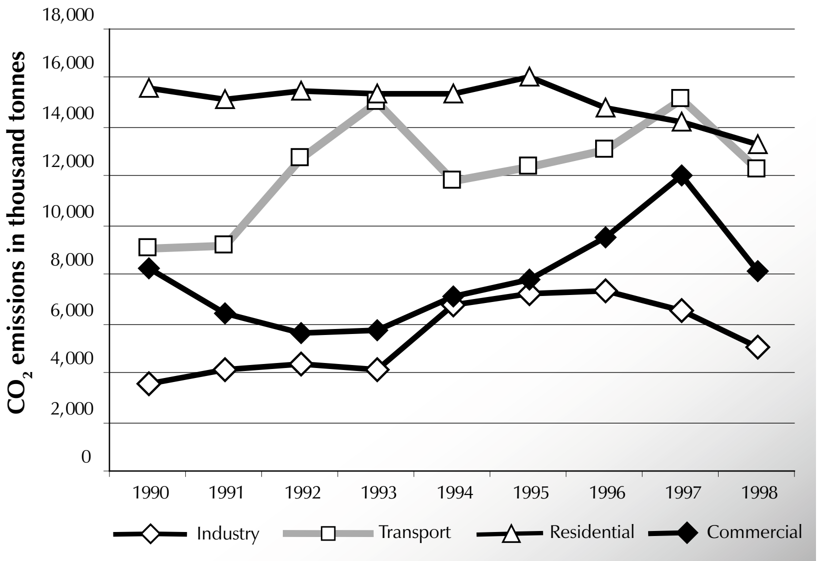
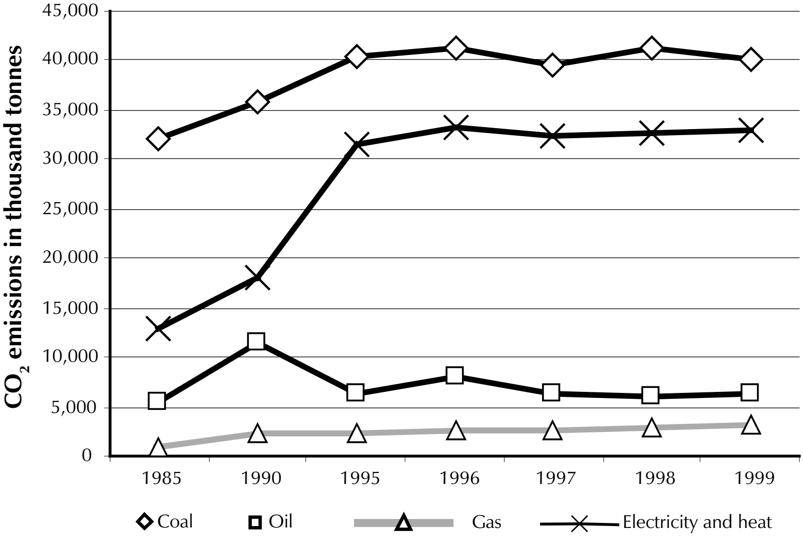


Figure 4.3B CO_2 emission from energy use in Seoul



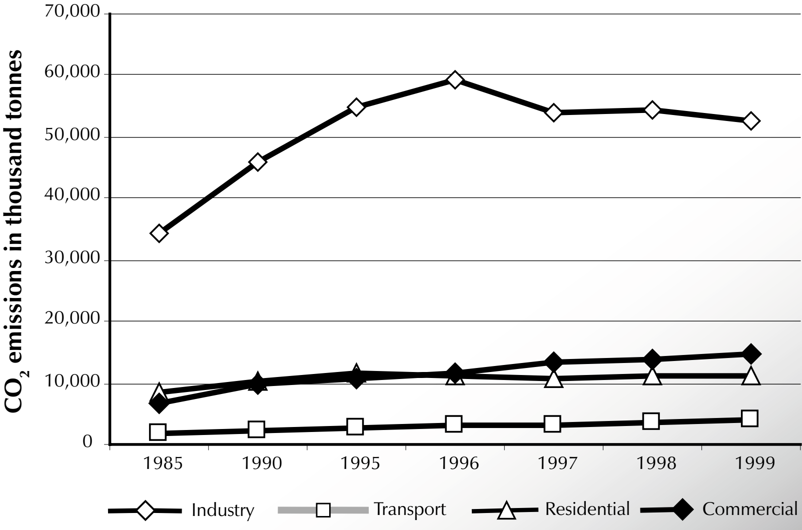
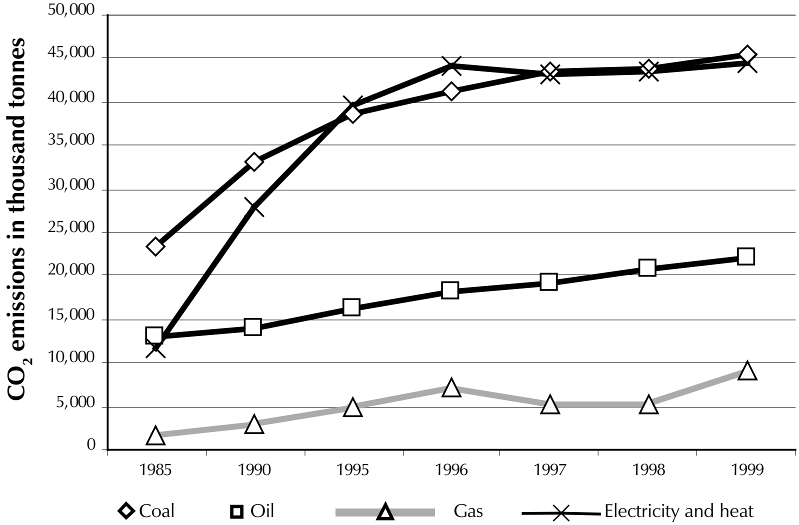


Figure 4.3C CO_2 emission from energy use in Beijing



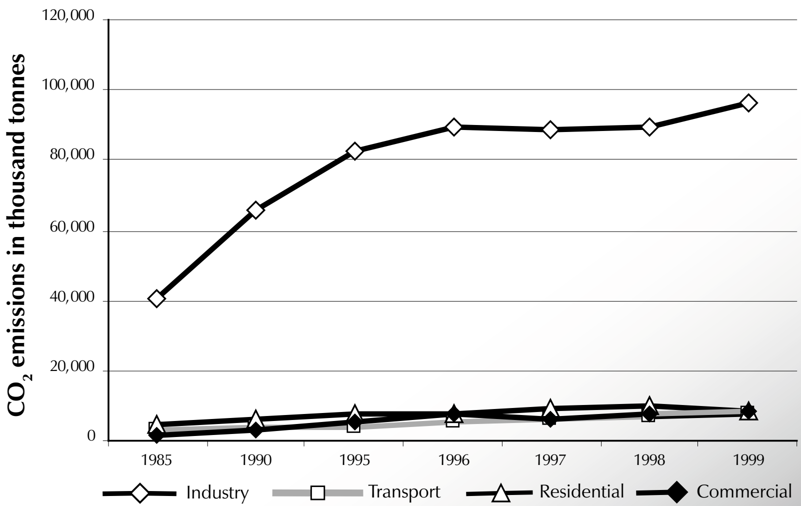
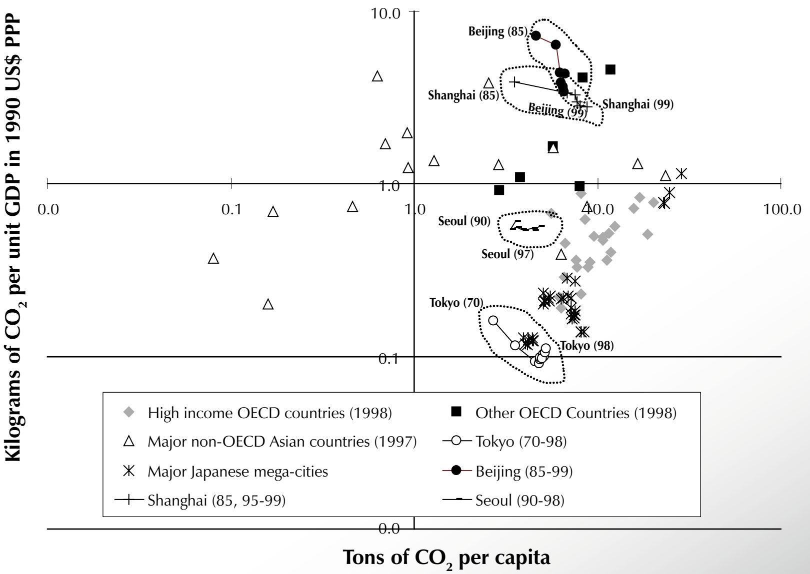


Figure 4.3D CO_2 emission from energy use in Shanghai

4.5 CO_2 Emissions of Cities Per Capita and Per Unit of Economic Activity

Figure 4.4 evaluates the performance of the cities in terms of CO_2 emissions per capita and CO_2 emissions per unit of economic activity. Due to an insufficiency of data, 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.

The comparison reveals that the performance of large Japanese cities is, in general, better than that of other cities and countries. The performance of Tokyo is outstanding. In recent years, especially after 1990, the performance of Tokyo has worsened slightly mainly due to the slowing down of the economy and the inability to cut down on CO_2 volume. In Tokyo, economic recession has not reduced emissions significantly because the share of the industrial sector in total CO_2 emissions is small. CO_2 per unit of economic activity in Seoul stagnated between 1990 and 1997 but



Source: Internal database compiled from statistical yearbooks

Figure 4.4 CO2 emissions per capita and per unit of GRP/GDP (in log-log scale)

CO_2 per capita increased. Beijing and Shanghai's CO_2 performance in terms of economic activity is improving rapidly. Reducing CO_2 emissions per capita seems to pose a major challenge to cities, all of which have clearly failed in that pursuit.

In deriving the per capita CO_2 emissions used in Figure 4.4, the daytime population was considered. However, studies report that 33% of the workforce of Tokyo commutes from outside Tokyo[12]. The ratio of the daytime and nighttime populations in Tokyo and Seoul were 1.25 and 1.04 respectively in 1999 (Yoon and Araki, 2002). Should commuting populations be included in per capita estimates, the performance of Tokyo would improve further (not shown in figures here). Since Tokyo is already operating at a relatively high level of performance, it may be able to serve as a model for rapidly developing mega-cities, particularly cities in Northeast Asia. Though every city grows differently and, in reality, no city can serve as a complete model for another, suitable elements can be utilised.

Tokyo is different from other cities as it belongs to Annex I countries in Kyoto Protocol. Accordingly, the responsibility for future CO_2 emission reductions by Tokyo may be higher than other cities due to its anticipated contribution towards meeting Japan's Kyoto commitment (reducing emissions by 6% of the 1990 level). Since Russia's recent ratification, the Protocol will enter into force and Tokyo may be further required to take specific steps to reduce CO_2. Already, bottom-up modellers have demonstrated that significant reductions in Tokyo are possible with different technological measures (Hanaki, 2002). If these measures are implemented in the future, Tokyo's performance in Figure 4.4 might improve further.

Despite the fact that these four cities have yet to converge in terms of per capita emission, they are converging in terms of per capita energy consumption, as Figures 4.5 and 4.6 show. The structure of energy use, therefore, clearly plays a very important role in the profile of emissions. Tokyo and Seoul, in particular, seem to converge in emissions, while emissions in Shanghai are rapidly growing. As it is less industrialised than Shanghai, per capita emissions in Beijing are growing at a slower rate than they are in Shanghai.

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

4.6 Factors Contributing to CO_2 Emissions in the Past

The factor decomposition method is a widely used tool for determining the relative contributions of various factors toward CO_2 emissions. In this section, CO_2 emissions have been decomposed into four factors: carbon intensity effect, energy intensity effect, income effect and population effect.

Economic activity, or the income effect, was the major driving force behind the changes in CO_2 emissions in Seoul during periods of economic growth as well as economic recession. In Tokyo, economic activity was responsible for the majority of emissions in its period of rapid growth, but its contribution toward reducing emissions in the economic recession was smaller (see 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 (see Figure 4.7).

The carbon intensity effect indicates the effect of fuel choices on emissions: movement up the fuel ladder to cleaner fuels results in lower emissions. In Tokyo, though carbon intensity effects and population effects were responsible for slightly increasing emissions in the 1970s and

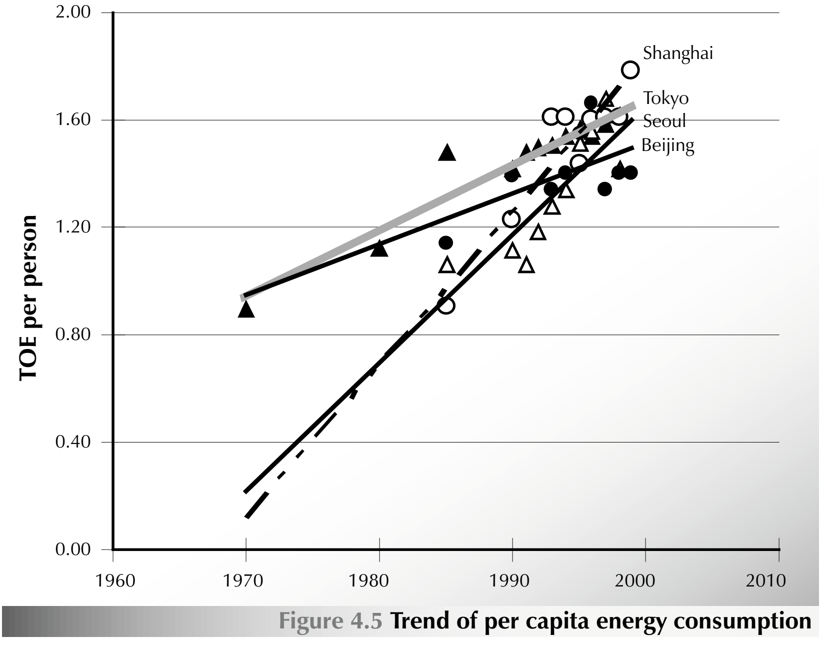


Figure 4.5 Trend of per capita energy consumption

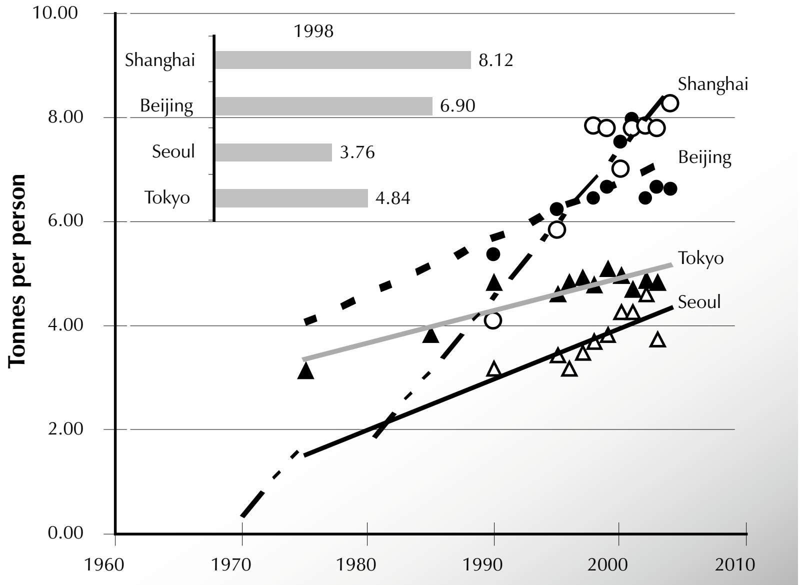


Figure 4.6 **Trends of per capita CO_2 emissions consumption**

1980s, their contribution was negligible in the 1990s. In Seoul, however, the carbon intensity effect was responsible for reducing a large amount of emissions during its period of rapid growth (1990-97), but its contribution was negligible in the recession of 1997-98. Shifting the structure of energy consumption from coal to oil and electricity is a major reason behind the positive contribution of carbon intensity (The share of coal decreased from 28.8% in 1990 to 1.3% in 1998 (KEEI, 1998).)

Energy intensity, which indicates the direction of technological changes and structural shift of activities, was responsible for the reduction of emissions by large amounts in Tokyo during the period of economic growth. During the recession, however, it had the opposite effect. The role of the energy intensity effect in Seoul was the reverse: it produced a negative effect (increased emissions) during the period of economic growth but had a substantive positive effect (reduced emissions) in the economic recession of 1997-98.

The income effect seems to be responsible for the reduction in CO_2 emissions in Tokyo in the 1990s. The contribution of energy intensity toward reducing emissions has decreased over time in Tokyo since the

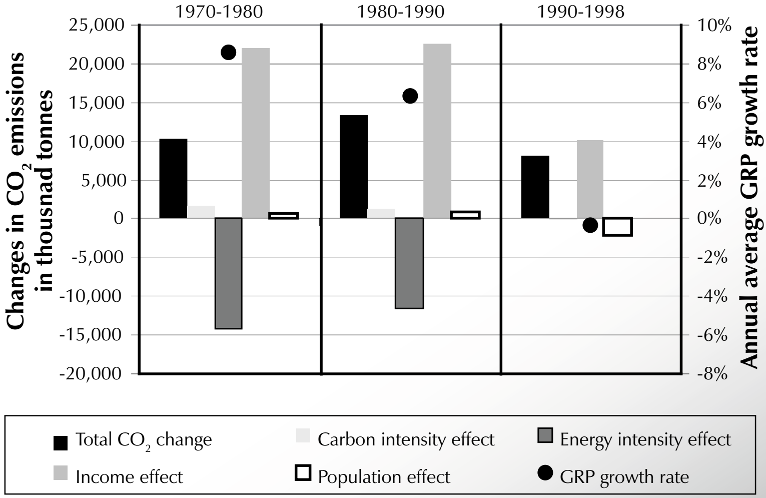


Figure 4.7A Factor decomposition of total CO_2 emissions from various energy uses in Tokyo

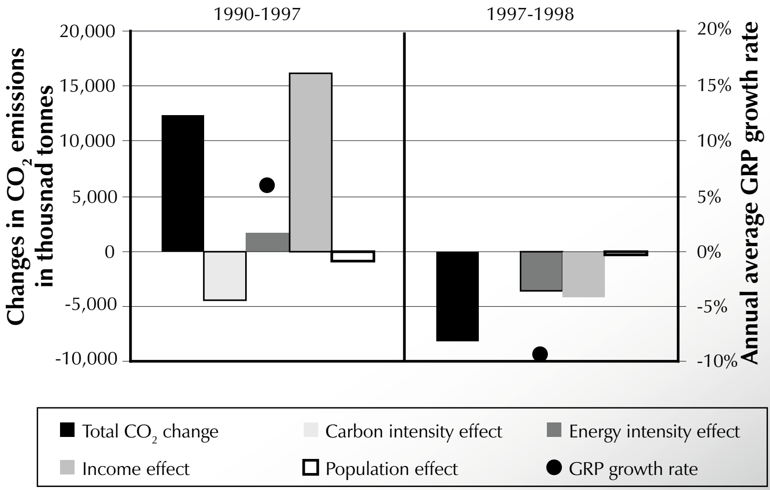


Figure 4.7B Factor decomposition of total CO_2 emissions from various energy uses in Seoul

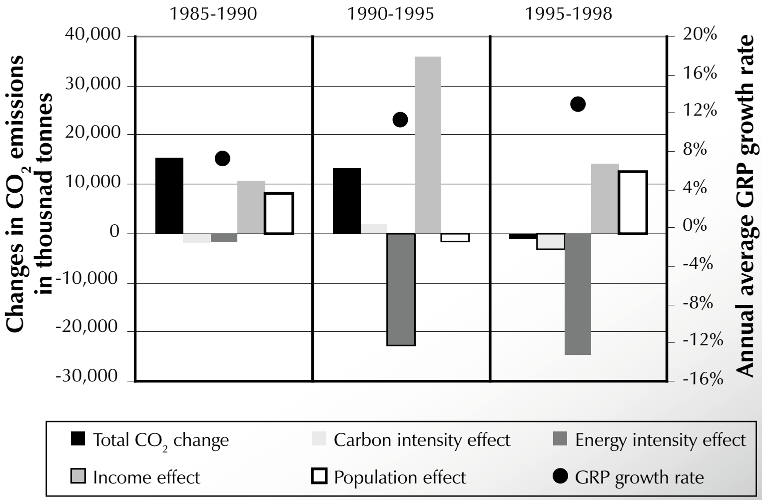
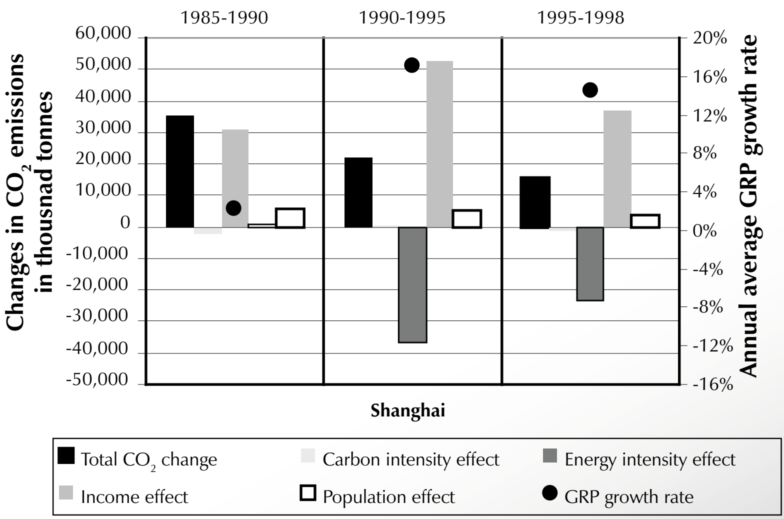


Figure 4.7C Factor decomposition of total CO_2 emissions from various energy uses in Beijing



Source (for all figures in 4.7): Dhakal S., S. Kaneko and H. Imura (2003). CO_2 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.

Figure 4.7D Factor decomposition of total CO_2 emissions from various energy uses in Shanghai

early 1970s; in fact, it was responsible for a major increase in CO_2 emissions in the 1990s.

Due to unprecedented economic growth, it is obvious that the income effect is the major factor behind increasing emissions in Beijing and Shanghai, while energy intensity was the major factor behind the reduction of emissions after 1990. Increasing productivity and improvements in energy efficiency might be responsible for these effects. Since coal continues to dominate the energy sector, CO_2 emission benefits from the carbon intensity effect are evident only after 1995, when fuel switching began. The role of the population effect is small in Shanghai but in Beijing it contributes significantly (this could be due to change in the political boundary).

In the transportation sector (not shown in any figures, see Dhakal *et al.* 2003), the number of vehicles is responsible for the majority of CO_2 emissions in all four cities. In Seoul, the vehicle utilisation effect (travel demand per vehicle) was primarily responsible for reducing emissions, but in Tokyo, it was the energy intensity effect which was primarily responsible.

In the residential sector (not shown in any figures, see Dhakal *et al.* 2003), the effects of contributing factors to CO_2 emissions are different for Tokyo and Seoul, primarily due to differences in building heating and cooling systems and fuel switching. In Tokyo, most emissions from the residential sector are attributed to the household income effect, unlike the scale effect (household population effect) operational in Seoul. Similarly, in Tokyo, the energy intensity effect is responsible for reducing emissions, but in Seoul, the fuel quality and income effects are responsible. In Beijing and Shanghai, carbon and energy intensity effects contributed to the reduction of emissions, while income and household population effects were mostly responsible for increasing emissions from 1985 to 1990. In Shanghai, unlike in Beijing, the volume of emissions, under the influence of energy intensity effects, actually increased from 1995 to 1998.

In the commercial sector in Tokyo and Seoul (not shown in any figures, see Dhakal *et al.* 2003), the labour productivity effect is dominant in increasing CO_2 emissions during periods of rapid growth periods and the energy intensity effect is key in reducing CO_2 emissions. In Beijing and

Shanghai, the energy intensity effect contributed to reducing emissions only in the period from 1990 to 1995. The labour productivity effect contributed to increasing emissions in the 1990s (less labour but more machines and energy).

Decomposition analyses need to be interpreted with caution. For example, the energy intensity effect of transportation resulted in changes in CO_2 emissions in transportation that could have resulted solely from changes in gross energy consumed per unit of passenger travel demand while keeping all other decomposed factors constant. Such changes are speculative in nature and must be closely co-related with actual policies and situations to yield correct interpretations.

4.7 Indirect CO_2 Emissions Embedded in Material Consumption[13]

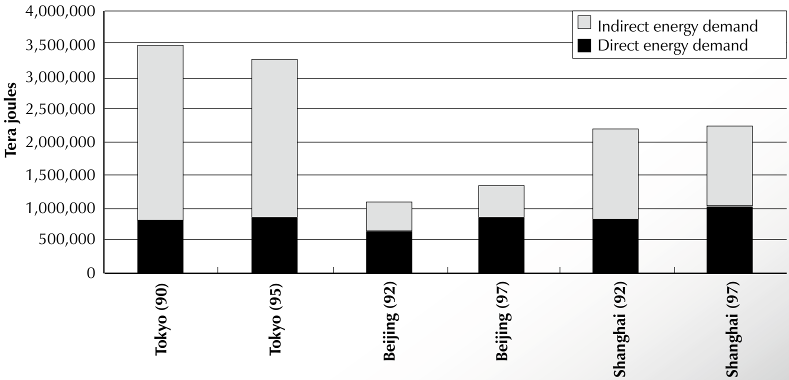
To minimise the contributions of cities to global environmental change, reductions in direct emissions alone are not enough. The consumption of large amounts of material goods by cities has an indirect effect on places outside cities where manufacturing and resource extraction take place. Since, on a global scale, it does not matter where emissions originate, cities should be judged by their contributions to the total environmental load. The impact of indirect emissions embedded in the consumption of goods could, in fact, be large enough to outweigh the impact of direct emissions. A similar concept is now being used while analysing other sectors, such as water use. "Virtual water" is a term commonly used by professionals who seek to reduce water use in cities.

An I-O table-based estimate of indirect energy demand shows interesting results for Tokyo, Beijing and Shanghai. In Tokyo and Shanghai, indirect energy demands are more significant than direct energy demands (see Figure 4.8).

A city does not always consume material goods; it also supplies them in the form of exports. The relationship between the direct and indirect energy consumption for which a city is responsible differs from city to

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

city depending on its scale of industrialisation and type of industries. The CO_2 emissions for which a city is responsible are those which are emitted as a result of direct emissions plus the net value of CO_2 emissions embodied in material goods that are consumed in a city after subtracting exported material goods. Table 4.2 shows that indirect emissions in Tokyo surpass emissions, while Tokyo is responsible for about 68% of the total emissions.



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.*

Figure 4.8 Direct and indirect energy demands of selected cities

Table 4.2 Direct and indirect CO_2 emissions in selected Asian cities

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

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

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

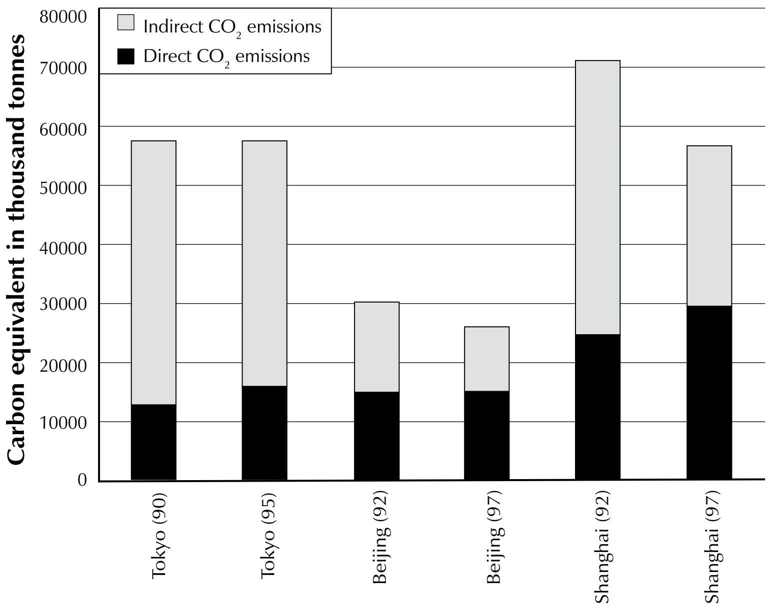
4.8 Sectoral CO_2 Emissions and Future Scenarios

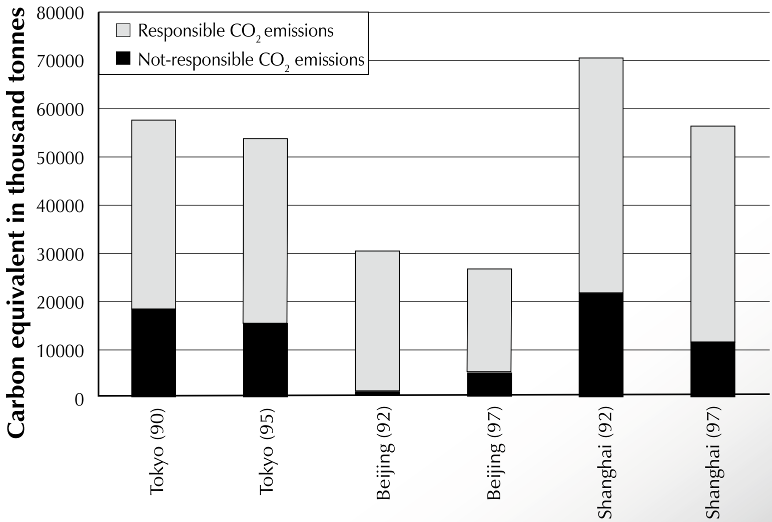
Road transport

Bottom-up modelling for energy use and CO_2 emissions for road transportation in all four cities reveal interesting results.

- The number of vehicles in Beijing and Shanghai is as few as one-tenth the number in Tokyo, but their total fuel consumption is one-third to one-half that of Tokyo because of lower fuel efficiency and greater mileage of vehicle travel.
- Growth in the number of vehicles in Tokyo and Seoul is slow and structural changes in vehicle composition are few.
- The relatively small number of vehicles in Beijing and Shanghai emitted a relatively large amount of pollution (in 2000).
- The contribution of light-duty gasoline vehicles to emissions is expected to rise dramatically in Beijing and Shanghai in the future.
- In Beijing, oil consumption in road transportation is expected to increase 2.4 times between 2000 and 2020; oil consumption in Shanghai is to double[14] (Figure 4.10).
- Even if all the expected measures (see footnote 15) are implemented—and that may be the wishful thinking of policy makers—future emissions of CO_2 from urban transportation in these cities will still be tremendous. Figure 4.11 shows that the absolute volume of emissions is far from decreasing. In the case of Tokyo, it considers only the number of vehicles, which will soon be saturated; then, gradual improvements in energy performance will reduce emissions. Other factors such as structural changes towards larger-sized engines, which

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

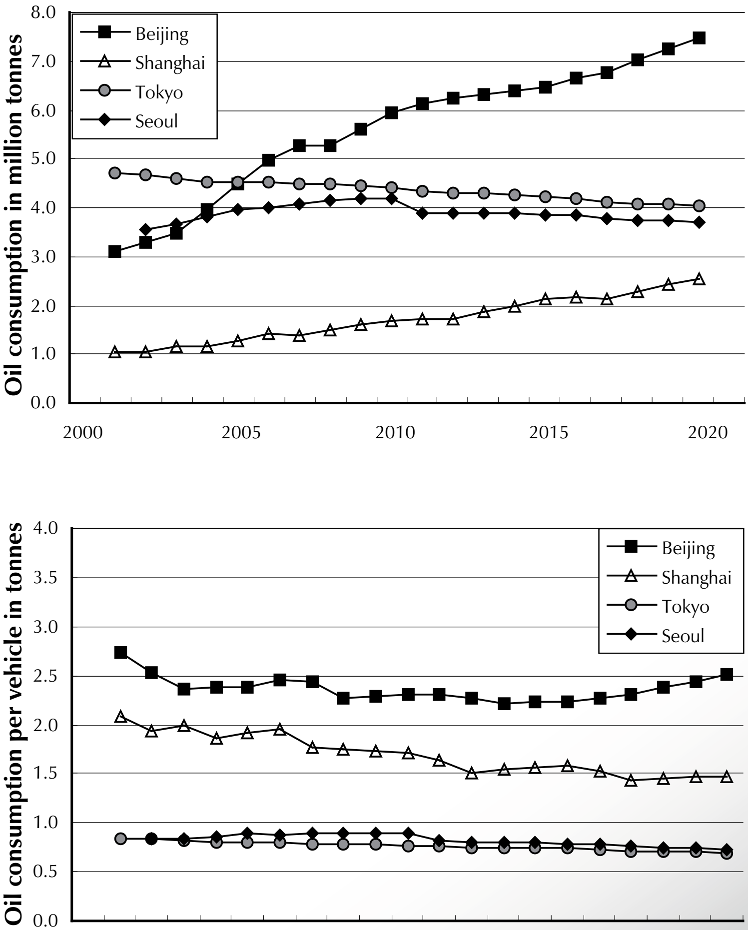




Source: *Kaneko S, H. Nakayama and L. Wu (2003). Comparative study on indirect energy demand, supply and corresponding CO2 emission of Asian mega-cities. Proceedings of IGES/APN International Workshop on Policy Integration towards Sustainable Energy Use for Cities in Asia, 4-5 February 2003, East West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

Figure 4.9 CO_2 emissions in selected Asian cities

is Tokyo's present trend, are not included. The aim of this figure is to show the speed with which CO_2 emissions from cities, especially Beijing and Shanghai, might increase.



Source: *Commissioned report prepared by Dr. Kevin He for this project*

Figure 4.10 Oil consumption of road transport

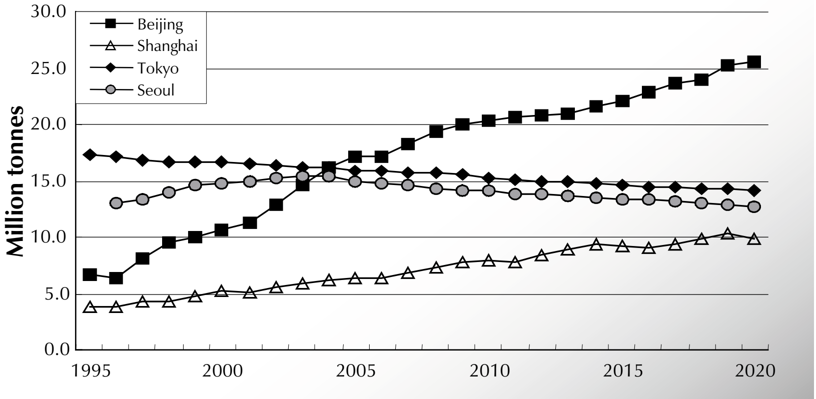


Figure 4.11 CO_2 emissions from road transportation (indicative only)

Households and businesses

The residential CO_2 emissions of Beijing are expected to surpass those of the other three cities in the future, while Shanghai is likely to catch up Tokyo[15]. Changing lifestyles[16] and improving appliance efficiency[17] are measures that could reduce the maximum volume of emissions in Tokyo. In the commercial sector, the emission volume of Shanghai is expected to increase drastically. Stabilising the absolute volume of emissions is likely to be a very difficult task in Tokyo and Seoul as CO_2 emissions from residential households and commercial sectors are already saturated; although emissions are not increasing greatly, reducing them will not be an easy task. Japan has committed itself to the Kyoto Protocol, which calls for reducing reduce GHG emissions by 6% of the 1990 level. Large cities such as Tokyo play a key role in any effort to reduce global emissions; stabilisation alone will not be enough.

15 From the work of Dr. Toru Matsumoto commissioned for this study.

16 Promotion of energy-conservation in residences, such as switching off unnecessary lights, efficient use of heating and cooling equipment, etc. (An attitude survey conducted by the by Japanese government suggests that 16% of total energy consumption can be saved by such conservation behavioural factors).

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

4.9 Waste Treatment Methods and Utilising Waste Heat for District Heating[18]

As discussed earlier, the volume and composition of waste and its method of disposal have a key impact on GHG emissions. In Tokyo, 18 incineration plants operated by the Bureau of Waste Management of the Tokyo Metropolitan Government have been processing about 87% of post-recycled and 100% of Bureau-collected wastes since 1998. In Seoul, only 5% of the total waste is incinerated, but Seoul had 27 incinerators with a total capacity of 52,957 kg per hour in 1999 (with the exception of the incinerators in Yangchun and Newon, all are small). The utilisation of the waste heat and steam from the 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 cultural centres, citizen halls, and sports centres in neighbouring areas. Steam from the incinerators is converted into electricity and sold to Tokyo Electric Power Co., Ltd. In FY 1996, 690,980,000 Kwh of energy was generated, 45% of which was sold at a total value of 2.69 billion yen in 1996 (TMG, 1999).

Using IPCC-recommended methods, the author carried out a study comparing the utilisation of waste heat for running district heating systems with its utilisation for operating a LNG-based centralised system. The Newon incineration plant in Seoul (1999: capacity 33,333 kg/hour; treatment amount 79,936 tons; construction cost 64,666 million won; 1,200 won = US$1) was contrasted with the Minato incineration plant in Tokyo (capacity 600 tonnes/day). The reduction in CO_2 emissions and possible benefits from Clean Development Mechanism (CDM) at the rate of US$50/tC are estimated as is given in the table 4.3.

The results above are not detailed, but, as intended, they do show that GHG benefits from such utilisation should be an important consideration, especially since CDM and emission trading are emerging as a tool to facilitate the reduction of GHG emissions. The cost and viability of district heating depends on a number of factors, including the matching of supply and demand.

18 This research was carried out in collaboration with Dr. Eui-Yong Yoon.

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

	Newon plants, Seoul		Minato plant, Tokyo	
	Utilising waste heat directly	LNG-based boiler for centralised heating	Utilising waste heat directly	LNG-based boiler for centralised 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

Source: Work carried out by Dr. Eui-Yong Yoon for the project.

The utilisation of gases from landfill sites, especially methane, could also be a viable option for reducing emissions and is of special concern to Seoul, Beijing and Shanghai, which rely more on landfills than incinerators.

section B

Local Priorities, Recent Developments, Opportunities and Barriers

5 City Policy Makers and CO_2 Emissions

Although the primary focus of city and municipal policy makers is on local environmental issues such as the management of solid waste, air quality and wastewater, there is a growing need to incorporate global environmental concerns into local policies. Authorities in cities in developed countries, including those in Tokyo, realise that cities are centres of high population density, much business activity, a high demand for mobility, and upscale lifestyles, and that they must contribute toward reducing energy consumption and CO_2 emissions. Tokyo's volume of CO_2 emissions exceeds that of many smaller nations. Tokyo's contribution to CO_2 emissions[19] is about 1% that of all developing countries (TMG, 2002). While well-placed plans and programmes can simultaneously reduce local environmental concerns, improve energy efficiency, and reduce CO_2 emissions, formulating such multi-purpose strategies is not easy. Given that the developed nations of Annex-I[20] are still struggling to formulate their response strategies at national levels, the expectation that cities do the same is premature. Some of the general challenges which cities do need to grapple with follow:

- lack of awareness among local policy makers about global issues;
- lack of scientific studies, inventories of energy consumption and CO_2 emission, and related information;
- limited financial, human and technical resources even to tackle urgent issues such as local air pollution;
- priorities in resources allocation; and
- awareness of global environmental issues amongst citizens.

19 Direct CO_2 emissions as a result of energy use

20 Of the United Nations Framework Convention on Climate Change.

Despite these limitations, urban policy makers in mega-cities, especially those in Northeast and Southeast Asia, are aware, to some extent, of the need to reduce CO_2 emissions. In years to come, mega-cities will have to confront these issues as the growing trend toward decentralisation is empowering local authorities to tackle their own problems.[21] Power shifts from nations to cities have become evident in the last few decades in both the developed and the developing world. Policy makers in cities, especially large cities, now have more avenues which they can pursue in order to reduce CO_2 emissions and energy demand. Russia's ratification of the Kyoto Protocol in October 2004 paved the way for putting the Protocol's climate policy into effect. The role of cites in international debates will, accordingly, grow. This section presents discussions of the following issues:

- *Local environment priorities and challenges* in Tokyo, Seoul, Beijing and Shanghai and their significance for GHG emissions;
- *Recent developments in policy dimensions* at the city level in relation to GHG emission concerns, with a special focus on Tokyo and Beijing (which represent respectively a developed city and a rapidly developing city); and
- *Opportunities for and barriers to policy integration* for local governments and for different scales of environmental governance. The response and set-up of national governments is important in enabling local authorities to act in Asia because historically speaking national governments have been prime movers. This paper explores several perspectives on domestic policies for GHG reduction in Japan (and, to a lesser extent, in cities) and highlights the role of international institutions.

21 Many nations have already enacted self-governance acts for local bodies. There is a growing trend toward empowering and strengthen local authorities in this tackling of local issues. In terms of the environment, 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 also being gradually addressed. Local governance is well established in East Asia (in countries such as Japan, China, Korea and Taiwan) and is rapidly gaining momentum in Southeast and South Asia.

6 Local-Global Environmental Priorities and Challenges

6.1 Local Air Pollution Priorities and Challenges

Concerns about emissions of a particular air pollutant vary from city to city. Particulates of various sizes are a common concern for many cities in Asia. NO_x emissions have become a more important issue in developed cities in recent years. In industrial cities that use coal as a major source of energy, trans-boundary environmental problems are a serious threat as acid rain may accelerate the problem of desertification on a regional scale. SO_x emissions are usually associated with coal use in stationary sources such as power plants, industries, and domestic and commercial boilers. Mobile sources are becoming increasingly responsible for emissions of NO_x and particulate matter. In general, cities are diversifying their energy mixes to gradually incorporate cleaner energies yet cost, availability and energy security remain big concerns in the need for a speedy transition.

6.1.1 Problems with SO_x, NO_x and particulate matter

Tokyo was successful in drastically reducing its concentration of SO_2 between the mid-1960s and the early 1970s; Seoul did the same after 1988. Beijing and Shanghai have higher concentrations of SO_2 and particulate emissions than Tokyo and Seoul do (see Table 6.1). 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, emissions are likely to continue to rise. Serious policy efforts must be developed and implemented if policy makers are to reduce emissions to within acceptable limits.

Table 6.1 Air quality in selected cities, in micrograms per cubic meter

City	Particulates (1997), mg/m^3	Sulphur dioxide	Nitrogen dioxide
Beijing	377 (TSP*)	71 (2000)	126 (NO_x, 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 (PM_{10})	31 (1997)	62 (NO_x 2000)

*TSP: Total suspended particles

Box 6.1 Issues and concerns in the current development paths and transitions related to energy and transportation in South Asia

Mapping key physical issues

The major energy, environmental, and transportation issues in South Asian cities include increasing energy use; emissions of CO_2 and local air pollutants, especially PM_{10} and dust, whose concentrations far exceeds WHO guidelines. Key South Asian cities are characterised by rapid motorisation, growing traffic congestion, and increasingly overburdened public transportation systems.

Two- and three-wheelers, the majority of which run on two-stroke engines, dominate South Asian cities. In recent years, some effort has been made in Dhaka, Kathmandu, and a few other cities to phase out these vehicles. In the quest for cleaner air for citizens, the judicial system ordered that CNG be used in public transportation in New Delhi. Similar efforts towards CNG conversion of three-wheelers are underway in Dhaka. In Kathmandu, battery-operated three-wheelers have replaced smoke-belching diesel three-wheelers for commercial operations. These changes do represent a transition towards cleaner vehicles and fuel but, unfortunately, are limited to a small sector of transportation.

Improvements in public transportation systems are progressing at a slow pace in the region as a whole. The number of private vehicles is increasing at an alarmingly high rate, but the efficiency and coverage of public transportation remains poor. Traffic management and road conditions have not kept pace with the growth in the number of vehicles.

Though vehicle emission standards and regulations are in place for new vehicles, it is in-use and old vehicles which pose much of the problems. Old vehicles perform poorly in terms of energy use and emissions. Although they are not desirable, socio-political dynamics and public protest have prevented their being phased out. Often the lack of financial resources are blamed for placing constraints on policy makers, but policy makers have not been able to implement measures that do not demand much funding either. In major cities in the region, levels of local air pollution have worsened to such an extent that the problem is visible even without reference to scientific data. Data confirms what is obvious to all: energy consumption and emissions of local air pollutants and CO_2 are on the rise in all cities in South Asia.

Lack of scientific understanding

The lifestyles of urban dwellers in cities are becoming more and more energy intensive. Consumption of material goods and water is on the rise. Over-motorisation, which is an example of over-reliance on commercial energy use, and dependence on electrical and electronic equipment are common features of cities. There is little understanding of the various forces leading to these changes or of 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 using 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 has been done on urban transportation issues but its depth and coverage is limited. Data on the local emission factors of various transport modes and the number of vehicles, their ages and engine sizes, for example, does not exist in many cities. A number of technical and non-technical gaps in understanding prevail and the roles of technological and non-technological options and measures have not been clarified.

Scientific studies of other urban sectors are 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 does *not exist. Since policy makers are largely unaware of the full range of issues, scientific findings seldom influence actual policies. Lack of sufficient research has also limited the influence scientific studies have had on policy making.*

Policies and institutions

Policy failure (due to a combination of market failure and institutional failure) is a common phenomenon in South Asia. Institutional arrangements 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 to the market of the correct signals for private sector participation. Inappropriate systems of incentives distort the market. Most 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 public transportation systems, along with an appropriate systems of incentives, is a key need in South Asian cities. 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. A policy needs to be in place for appropriate land development patterns that are consistent with transit and non-motorised 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 toward environmentally sustainable cities like Zurich, Curitiba, and Singapore for measures which divorce economic growth from environmental degradation.

Economic growth in South Asia in slower than that in East Asia and Southeast Asia. This slow pace hinders reforms as transportation issues are intertwined with low-income groups and equity issues. In addition, improvements in processes and productivity related to production and consumption systems are hard to achieve without fast growth.

Since the market for environmental services is not well established, 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 approaches especially in areas relating to urban physical infrastructure. Regulatory and governance issues are the key issues facing South Asia: current regulations are not adequate and institutional problems hinder policy implementation.*

Key transition needs in South Asia and research questions

Below is a list of key observations on the needs for transition in South Asia. They are consistent with the concepts of the IT project.

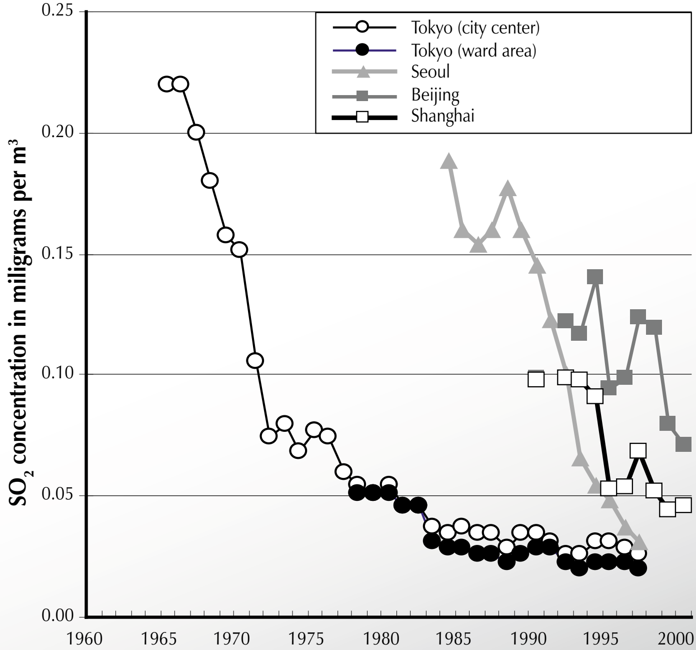
Introducing interventions other than end-of-pipe management: *As mentioned above, most interventions are end-of-pipe, whereas interventions in the system are what is needed, especially from the policy perspective. Shifting from clean vehicles to clean transportation systems, moving towards energy-efficient buildings, adopting a watershed approach to urban water management, and switching to clean energy use are essential. Usually end-of-pipe policy interventions are reactive and systems interventions are proactive in nature. Awareness and research in this direction but the trend is insufficient.*

Shifting from strong government interventions to strengthening multiple-sector and 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 minimisation to optimisation. Institutions and policies should play a key role in such changes.*

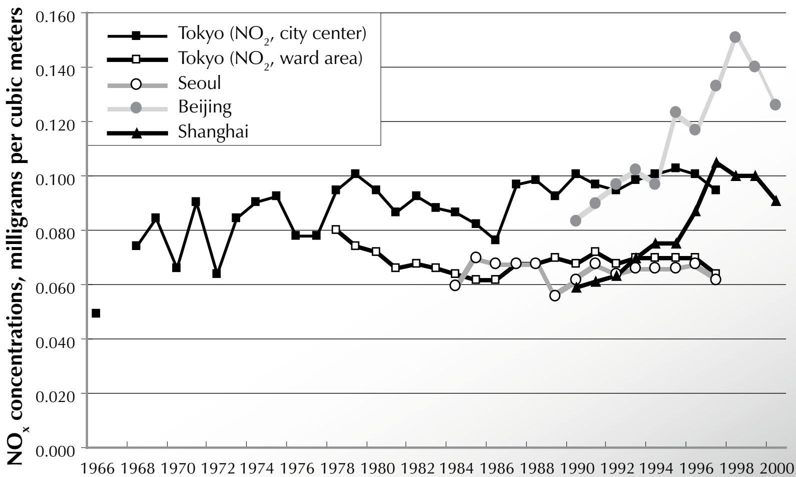
Using a market-based approach while keeping equity issues at the forefront: *The need to create systems for a market-based approach and public-private partnerships is evident in South Asia. This will help overcome some infrastructure-related constraints too. Getting polluters to pay principle-based fees and tariffs and taxes without distorting the market are essential moves. Regulatory and institutional reforms are a necessary prerequisite for this transition.*

Source: Dhakal and Norman (2003)



Source: *Internal database compiled from environmental statistics of cities*

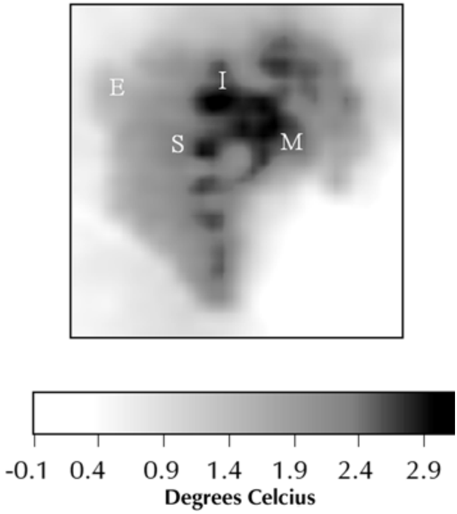
Figure 6.1 Trends in SO_2 concentrations



Source: *Internal database compiled from environmental statistics of cities*

Figure 6.2 Trends in NO_x concentrations

In the last three decades Tokyo has been successful in reducing concentrations of key air pollutants related to industry, including dust, carbon monoxide and sulphur dioxide. However, it struggled to control suspended particulate matters, nitrogen dioxide and photochemical oxidants, most of which are emitted by businesses, households and lifestyle-related activities. Problems other than GHG, such as controlling diesel vehicles, are of the highest priority in Tokyo. Most Japanese cities, including Tokyo, suffer from SPM and NO_x problems. In Tokyo, diesel vehicles were responsible for almost all particulate matters and about 70% of NO_x emissions in 2003 (TMG, 2003). An earlier estimate shows that in 1995 automobiles were responsible for 67% of total NO_x emissions, of which trucks and buses contributed 73% (TEW, 1997).



Source: *Dhakal and Hanaki (2002)*

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

In Seoul, SO_2 and PM_{10} are not a major concern because they are within the WHO recommended guidelines, and, in the last two decades, their levels have been decreasing with the increasing supply of clean fuel, better road paving, etc. However, the level of NO_x (especially NO_2) and ozone are increasing, primarily due to the increase in volatile organic compounds often blamed on the slowing flow of traffic on roads.

6.2 Nature of Urban and Global Warming Challenges and Options Available

6.2.1 Urban warming challenges and options

Apart from air quality, energy use also affects other local problems, such as urban warming, or the phenomenon of urban heat islands, a condition in which the temperatures of urban areas are about 2 to 7°C higher than those in surrounding rural areas. In the past, this phenomenon was observed during the winter in high latitude cities, mostly in Europe and North America, but today it is increasingly affecting tropical cities during the summer. Excessive energy use is one of the causes of urban warming. Urban warming results in heat stress, an increase in the demand for energy for cooling, an increase in ozone (smog) events and associated economic implications. In Seoul, urban warming is becoming a growing concern, and the number of days each year that exceed acceptable ozone levels is increasing. In 1995, it was reported that only five days exceeded the limit, whereas in 1997 the number had increased to 33 days (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 in Tokyo to act. Tokyo suffers from the urban heat island phenomena, whose impacts are aggravated in the summer (Dhakal and Hanaki, 2002). Measurements made by the Tokyo Metropolitan Observatory indicate that the number of nights over 25°C increased from 14 in the early 1960s to 32.4 in 2000 (TMG, 2003). The vicious cycle of urban warming, which results in the increased use of air conditioners and the consequent high rate of discharge of waste heat into the urban environment, has had a significantly toll on health and the economy.[22] Various measures, including interventions in buildings, land use and energy systems, can alleviate heat island effects (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

22 Studies by Lawrence Berkeley National Laboratory in USA estimate the costs in terms of ozone, smog incidence, additional electricity use and the resultant economic valuations. See: http://eetd.lbl.gov/HeatIsland/

other parts of Tokyo; the maximum contribution of energy use to the heat island effect recorded is 3.4°C (Dhakal and Hanaki, 2002). In Shanghai, the rural and urban temperature difference is 2.7°C (Shu *et al.*, 1997). Seoul is increasingly affected by urban heat island problems, and in response, the Seoul Metropolitan Government is actively studying various measures to mitigate them. Future increases in energy consumption are likely to aggravate the phenomenon. Interventions which reduce urban warming, such as energy management and greater areas of urban green space can reduce CO_2 emissions and enhance carbon sink.

6.2.2 Nature of GHG management challenges and available options

Commercial and transportation sectors are responsible for the majority of GHG emissions in Tokyo. The commercial sector includes large-scale businesses such as office blocks, department stores, hotels, and retail businesses; office buildings and restaurants are responsible for the majority of energy consumption (TMG, 2002a). Despite the economic slowdown, emissions are rising in Tokyo[23]; the fact that the rise comes from non-industrial sectors makes these challenges more serious for local policy makers. Office automation and the increasing use of computers and other office appliances, together with air conditioning systems, are the major sources of CO_2 emissions. In the transportation sector, there has been a structural shift towards larger cars in Tokyo; therefore, despite significant improvements in the fuel efficiencies of different car sizes (which meet existing standards) and stagnant rates of per capita car ownership, CO_2 emissions from automobiles are increasing. In Tokyo, heavy vehicles (gross weights over 2.5 tonnes) account for about one-third of emissions from all automobiles, yet those vehicles are not subject to any standards (TMG, 2002b).

23 This is based on data from 1970 to 1998. At the national levels the peak for CO_2 emissions was in 2000; a 2.7% decline in 2001 from 2000 has been reported. The author did not, however, carry out estimates for Tokyo after 1998. Despite the fact that over 30% of electricity use in Japan comes from nuclear energy located in the north and in Tokyo, the nuclear share must be high. The author used the national average of CO_2 intensity. Since the Tokaimura nuclear accident in 1999 and several other accidents, nuclear plants have been shut down in recent years and the CO_2 intensity of Tokyo's electricity must have increased significantly.

In Tokyo, the major options for policy interventions are in business operations, buildings (particularly office buildings) and the transportation sector. Energy and CO_2 interventions in urban households can be accomplished through improving appliance efficiency, applying fuel pricing mechanisms and using the market to build energy efficiency standards. Lifestyles can be influenced through campaigning and raising awareness. These interventions treat only perceived challenges from direct emissions. In terms of embedded emissions, only those in electricity use are being tackled. City policy makers who aim to reduce direct CO_2 emissions will probably address embedded emission in material use only in the distant future because it is not a local issue. With the recent enactment of a law providing for Material Recycling-Oriented Societal Development in Japan some action may be forthcoming. Despite these challenges, the per capita and per unit of GRP emission performances of Tokyo are better than those of other East Asian cities such as Seoul, Beijing and Shanghai (Dhakal *et al.*, 2002a). Reasons for this could include the compact settlements; the well-developed rail-based mass transportation infrastructure; efficient electric appliances and automobiles; the city's function as a commercial, rather than an industrial hub; and mild winters and summers.

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 can reduce emissions by promoting district heating systems.

In Beijing and Shanghai, industry, buildings and urban transportation are sectors with great potential for interventions which reduce GHG emissions. In both cities, fuel switching in industries is a viable option. Insulating buildings, improving the efficiency of electric appliances and switching the fuel used in central heating systems can also play important roles in reducing energy consumption, local emissions and GHG emissions. The use of energy-inefficient building designs, materials and construction persists despite the construction booms in these cities since 1990. Some improvements have been made in recent years, especially since 2001, when China's Ministry of Construction issued new regulations, yet old practices still continue (Feng, 2002). There are a number of other associated problems such as the discrepancy between heating costs and household income, the lack of market infrastructure and regulations, and the lack of know-how about carrying out energy efficiency improvements (Feng, 2002).

GHG emissions from urban transportation may seem low at the moment for both Beijing and Shanghai, but the massive investment in the transport systems planned for the coming years will increase the potential for energy use, air pollution and CO_2 emissions. Although they have fewer private cars than other mega-cities, Shanghai and Beijing are already suffering from serious air pollution problems due to urban transportation. Furthermore, China's growing economy and WTO membership are likely to increase income, reduce tariffs on automobiles (due to competition and trade barrier reductions) and enhance credit facilitation mechanisms for the purchase of new cars. Thus, urban planners in Beijing and Shanghai are already projecting a three- to four-fold increase in the number of cars and trucks by 2020 (Zhou and Sperling, 2001). Transportation in both cities, but especially in Beijing, is highly dependent on road transportation infrastructure. The Chinese government is increasingly viewing growth in private vehicle ownership, the automobile industry[24] and infrastructure development as a driving force which can stimulate personal consumption and thereby economic growth. As a result, policies designed to stimulate private vehicle use, such as purchase loans, reduced fees for vehicle use[25] and lengthening the useful life of passenger cars from 10 to 15 years, are being implemented (Lin, 2003). In Beijing, massive growth in the transportation infrastructure is being planned ahead of the 2008 Olympic Games and ambitious goals for environmental management have been set. Key management challenges include controlling two-stroke engine two- and three-wheelers.

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24 In 1998, China was ranked 10th in automobile production in the world. It produced two million vehicles in 2000.

25 The Chinese government has 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 like 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, improving public mass transportation systems and limiting private cars, and appropriate land-use planning. These measures should reduce travel demand as well as trip length and frequency.

In Beijing, light-duty gasoline trucks and cars are expected to become a key component in future reductions of energy consumption and CO_2 emissions. Limiting the number of new vehicles alone will not suffice in Beijing and Shanghai; greater efforts are needed to control vehicles in use and to reduce vehicle mileage. Operating efficient public mass transportation systems is crucial. Car-limiting policies are difficult to implement in Tokyo and Seoul. In terms of improving fuel efficiency, fuel quality and end-of-pipe technology at vehicle tailpipes, there is limited scope for further drastic improvements in Tokyo and Seoul; the most promising approach is to implement policies that motivate people to change their lifestyles (including their 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. They include introducing improvements in building insulation, appliance efficiency, and efficient central heating systems. To promoting appliance efficiency, government policies can target building codes, laws, and standards. Simple measures such as changing from incandescent lamps to fluorescent lighting can save a great deal of electricity. The scope for drastically improving appliance efficiency may be much less in Seoul and Tokyo than it is in Beijing and Shanghai. Using renewable energy such as solar panels for hot water production, enforcing appropriate temperature settings for heating and cooling systems and avoiding wasting electricity are other steps which conserve energy.

7 Policy Developments, Countermeasures and Challenges in Cities

7.1 Policy Trends in Cities

Making and implementing policy is a complex process. Although the countermeasures that can address energy demand, local pollution and GHG emissions are many, mobilising just the right mix of different policy instruments suitable for local conditions is difficult. Making and implementing policies in cities in developing countries face the additional challenges of severe technological, financial, regulatory and institutional constraints. A strategy that works well in one city may not work well in other cities due to differences in various prevailing conditions. Even if beneficial policies are in place, institutions may fail to implement and enforce them. In comparison to other cities in the region, Tokyo and Seoul are well-managed. Beijing and Shanghai also have good institutional structures for policy making and implementation. In addition, the decentralisation of environmental governance in Beijing and Shanghai is far better than it is in many cities in Southeast and South Asia. All four cities have constitutional mandates to fully govern the local environment. Despite these advantages, policy barriers and constraints do exist. Better regulations, greater use of economic instruments and market-based approaches, innovative financial mechanisms based on public-private partnerships, and increased institutional capacity to implement policies are necessary developments.

Several successful experiences in building- and transport-related policies implemented elsewhere could be useful for these cities. For example, Singapore has had a successful experience with integrated land use and transportation and vehicle emission control strategies. Singapore implemented strong policies to control the number of vehicles and used congestion pricing and other policy instruments to limit their use. 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 on a small scale (by charging batteries with electricity largely produced by hydropower), shows that various niches for clean fuel need to be tapped even if promoting such measures is a complex process (see Appendix B). Appendix C describes the step-by-step implementation of various measures to control SO_x emissions in Kitakyushu. A balance between curative (end-of-pipe approach) policies for short-term problems and proactive approach policies for long-term problems is essential.

Comprehensive policies focused on GHG mitigation do not currently exist at the city level in Asia, but many cities in relatively developed countries such as Japan and Korea have recently started formulating such policies. Japanese cities are obliged by law to prepare countermeasure plans and several cities in other countries have also opted to make such countermeasure plans. Tokyo is ahead of all other cities in Japan although it has not yet enforced mandatory GHG mitigation plans. Tokyo is trying to integrate GHG reduction into a number of areas such as plans for improving building energy performance, urban warming mitigation, appliance efficiency and road transportation. No such concrete plans have been formulated in Seoul, but the Seoul Metropolitan Government is weighing various options and trying to find avenues to begin with. Shanghai's 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 the potential to cut back CO_2 emissions without introducing any explicit CO_2 countermeasures. Like other cities in developing countries Asia, they, in essence, do not have any explicit policies or targets for CO_2 reduction.

Thus far, the synergy and conflict between air pollution mitigation and CO_2 mitigation is poorly understood in the four selected cities. Improvements in energy efficiency always reduce CO_2 emissions although a change in fuel and a structural shift in activities and fuel type may not necessarily produce a synergy between air pollution and CO_2 emissions. All four cities have largely neglected such considerations. The use of market-based mechanisms such as trading are not on the policy agendas Tokyo and Seoul, and countermeasures are likely to rely too heavily on efficiency improvements in the energy sector. The following section describes in detail the policy initiatives in Tokyo and Beijing.

7.2 Japanese Domestic Policies and Their Implications for Local Governments

Japan's commitment to the Kyoto Protocol, which was ratified by the Diet in May 2002, is a 6% reduction in the 1990 levels of GHG emissions by 2010. From 1990 to 2000, GHG emissions increased by 8%, so a 14% reduction in 2000 levels is needed to meet the Kyoto commitment. The burden lies not only with the national government: without cooperation from local governments, it will impossible to meet this goal. Japan's Law Concerning the Promotion of Measures to Cope with Global Warming[26] clearly seeks the assistance of local governments. Article 4 identifies the responsibilities of local governments as follows: (1) Local governments shall promote policies to limit GHG emissions and to enhance sinks in accordance with the natural and social conditions of their areas. (2) Local governments shall take measures to limit GHG emissions and enhance sinks in their own business activities, strive to provide information on policies specified in paragraph 1, and adopt other measures encouraging enterprises and residents to limit GHG emissions and to enhance sinks. Article 8 seeks the cooperation of local governments in formulating action plans for their business activities and publishing the plans and their implementation status).

Japan's national CO_2 emissions hit a record high in 2000—1.237 billion tonnes, 0.2% higher than in 1999—but dropped 2.7% from 2000 the following year (JFS, 2003). The salient features of the policies of the Japanese government thus far as they relate to the huge task of complying with the Kyoto commitment can be summarised as follows:

26 Promulgated in October 1998. "Shared responsibility" is the key term in Japan's policy; it emphasises the roles and responsibilities of all stakeholders (local governments, citizens and the private sector). The basic policy has four principles: (1) contributing to both the economy and the environment (2) adopting a step-by-step approach in implementing policies and measures (3) sharing responsibility amongst stakeholders, and (4) ensuring international cooperation.

- enactment of a comprehensive regulatory framework. The Law Concerning the Promotion of the Measures to Cope with Global Warming was promulgated in 1998; from 1999, the Japanese Ministry of Environment (then the Environmental Agency) started to implement the law by developing basic policies. A new guideline for measures to prevent global warming was issued in March 2002.
- promotion of domestic discussions, awareness among stakeholders and activity promotion centres
- promotion of voluntary action plans[27]
- national-local linkages: facilitation of local governments
- promotion of energy efficiency improvements and consolidation of other laws, such as the Law Concerning Rational Use of Energy, and their measures[28]
- promotion of a package of more than 100 measures

Despite these measures, the core issues related to implementation are not yet clear. In comparison with other developed nations, especially those in Europe, Japan lacks concrete measures. Some of the shortcomings of its domestic policies are listed below:

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

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27 Keidanren (Japan Federation of Economic Organisations) established its voluntary action plan in June 1997.

28 This includes energy management and 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 implementing CO_2-related policies. Tokyo is working on a comprehensive strategy to simultaneously combat urban and global warming and institutional arrangements inside the Tokyo Metropolitan Government have changed accordingly.[29] A recent survey in Tokyo revealed that more than 90% of respondents felt threatened by rising temperatures in the city and were concerned about global warming.[30] About 96.3% of respondents indicated that they were willing to cooperate and would accept some inconvenience if necessary.[31]

Even with such an overwhelmingly positive response, framing global issues to suit local interests is not easy. One of the three basic principles set out by the Tokyo Metropolitan Government in its Stop Global Warming Campaign is stimulating Tokyo's economy through anti-global warming initiatives. Its slogan underscores the difficulty that a local government faces in rationalising policies for global problems. Other Japanese cities face the same problem Kitakyushu has tried to promote its concept of constructing an eco-city by attracting environmentally friendly industries. Any action based on global environmental considerations alone is difficult to implement; there must be an accompanying economic benefit or direct local environmental benefit.

Institutional response from the Tokyo Metropolitan Government

Regulatory framework

Unlike many cities in Asia, whose mandates for governing the urban environment are limited, the Tokyo Metropolitan Government is empowered to govern Tokyo comprehensively. This includes making rules, standards and regulations for enforcement. At the national level, the Basic Environment Law of Japan (November 1993) provides a framework

29 The Tokyo Metropolitan Government's Bureau of Environment has had a separate department called Urban and Global Warming Department (translated from the Japanese by the author) since 2001.

30 For details see the Japan-for-Sustainability Information Centre, Update of 10 March, 2003. http://www.japanfs.org/

31 Eighty percent said that they were unaware of the TMG's campaigns.

for individual laws related to CO_2 emissions and air pollution, namely, the Air Pollution Control Law (June 1968), the Automotive NO_x and PM Law (June 1992), and the Law Concerning the Promotion of the Measures to Cope with Global Warming (October, 1998).[32] Similarly, the Tokyo Metropolitan Government has enacted its own Basic Environmental Ordinance (July 1994) containing basic environmental regulations. The TMG Master Plan for the Environment (January 2002) provides basic plans to support all individual ordinances (some of which, like the Ordinance on Environmental Preservation, were completely revised in December 2000.)[33] TMG's Global Warming Action Plan was thereby formulated.

Numerical targets

The Tokyo Metropolitan Action Plan for Environmental Conservation sets numerical targets to reduce GHG emissions from Tokyo by 6% of 1990 levels by 2010. This means a 14% reduction from 2000 levels, or about a 20% reduction from business-as-usual emissions in 2012. While this goal is ambitious, such targets have acted as a prime mover for action towards emission mitigation.

Institutional arrangements

In order to facilitate a comprehensive response to global warming problems, TMG established a separate department[34] 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, and buildings. This is a unique institutional arrangement seldom seen in other cities. Although this department is theoretically responsible for comprehensive planning, in reality, it does not include a number of core sectoral issues, such as transportation, primarily because it is politically risky for a city to embark on GHG emission reduction when there is a urgent need to tackle growing SPM and NO_x problems. The newly instituted department was given a mandate for tackling the first

32 Ministry of Environment, Japan, see http://www.env.go.jp/en/index.html

33 Personal interview conducted by author at the Local and Global Warming Control Department (tentative translation) of TMG in June 2003.

34 Urban and Global Warming Department (tentative translation by author)

three of the six key challenges identified after Stage I of the TMG's Stop Global Warming Campaign (see below); these deal with energy use in buildings and appliance efficiency. Since this arrangement may create a greater sectoral focus on buildings and appliances at the expense of including automobiles in comprehensive global warming plans, it may cause unwarranted increases in CO_2 emissions. For example, controlling diesel vehicles by strict regulation of SPM and NO_x may increase the use of gasoline vehicles. Since diesel is more CO_2 friendly than gasoline, this substitution may increase CO_2 emissions. Controlling diesel vehicles through fuel quality, in contrast, may not add penalties to users and thereby may not result in a switch to gasoline vehicles. Close coordination is essential if such problems are to be avoided.

Plans, policies and countermeasures

Most of Tokyo's existing plans and policies revolve around energy efficiency improvements that target appliances, building energy use (office buildings contribute over 60% of the total energy use in the commercial sector) and, to some extent, alternative fuel vehicles. The Tokyo Green Plan (December 2000) is expected to enhance sinks in order to offset CO_2 emissions and alleviate urban warming. Under this plan, Tokyo has recently passed mandatory rooftop greening requirements for new private and public buildings.[35] To implement the Global Warming Action Plan and the Green Building Program as stipulated by the Ordinance on Environmental Preservation, large buildings (over 10,000 m^2 in floor space) are required to publicly disclose environmental plans in the planning stage. The ordinance also requires large energy-consuming businesses[36] to publicly disclose plans to reduce their energy use (from June 2002).[37] In addition to energy considerations, the Green Building Program also looks into a number of other considerations, such as material use and water reuse, and includes a rating system in which buildings receive a grade of 1, 2 or 3.

35 For buildings constructed on land areas of over 250 m^2 (public facilities) or over 1,000 m^2 (private facilities). The Tokyo Green Plan (2000) also requires the submission of rooftop greening plans for new buildings with a total floor area of over 10,000 m^2.

36 For large-scale developers consuming over 1,500 KL/year of crude oil equivalent or over 6 million KWH/year.

37 The Green Building Guideline was issued on 28 March 2002.

The Stop Global Warming Campaign was initiated by the TMG in late 2001 to promote awareness and debates on countermeasures for global warming amongst city residents and the corporate sector. Stage I of this campaign (February 2002 to November 2002) was an information campaign to accelerate discussions about very ambitious five policy proposals:[38]

- introducing obligatory reduction of CO_2 emissions from large corporations, including businesses 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
- imposing restrictions on buying, selling, and making energy-intensive products

The first stage of the campaign, after a series of discussions, basically highlighted some of the key challenges to be addressed. It developed ideas for a single-policy framework for mitigating urban and global warming and provided a starting point for Stage II (November 2002 onwards). The package includes the following goals:

- making CO_2 cuts mandatory for business operations, including office facilities
- strengthening standards of energy efficiency for new buildings
- creating a system which fully informs consumers about 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

In association with other national institutions, the TMG has initiated its own eco-labelling programme to promote public awareness and allow the public to choose energy-efficient products (Figure 7.1). The programme was started in collaboration with seven prefectures and 149 store chains

38 Press release from the Bureau of Environment of the Tokyo Metropolitan Government, 20 February 2002.

Figure 7.1 **Appliance labelling in Tokyo**

in mid-2002. The label shows the cost of the appliance alongside the energy cost for five years and rates appliances from A to D depending on their performance against set standards (JIS).

Other measures that are under discussion are (1) passing an ordinance calling for the mandatory reduction of CO_2 by large business facilities and especially targeting 1,000 factories and offices which produce 10 million tonnes of CO_2 annually; (2) offering social and economic incentives to businesses with proactive and supplementary measures such as emission trading; and (3) introducing green taxes.

Although exact replication is impossible, some of the measures used in Tokyo could serve as guiding principles for other cities in Japan as well in other countries. Tokyo can be viewed as a front-runner in that many local governments in Japan may follow Tokyo's lead, and ultimately increase the positive impact.

7.4 Policy Trends in Seoul

Unlike Tokyo, Seoul has not formulated any explicit policies or plans for GHG mitigation. The Korean capital is, however, carrying out basic research to clarify the status of emissions by developing detailed inventories and to assess the prospects of reducing emissions through various options. The city government aims to implement an integrated approach, in which it synergises its measures for reducing air pollution and GHG emissions. Some of the policies being investigated are listed below:

- provision of clean fuel in the energy sector, especially expanding the provision of district heating to 453,000 more households, increasing city gas coverage by 98.3% in 2007 and gradually introducing clean fuel in boilers
- reduction of GHG emissions from waste by controlling waste generation through a volume- based fee system and introducing appropriate waste treatment systems (which will include restricting small incinerators)

- reduction of emissions by controlling vehicleidling, strengthening inspection systems and promoting low-polluting cars
- introduction of environmentally-friendly traffic measures, such as a no-driving-on-one-weekday system
- restoration of certain city areas and enhancement of the city's carbon sink through greening

Korea joined UNFCCC in 1993 and submitted its ratification of the Kyoto Protocol to COP 8 in October 2002. Since the latter date, efforts have been made to form a government-wide coordination mechanism to establish policies for GHG mitigation. This set up would comprise an inter-ministerial committee led by the Prime Minister and supported by several working groups concerned with issues like energy, environment, forestry and research and development. To date, such plans exist only at the national level and have not trickled down to local governments in terms of any pre-defined demands for compliance. In 1998 the national government signed voluntary agreements for energy auditing with 15 companies; in 2001 the number of signatories had reached 374. A few countermeasures in the forestry and waste sectors, such as forest management and landfill gas utilisation, have been implemented. Such small pilot programs are only in their initial stages, however, and are unlikely to affect GHG emissions on a large scale.

To tackle local pollution, the Ministry of Environment of Korea has unveiled an ambitious plan called "Special Measures for Seoul Metropolitan Air Quality Improvement (2003-21012)." Under this plan, PM_{10} and NO_2 will be reduced from 71 to 40 mg/m^3 and 37 to 22 μ/m^3 respectively between 2001 and 2012 (Seong, 2004). The scheme aims to estimate the environmental capacity of pollutant volumes and to allocate the maximum permissible emission of air pollutants to large point sources. The objective is to control air pollutants by volume within the environmental capacity calculated. To control mobile sources of pollution, this scheme focuses on significantly strengthening emission standards,[39] making it mandatory for automobile manufacturers to sell clean vehicles by certain rates, making

39 By 2006, gasoline vehicles are to meet ULEV levels; and diesel vehicles, EURO IV levels. By 2010, standards are to be an additional 50% stricter.

it obligatory for selected public agencies to buy clean vehicles, offering economic incentives to promote the market penetration of clean vehicles, and strengthening the emission standards for vehicles in use. Government and private sector cooperation is essential if this scheme is to succeed. The role of the Seoul Metropolitan Government is also very important because although the basic plan is being developed by the Ministry of Environment, the implementing agency in this scheme is the local government.

7.5 Policy Trends in Shanghai

In Shanghai, most interventions which will ultimately reduce CO_2 emissions fall under the restructuring of the energy sector. In 1999, the Shanghai Municipal Government drafted a plan for sustainable development in which energy and environmental policies were addressed. According to this plan, coal consumption will be curbed so that by 2010 there will be a 55% reduction in the use of coal as a primary energy source. The transition involves securing the input of three GW of electricity from the Three Gorges Dam and the nuclear plant at Qinshan and increasing the natural gas share to 10 to 12%. Regulatory measures prohibiting the installation of new coal boilers in core city areas are already in place. The policy also aims to control the number of registered vehicles so that it does not exceed 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, for example, the city has adopted the Singaporean practice of auctioning registration permits for new vehicles.[40] A key question is whether or not Shanghai will be able to continue such policies in the future. The 10th Five-Year Plan (2000-2005) aims to stabilise coal consumption in Shanghai; accordingly, changes in the structure of fuel consumption are expected. In particular, Shanghai will benefit from the national programme of transferring natural gas and power from west to east. If distribution infrastructure can be developed in a timely manner, this transfer will compliment Shanghai's plan to establish zero-coal burning zones in the city. To complement these plans, Shanghai

40 In 1998, a cap on the annual registration of new cars and trucks was set at 50,000. See Zhou and Sperling (2001).

has implemented a number of regulatory measures such as the Shanghai Energy Efficiency Regulations, the Shanghai Action Plan on Sustainable Energy Production and Consumption, and Energy-Saving Regulations (Shi, 2004). A number of other measures are being implemented in order to regulate mobile sources. Since the major thrust is on the energy sector, Shanghai can greatly benefit from international funding mechanisms such as Clean Development Mechanisms (CDM).

7.6 Policy Trends in Beijing

In China, decisions about environmental policy are made mainly by three organs (He, 2004). The Environment and Resources Protection Committee (ERPC) of the National People's Congress (NPC) makes policy decisions related to protecting the environment, passes legislation, and supervises its enforcement. The State Environmental Protection Commission (SEPC) of the State Council drafts policies, regulations, and laws for environmental protection. The third body is the State Environmental Protection Agency (SEPA) of the State Council, which supervises and administers environmental protection laws throughout the country. The Beijing Environmental Protection Bureau (EPB) is directly under the 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; it was 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 concerning air quality protection and implemented a series of emergency measures.

In December 1998, the Beijing municipal government announced and started implementing the first of six stages of emergency measures to combat air pollution (BMG, 1999). These measures mainly targeted coal-fired, mobile and dust sources. Coal-fired sources were to be controlled by using high-quality coal, switching from coal-fired to natural gas boilers, and installing 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 of in-use vehicles, retrofitting taxis with dual-fuel engines, and banning vehicles with high emissions from entering downtown areas. In addition, industries were required to apply advanced, low-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. Since the six phases of emergency measures were implemented, SO_2 concentrations have dropped a significant 33% to 80μg/m^3 33%; PM_{10} concentrations, however, decreased just 8% to 162μg/m^3 (Yuan et a.l, 2002). These emergency control measures alone will not meet the future targets adopted by the Beijing municipal government, which require that the concentrations of major pollutants 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 up for the 2008 Olympic Games and the municipal government is unveiling an ambitious plan to decrease local pollution and to extend its transportation infrastructure.

8 Opportunities for and Barriers to Policy Integration

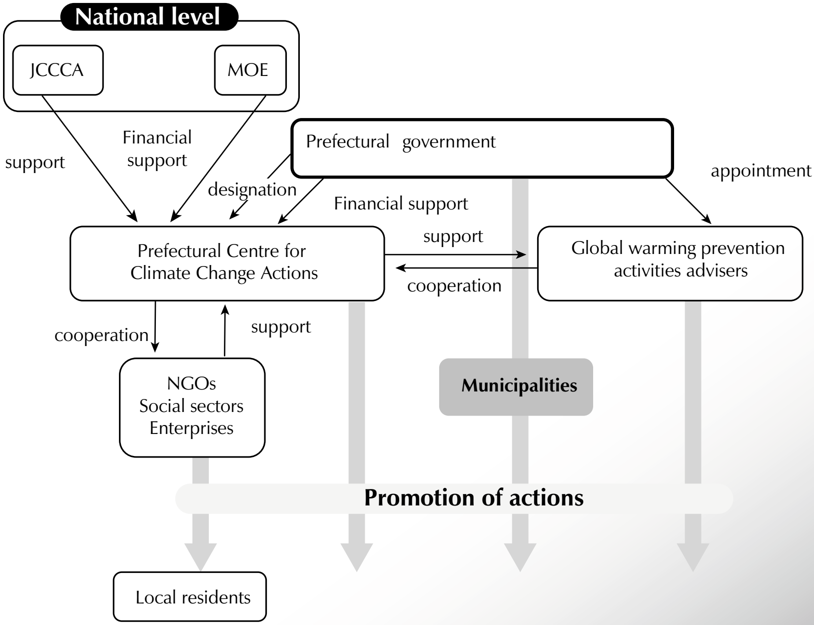
The analyses of Tokyo, Seoul, Shanghai and Beijing included in this report have demonstrated that dealing with energy-related issues at the local level requires two types of policy integration. The first is the integration of energy-related environmental concerns into the overall urban development policies for all sectors. This is a long-term policy issue in which national governments, because of the governance structure of Asian cities, must play a key role. 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 restructuring. The second type of policy is the integration of air pollution and GHG concerns at the local level. This step is necessary because it is perceived that the policies aimed at reducing at GHG emissions alone are difficult to put into operation if there are no accompanying local benefits (such as improvement in air pollution or the urban heat island effect, an increase in energy efficiency or other economic benefits). Cities such as Tokyo, however, may not need such rationalisations in the future if the national government enforces obligatory reductions in GHG emissions in order to meet Japan’s 6% Kyoto Protocol commitment. Besides, many of the countermeasures have the potential to simultaneously contribute to local as well as global concerns; such countermeasures are likely to gain acceptability among local policy makers, the private sector and the general public. Using Tokyo as a yardstick, this section discusses the barriers to and opportunities for such integration. More emphasis here is given to the second type of integration.

8.1 The Role of National Governments and Local-National Cooperation

National-local cooperation is essential for effective mitigation of GHG emission in cities in developed countries. This is also essential for policy integration of air pollution and GHG emission in cities in developing countries, including those in Asia. Mechanisms for cooperation have been introduced 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 cooperation is at the developmental stage. As Japan is the front-runner in climate policy in Asia, major references to cooperation in this section are attributable to Japan.

The Climate Change Policy Law of Japan enacted in October 1998 and amended in June 2002 seeks to develop action plans to limit GHG emissions in the business activities of national and local governments. Accordingly, 47 prefectures, 1,017 municipalities and 360 municipal cooperatives had formulated plans as of early 2004 (Takagi, 2004). The Ministry of Environment provided guidelines for the promotion of local action, which included voluntary plans as well as plans to promote actions to reduce GHG emissions and enhance sinks keeping local conditions in mind. By early 2004, 39 prefectures and 43 municipalities had formulated such plans (Takagi, 2004). National-local cooperation is limited to the provision of such guidelines and regulatory frameworks; concrete partnerships in action-oriented activities are lacking. Figure 8.1 outlines the structure of such cooperation in Japan. This system has yet not been operationalised in terms of financial or other supports. The fundamental limitation to running effective programmes to reduce CO_2 emissions in progressive cities like Tokyo comes from the "watch and see" situation in terms of Japan's national climate policy. In line with national policy, interventions are being made in sectors that are relatively easy to tackle such as energy efficiency and construction sectors; 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 supporting research, assessing the technical feasibility of the integrated approach and promoting donor-assisted projects in cities[41]. In these countries, the role of the national government is especially important because, as will be discussed in the next section, local governments lack the capacity for policies.



Source: *Takagi (2004)*

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

8.2 Institutional Capacity and Arrangements for Addressing Policy Integration

Although the institutional capacity and arrangements of the local governments of Tokyo, Seoul, Beijing and Shanghai are better than those of the majority of other cities in Asia, their capacity for integrated policy is not well-developed.

41 One example is the support for and coordination of the Integrated Environmental Strategies (IES) Program of US-EPA provided by the State Environmental Protection Administration of China and Ministry of Environment of Korea.

To establish effective interventions with regard to climate policy, the institutional mechanisms within the Tokyo Metropolitan Government need to be strengthened. The existing set-up is such that the Urban and Global Environment Division is unlikely to have a significant influence on other divisions within the Bureau of Environment or on other powerful sectoral bureaus, such as taxation, housing, construction, and city planning. The Department of City Planning can play a more effective role in policy integration than can the Department of Urban and Global Warming, which has a limited mandate. Institutional coordination and the development of comprehensive measures is indeed a challenge. Because influencing stakeholders is a difficult task, existing programmes in Tokyo focus on voluntary mechanisms and shy away from mandatory measures. In the case of buildings, for example, most countermeasures involve the voluntary disclosure of information. While the corporate culture in Japan may force big businesses to comply, this may not be true for medium-size or small businesses. Mandatory measures are being discussed in Tokyo but their implementation, in light of the absence of national-level policies, is a key challenge. The first step is to build consensus among stakeholders for enforcing obligatory emission reductions.

The extent of the benefits which Seoul could derive from the integration of policy measures for reducing emissions of both local air pollutants and GHG is largely unknown due to the lack of information about and detailed studies of various options. Chinese cities are in a better position than Seoul 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, these cities have the institutional capacity to force companies to comply with government policy.

8.3 Exploiting Market Mechanisms

Considering how important a role the corporate sector plays in the city's emissions, it is clear that Tokyo ought to exploit market mechanisms in order to reduce CO_2 emissions. However, establishing obligatory or trading mechanisms will not be easy, especially as the national government has not done so. The Japanese national government is expected to implement strong measures like the establishment of an emissions trading system, and thus of credit markets and obligatory emission reductions only after 2005. Exploiting market mechanisms as early as possible is a key challenge for Tokyo. Tokyo has acted with greater alacrity than the national government has in areas like introducing low-sulphur fuel; similar swiftness is warranted in climate affairs.

It cannot be expected that other cities will implement market mechanisms for reducing CO_2 emissions. However, various economic and regulatory instruments that provide the market with appropriate signals for promoting an integrated approach can be introduced. In the case of mobile sources, Singapore's practice of auctioning licenses for new vehicles through competitive bidding, congestion pricing through electronic road pricing (or a less technical method, the area licensing system) and other fiscal measures are good examples (see APPENDIX A). Among other measures, regulating parking charges, promoting public transportation, and creating a niche market for clean vehicles such as battery-operated electric vehicles[42] or hybrid cars can reduce local air pollution and GHG emissions simultaneously.

8.4 Prospects for Sharing Experiences

In a number of other areas, too, sharing experiences amongst cities would be beneficial. The cities identified below could initiate profitable exchanges in the itemised areas of experience:

- **Seoul and Beijing:** district heating
- **Seoul:** reduction in waste volume and utilisation of landfill gas
- **Tokyo:** development of mass transportation
- **Shanghai:** control over the registration of new vehicles
- **Tokyo:** incentives to low-and ultra-low emission vehicles

The flow of information and sharing of lessons should go both ways, from developed to developing cities and vice versa. For example, Tokyo could learn a lesson about district heating and cooling as it is practice in

42 Depending on the fuel mix used to generate the electricity for charging batteries.

Beijing and Seoul. By mid-2001, 72 districts in Tokyo with an estimated area of 1,366 hectares (13.66 km^2) were designated as district heating and cooling zones; the system is now in operation in 63 districts[43]. Since places like Marunouchi and Shinjuku have large concentrations of office blocks (in Marunouchi, Dhakal *et al.* (2004) estimated that the density of building floor area in a one-km grid was as high as 3.5 times more than land areas in the mid-1990s), the potential for district heating and cooling is tremendous. In 2001, over 350,000 households in Seoul were using district heating; the number 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 of these Asian cities and of European cities. The box below shows the potential for, barriers to and lessons contained in the success of district systems in European cities.

Box 8.1 Lessons derived from successful district cooling and heating systems in European cities

- *If cooling and heating systems (CHS) are to be developed, there must be appropriate municipal ownership and planning regulations, such as the requirement that building designers demonstrate the feasibility of CHS.*
- *The heating and electricity prices of alternative supply systems must be competitive.*
- *Technically and economically reliable energy must be supplied to all connected consumers under a variety of external conditions.*
- *Connection rates must be high because the marginal cost of connecting additional consumers is relatively low.*
- *Local efforts must be strong not only so that the connection rate will be high but also so that economic investments will be fully utilised and paid for.*
- *Both the local and global environment must be improved.*
- *Stakeholder participation must be ensured.*

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

43 Tokyo Metropolitan Government: http://www.kankyo.metro.tokyo.jp/kouhou/english2002

8.5 Strengthening CO_2 Concerns Related to Transportation

Responses to CO_2 emissions in Tokyo's transport sector are weak, especially because of its focus on existing problems with SPM and NO_x. Most local emissions come from diesel vehicles, which are more CO_2 friendly than gasoline. Adopting diesel has been eyed as one of the major options for limiting CO_2 emissions from automobiles in Europe, among other places. Regulating diesel vehicles in Tokyo (in particular, light-duty trucks) to control NO_x and SPM, however, has the potential to push automobile manufacturers towards introducing more gasoline vehicles and thus towards creating an eminent threat to attempts to reduce CO_2 emissions. Engaging in active dialogue with the automobile industry is key to enforcing climate-friendly policies. Despite the fact that fuel efficiencies have improved over the time and the number and utilisation rate of vehicles is relatively stagnant in Tokyo, one of the major reasons for the increase in CO_2 emissions is the structural shift towards cars with larger engines. Since emission standards for small and large cars differ, even if individual automobiles meet the standards, the net emission volume will still increase. To counter this phenomenon, a separate emission standard based on the average emission factor for an automobile fleet[44] needs to be implemented in addition to the emission standards for individual vehicles. With this 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 such emission standards exist in other parts of the world, and Tokyo can learn from their example.

The majority of modern rail networks in East Asian cities are electricity-based. Thus, thee fuel mix of electricity generation plays an important role in determining a city's volume of CO_2 emissions. Strategically locating a national gas pipeline network and tapping more hydro power may help Beijing and Shanghai to reduce the GHG intensity of the electricity used in public transportation in the future.

It is essential that mega-cities develop new modes of mass transport and strengthen existing modes. For example, Beijing, as described above,

44 Introduction of Corporate Average Fuel Economy (CAFÉ)

is planning a massive subway development by 2008. In addition, road development should also include environmental considerations and the strengthening of public transportation is essential. Financial capacity is often a serious constraint for such policies, but sound public-private-partnership in transportation services has the potential to overcome such limitations. New international financial mechanisms aiming at improving the environment are also being developed. The Global Environmental Facility (GEF) provides financial support towards infrastructure projects based on "environmental additionality" criteria. CDM, which is under considerable debate and negotiation, may open a new avenue for financing infrastructure projects aimed at integrating air quality policies and reducing GHG emission in cities.

8.6 Creating Momentum for Change by Targeting Available Niches

The integrated approach can get a boost by capturing opportunities existing in specially niches. Though the real effect of narrowly focused measures may be small, directing measures and campaigns toward niches can provide the momentum needed to encourage wider actions. Buses which run on CNG and liquid petroleum gas (LPG) taxis have long been used and their numbers in cities across Asia now run in the several hundreds of thousands. Other niche opportunities exist in promoting demonstration projects and pilot experiments in areas like clean vehicles (see Kathmandu's experience of battery-operated three wheelers in Appendix B), renewable energy technologies, biomass utilisation and waste reduction schemes, all of which would create awareness and impart environmental education. One obvious opportunity for Tokyo to save energy is to use natural lighting as much as possible and to integrate renewable energy technology in building systems. Government policies need to support opportunities in niches as otherwise they cannot take off.

Tokyo has the potential to be a front-runner in CO_2 mitigation and to foster positive changes in the attitudes of other local governments in Japanese with regard to CO_2 emissions. Several other cities, such as Kyoto, are planning to enact an ordinance tentatively called Ordinance on

Global Warming Prevention to promote effective measures against global warming. The city is planning to enforce the ordinance from the fiscal year 2004.[45] Kitakyushu, which is historically an industrial city, is active in global issues and may follow suit. Although the measures currently existing in Tokyo will not suffice if Japan is realistically to meet its 6% reduction target, Tokyo can act as a catalyst for positive change.

8.7 Transition from a Sectoral Approach to Holistic Planning

In general, urban planning-related policies which tackle air pollution and GHG emissions are weak. General observations of East Asian mega-cities reveals the following facts.

- Cities are expanding and extended metropolises put tremendous pressure on urban planning and management. As seen in Beijing, Bangkok, and Shanghai urban sprawl towards the periphery is detrimental to the integrated approach. Containing growth requires new approaches in urban planning, such as growth management and transit-oriented development (TOD), alongside the traditional methods of land use, zoning and building control.
- Traditional urban planning practices do not adequately take into consideration urban environmental considerations, such as waste, air pollution and the urban heat island effect. The development of peri-urban areas due to the dynamics of socio-economic change and the relocation of industries from the city centre is cause for great concern.
- Sound urban planning practices set up a holistic system under which all aspects of a city operate. In this scenario, reducing CO_2 emissions is possible by optimising energy use in urban transportation and households and by choosing appropriate energy supply systems.

Although past efforts to reduce air pollution and CO_2 emissions have, in general, focused on individual sectors, the need for a holistic approach is being realised. Tokyo has begun holistic planning but a few sectors,

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

such as transportation, have responded weakly. Since Seoul is developing GHG mitigation plans, developing comprehensive urban-scale plans by consolidating existing plans and by setting clear goals will be necessary, as will ensuring that there are proper institutional arrangements in the municipality. In rapidly developing mega-cities such as Beijing and Shanghai, provisions for a holistic approach must be made soon as the window of opportunity to act is rapidly closing. Once Beijing and Shanghai are locked into a particular urban structure, remodelling will be extremely difficult.

Comprehensive interventions can only achieved with political or institutional leadership. This requires a number of logical steps, as are listed below.

- preparation of a detailed inventory of selected strategies and their effects
- implementation of selected GHG emission-reducing measures
- establishment of a GHG emission reporting system
- development of an climate action plan and follow-up and monitoring systems

8.8 Unclear Prospects for Synergy and Impediments to Policy Integration

Unlike air pollution, which is widely studied, what opportunities for and barriers to integrated approaches exist is largely unknown. All countermeasures optimising air pollution benefits may not necessarily be the best ways to reduce GHG emissions. When there are several choices for controlling air pollutants, a carefully crafted policy might yield benefits for GHG. The possibilities for and constraints on synergy are unclear to policy makers although many studies have been carried out to evaluate the effects of specific countermeasures on specific pollutants.[46] Table 8.1 shows both how selected local countermeasures against air pollutants can synergise and conflict with global GHG emission control. Since policies

46 For example, what is the impact of measures and policies which have successfully reduced PM_{10} in many cities on GHG emissions?

are implemented in the form of a package of measures, the cumulative effect of such measures must be clarified so that policy makers can be guided towards choosing the most effective combinations.

Table 8.1 Possible synergy with and conflict between local pollution measures and GHG emission reductions (indicative only)

Local countermeasure	Synergy with global concerns	Conflicts with global concerns
Urban transportation		
Introducing CNG or propane Interventions	CNG has been introduced for air quality improvement in cities such as Delhi, Beijing, Bangkok, etc. CNG or propane vehicles, in general, emit less NO_x and PM, and at the same time are more CO_2 friendly than conventional vehicles.	While CNG reduces CO_2 emissions, it may also outweigh CO_2 benefits by increasing un-burnt CH_4 (due to poor maintenance) in heavy- duty engines such as those of buses and trucks. A city's inspection and maintenance system may have an important role in determining the level of gains in GHG emissions. Thus, engine and fuel management technologies need to be balanced. Effects could be different for the dual, retrofitted exclusively designed vehicles.
Controlling NO_x and SPM released by diesel vehicles	High-quality diesel with a maximum sulphur content of 50 PPM diesel may help reduce CO_2 emissions if additional CO_2 emissions at refineries do not offset such gains.	Diesel is now CO_2 friendly than gasoline. Since diesel vehicles are major contributors to NO_x and PM, stringent measures to control diesel vehicles (such as diesel cars, which are small) may result in increasing the number of gasoline vehicles.
Promoting electric and hybrid vehicles	Electric vehicles have no tailpipe emissions of air pollutants or CO_2. Hybrid vehicles reduce air pollutants and CO_2 significantly.	Electric and hybrid vehicles perform poor and are expensive. CO_2 benefits from electric vehicles depend on the fuel mix of electricity generation. If a major share of electricity is generated by coal, the CO_2 benefit may be negative. Only life cycle assessments can provide a clear picture.
Introducing 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 vehicles with bigger engines, the total volume of CO_2 might increase even if such emissions/fuel efficiency standards are met. To reduce the risks of increasing both local pollutants and CO_2 emissions, additional standards based on the average fuel/emission efficiency of a fleet of vehicles (or corporate average fuel efficiency) would be useful.

Local countermeasures	Synergy to global concerns	Conflicts to global concerns
Promoting mass transport and discouraging private cars	Usually such measures reduce CO_2 emissions, as them improves energy performance and reduce gasoline use, which emits a large volume of CO_2. Mass transport reduces congestion and associated CO_2 penalties from vehicles.	Inefficient operation of mass transportation such as metro and bus systems tend to reduce their occupancy and promote private modes which are usually more CO_2 intensive per passenger-km.
Introducing reformulated gasoline for reducing smog, VOC and toxic air pollutants		Reformulated gasoline compromises fuel economy nominally by 1% or 2%; therefore, CO_2 might increase.
Improving fuel quality	Little effect	Little effect
Improving inspection and maintenance systems, changing driving conditions and driving behaviours	May improve fuel efficiency and thereby reduce CO_2.	Rebound effect needs to be watched.
Congestion pricing and traffic management	Reduces congestion, discourages car use and results in 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 reducing CO_2 emissions.	
Switching to natural gas	Helps reduce CO_2 emissions.	
Using low-sulphur coal (clean coal)	Helps reduce CO_2 emissions.	
Promoting renewable energy	Reduces the need for fossil fuels, which are major sources of CO_2.	In some cases only life cycle analyses determine how much gain is really made.
Waste sector interventions		
Reducing waste volume	Reduces the volume of waste to be incinerated or landfilled, GHG emissions will decrease and thus results in lower GHG emissions.	

Local countermeasures	Synergy to global concerns	Conflicts to global concerns
Promoting recycling	The overall impact is not very clear and depends on a number of factors such as the type of recycled products, the amount of energy consumed in making products from recycled materials and the method of disposal.	
Promoting landfill over incinerator usage	Reduces CO_2 from incineration.	Increases methane, whose greenhouse effect is 22 times greater than that of CO_2.
Urban planning interventions		
Controlling sprawl and promoting a 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 spaces	Enhances carbon sink.	

8.9 Role of International Institutions in Policy Integration

International institutions such as UN organisations, various inter-governmental panels, international research institutions and NGOs play a major role in directing international environmental debates and formulating action plans, such as those governing climate policy and trans-boundary air pollution. Such action plans influence the cooperative international activities of bilateral and multilateral institutions that provide support to developing countries.

GHG and air pollution are both caused by burning fossil fuel in industrial, building and transportation sectors. Recently, international institutions have started to take an interest in the promotion of integrated approaches in industries and power plants, which improve energy efficiency and promote new financial mechanisms, such as CDM. Such measures currently exist only on a limited, pilot-project basis. Although it is fairly accepted that integrated approaches are necessary and have multiple benefits, most international institutions have not operationalised explicit policies to promote such approaches. For mobile sources, in particular, integrated approaches are still at the conceptual stage. Unlike stationary sources, mobile sources are diffused into physical space and involve a wide variety of stakeholders.

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

9 Conclusion: Pathways to a Sustainable Future

9.1 General Observations of Cities

The nature of energy use in and GHG emissions from cities in Asia is not well understood. Limited research on energy use by industrial and urban transportation sectors from the viewpoint of managing air pollution does exist, but an overall energy picture is missing. Since energy-related decisions are usually made at the national level, energy management at the city level was not a priority or even an important topic until recently. In some cities, especially those in coal-dominated countries such as China, energy restructuring is on the policy agenda of local governments. At the global scale, the scientific community has made a concerted effort to understand climate change. International frameworks such as the United National Framework Convention on Climate Change (UNFCCC) have been devised to promote the reduction of GHG emissions. Recently, due to the growing concern about GHG emissions at the global level, efforts have been made to understand this phenomenon at the city level in greater detail. Consequently, city policy makers are under growing pressure to take GHG emissions, especially CO_2 emissions, into consideration while planning, although any policy measure solely aimed at CO_2 reduction is unlikely to be adopted soon by any city in Asia except the most developed. The role of CO_2 emissions, especially in rapidly developing mega-cities, is significant, and integrating energy considerations into policy, either by integrating energy concerns into overall urban development or by synergising measures to reduce air pollution and CO_2 emissions, is very important. Efforts should be directed towards providing support to cities by building their understanding of the problem and their capacities to identify measures to tackle it and to implement sound policies.

In Asia, the high density pattern of urbanisation has lead to the evolution of compact and expanded metropolises. As a result, a large volume of energy is utilised in a relatively small area and the concentration of local air pollution is high. In the case of CO_2, urban density may open up possibilities for managing emissions effectively by exploiting compactness itself and by promoting energy efficiency in small physical spaces. Current and future trends indicate that the number of mega-and medium-size cities in Asia will increase drastically. Recent ratification by Russia has already paved the way for Kyoto Protocol to be in-effect by early 2005. In consequence, the challenges for local policy makers to manage air pollution as well as to reduce the CO_2 will increase.

To tackle these challenges effectively, it is important to conduct studies on the role of energy and the determinants of energy use in cities, especially mega-cities. This report discussed energy use, CO_2 emissions and their determinants in two mature mega-cities in Asia, Tokyo and Seoul, and two rapidly developing mega-cities, Beijing and Shanghai. It also analysed policy trends regarding energy, air pollution and CO_2 issues and provided insight into opportunities and obstacles for these cities.

9.2 Clarifying the Nature of CO_2 Emissions and Their Determinants in Selected Cities

Driving forces

A number of factors influence the energy use in and resulting CO_2 emissions from cities: the degree of compactness of urban settlements, urban spatial structure and urban functions, the nature of transportation systems, income and lifestyle, the energy efficiency of key technologies, industrial processes, building technologies, climate, and waste disposal methods. The analyses in this study showed that the impact of population and demographic changes on CO_2 emissions is nominal in Tokyo, Seoul, Beijing and Shanghai; instead, income and lifestyle have a major influences on energy use in all four cities. This also shows that improvements in energy intensity (energy use per unit of activity), which reflect positive technological change and more productive energy use, have played the most important role in reducing energy use and associated CO_2 emissions. The role of improvements in fuel quality and of fuel switching in reducing CO_2 emissions has become important in Seoul in recent years, but their effect in Beijing and Shanghai over the last two decades has been surprisingly little. In the latter two cities almost all CO_2-related benefits have come from increasing energy efficiency. In the transport sector, a rapid increase in the number of vehicles is the major contributor towards increased CO_2 emissions. In Tokyo, rail networks work toward stabilising emissions, but the increase in the number of large cars has the opposite effect. In the household sector, household income and changing lifestyles are responsible for increases in emissions. Interestingly, decreasing household size and the resultant increasing number of households are primarily responsible for increasing emissions in Seoul's household sector.

Waste treatment methods affect GHG emissions: CO_2 is emitted by incinerators and methane by landfills. Unarguably, waste reduction at the source is the best option. Despite huge income differences, Tokyo, Seoul, Beijing and Shanghai have small differences in per capita waste generation (1.13, 1.06, 1.107 and 1.04 kg/person/day, respectively). Because their waste management systems are weak and there is little effort to reduce waste at the source, GHG emissions from Beijing and Shanghai are poised to increase dramatically.

CO_2 emissions

It is not easy to estimate urban CO_2 emissions. First, data is often unavailable, and even if it is, it is problematic from a number of viewpoints. For example, data is often inconsistent because definitions of a city (political, functional, agglomerative, etc.) vary, different aggregation techniques are used to prepare energy balance tables, only aggregated local emission factors are available, and political boundaries change frequently. These factors render inventory making difficult and time-consuming.

Since commercial energy use and income are directly correlated, the per capita energy use has increased in Tokyo, Beijing, Seoul and Shanghai with the rise in incomes in the last three decades. The trend of per capita energy use of all four cities is converging towards a common point (between 1.3 and 1.6 TOE/person). Per capita CO_2 emissions, however, are disproportionately high in Beijing and Shanghai. This suggests that their existing policy interventions have relied too heavily on energy efficiency improvement with little consideration of carbon emissions. In 1998, per capita CO_2 in Tokyo was 4.84 tonnes, or 1.3 times the rate in Seoul; the respective rates in Beijing and Shanghai, on the other hand, were 1.3 and 1.6 times higher than that of Tokyo. The economic recession in Tokyo in the mid-1990s did not reduce its CO_2 emissions as it did in Seoul. This is partly because CO_2 emissions in Tokyo are affected more by lifestyle factors than changes in disposable income. Beijing and Shanghai, in contrast, moved from a phase of low economic and high emission growth in the 1980s to a phase of high economic and low emission growth in the 1990s. The shift can be attributed to technological advancements, increases in market competitiveness, the reform of inefficient state enterprises, the emergence of a strong tertiary sector and massive energy efficiency improvements.

The sources of CO_2 emissions in the four cities differ markedly. In Tokyo, commercial and transport sectors are most responsible, while industry contributes less than 10%, a substantial drop from 35% in 1970. In Seoul, household and transport sectors are dominant, while in Beijing and Shanghai industrial emissions are greatest. In the latter two cities, the transport sector contributes just 5 to 6%, but is growing rapidly, at a rate of over 10%. The transportation sector in Beijing and Shanghai is expected to continue to grow with economic growth, financial market liberalisation (more credit mechanisms will be available to buy cars) and WTO accession (tariff barrier will be reduced). Since transportation-related air pollution is already serious, the growth in the number of vehicles is alarming for local policy makers. The impact of structural changes in the various fuel types CO_2 emissions have been nominal in Beijing and Shanghai over the last two decades. However, they have ambitious plans to tap clean energy such as that from the Three River Gorge Dam project and from the national government's massive natural gas pipeline plan. In Tokyo and Seoul, coal usage has been almost eliminated in recent years and electricity is gradually playing a greater role. Oil dominates the market in Seoul because it fuels massive district heating and cooling systems, which are lacking in Tokyo.

A comparison of the emissions of these four cities with those of OECD and major non-OECD countries based on per capita and per unit economic activity reveals that Tokyo's performance is outstanding. None of the four cities performs well in terms of per capita rates although their performances in emission per unit economic activity are promising. Tokyo does well for several reasons: compact settlements, a well-developed rail-based mass transportation system, low dependency on automobiles, relatively clean energy, high technological efficiency of equipment, good governance, and strong institutional capacity.

Perspectives on the indirect responsibilities of cities

While direct emissions are impossible to miss, emissions embedded in consumption goods are often overlooked in CO_2 debates. Especially in the case of emissions, such as CO_2, which are not bound to certain localities, the true environmental load or footprint of a city needs to be clarified in order to explore alternative pathways for urban development. The role of consumption activities in cities and their effects on upstream production processes and natural resources use must be taken into account. To do so requires conducting a detailed analysis of the consumption activities of urban dwellers. In the absence of such detail analyses, studies using industrial I-O tables can provide some insight into the size of a city's environmental footprints. I-O analyses in this study have shown that the indirect emission of CO_2 in cities such as Tokyo and Shanghai could be over three times that of their direct emissions. Cities do not just consume goods also export them. Taking this fact into account, it is seen that the CO_2 emissions for which Tokyo, Beijing and Shanghai are actually responsible are about 70% of total emissions (direct and indirect). Although this estimate may not truly reflect all consumption-oriented indirect emissions, it provides a sound basis to show that indirect emissions from mega-cities are great and that policy makers should start to consider this issue.

The future of CO_2 and implications for air quality and options

Even the most optimistic scenario, this study found that CO_2 emissions from these four cities will not decrease. On top of that, whether or not optimistic scenarios themselves can be implemented is questionable. The results from bottom-up models show that the numbers of vehicles in Beijing and Shanghai are each about one-tenth the number in Tokyo, but that their total fuel consumption is one-third to one-half that of Tokyo because of lower fuel efficiency and greater per vehicle mileage among other reasons. As a result, the smaller vehicle fleets in Beijing and Shanghai emit a larger amount of local pollutants and CO_2 than is the case in Tokyo. Moreover, light-duty gasoline vehicles are expected to contribute to a drastic increase in CO_2 emissions, and a more than twofold increase in fuel consumption by road transportation is expected in Beijing between 2000 and 2020. Studies done in this project shows that policy measures that intervene in lifestyles and appliance usage will be the most important measures for reducing the volume of emissions from households and businesses, which is the major contributor in Tokyo.

Apart from CO_2 emissions, the concentrations of several local air pollutants in the four cities are already above desired limits. Even in developed cities such as Tokyo, NO_X, SPM and ozone levels are high; controlling them is already a major challenge for local policy makers. In Beijing and Shanghai, TSP, PM_{10} and SO_x levels surpass 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 drastically increase the health risks posed by local air pollutants. Such energy use would also accelerate the urban heat island effect, from which Tokyo and Seoul already suffer significantly.

Tokyo, Seoul, Beijing and Shanghai have a number of options available for tackling CO_2 emissions. Some include improving energy efficiency improvements in buildings and boilers, switching fuel, improving fuel quality, delivering efficient public transportation by improving supply side infrastructure and demand side management, and intervening in the corporate sector. As detailed accounts for each city are described earlier in the report, the discussions below focus on broad issues.

9.3 Policy Directions and Challenges

Efforts to reduce GHG emissions are hampered because local governments are often not aware of global issues; even if they are aware, they assign a little priority to them. In addition, human, technological and financial resources in cities are limited, and cities already face many challenges for local environmental management. With the exception of Tokyo, no city has an explicit policy about reducing GHG. In Tokyo policy measures jointly tackle urban warming and GHG emission issues and interventions have been mostly in terms of implementing changes in the building sector, encouraging the voluntary disclosure of information and conducting energy efficiency improvement programmes. Implicit considerations of GHG mitigation, through the implementation of local air pollution measures and energy sector restructuring have been observed in Seoul, Beijing and Shanghai. However, all air pollution improvement measures do not necessarily contribute to the reduction of GHG. Broader policy agendas, such as emissions trading and mandatory reductions in the corporate sector, do not exist in any of the cities; all market mechanisms. In order to be able to influence powerful stakeholders, such as the corporate sector, local policy makers need to build consensus about the formulation of plans. Institutional barriers to mainstreaming concerns about GHG in overall policy agenda exist even in developed cities such as Tokyo, where the mandate and role of responsible units are limited not only by issues of local priority but also by the institutional structure.

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

This section highlights some of the major opportunities for reducing CO_2 emissions and methods for removing barriers.

- In terms of major infrastructure and energy-emission related indicators, the gap between the developed cities of Tokyo and Seoul and the developing city of Beijing is about 20 years. This gap may assist Beijing in learning from the past successes and failures of

Tokyo and Seoul. However, exchanging experiences from both sides is essential. For example, Tokyo can learn from the district heating and cooling programs in Seoul, while Beijing can learn from the mass transportation and energy efficiency improvement programmes of Tokyo. Seoul's volume-based system of charging for waste and its utilisation of landfill are other model lessons. For such sharing of experiences, it is essential to promote forums that can facilitate information exchange, inter-city cooperation, and the creation of an information base.

- Local authorities must be empowered as, especially in South and Southeast Asia, their role and jurisdiction in environmental management is often too little. Building their capacity to support GHG issues, partly by improving institutional arrangements, is crucial.
- Improving local-national coordination mechanisms and generating concrete national support is essential if GHG mitigation measures are to be effectively implemented.
- Some policies and policy instruments related to emission efficiency of economic activity and emission per unit of vehicular travel have been successful but they have largely failed to control the scale of activity or to encourage a structural shift away from environmentally damaging choices (Figure 9.1). In the transportation sector, for example, existing standards based on emission per km are not sufficient; they must be supplemented by standards based on the average emissions of fleets of vehicles handled by the corporate sector and auto sellers.

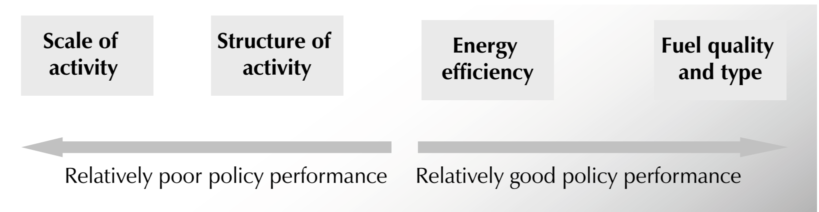


Figure 9.1 Determinants of emissions

- Making the transition from sectoral planning, the current focus of most cities, to urban-level integrated planning, in which an overall urban structural set-up for handling individual sectors is created, is essential. Urban planning practices must accommodate the serious challenges proceeded by metropolitan growth, dense population, dense infrastructure and urban activities. In addition, planning must be able to accommodate newer energy efficiency and CO_2 concerns.

- Developing an energy and emission-efficient transportation infrastructure is essential. Depending on the city, a number of measures can be used, including promoting bus networks, restricting private cars, providing bus lanes, and developing rail-based mass transportation. Investment may pose a challenge, but new financial mechanisms such as public-private partnership schemes and foreign investment can share the costs with the government if the government can facilitate a good working environment from a regulatory, institutional and financial viewpoint. Many Asian cities, especially mega-cities, are rapidly developing infrastructure. Once construction is complete, these cities will be in no position to significantly alter it; to avoid future lock-in, policy makers should incorporate the concepts of energy efficiency and environmental friendliness now, during construction. Although windows are rapidly closing, it is not too late for policy makers to develop visionary policies to make energy-efficient cities in terms of infrastructure.
- In developed cities, securing stakeholder consensus is a key factor in the implementation of any plausible GHG mitigation policy. If mandatory mechanisms do not work in the initial stages, efforts should be made to promote voluntary mechanisms. Using market-based mechanisms such as emissions trading is essential as interventions in the energy sector alone cannot deliver meaningful reductions in the long run.
- Because their priorities are elsewhere, cities in developing cities cannot, at this time, be expected to adopt explicit GHG policies. Instead, promoting integrated approaches—measures which can reduce GHG without seriously compromising air pollution priorities—is a key first step. In the past, the synergy and conflicts between such measures have been inadequately evaluated. Even in cases where it was evaluated, the results were not incorporated in policy implementation due to the lack of serious consideration given to the issue. While industries and power plants have shown some interest in integrated approaches in

terms of CDM and other financial and pollutant-reducing benefits, efforts to evaluate the benefits of an integrated approach have been fewer in the transportation sector. Identifying barriers and opportunities at different scales of environmental governance (local, national, international) is necessary, as is lobbying at the national and international level for extended support for integrated approaches In their capacity-building efforts, cities need to make an especial appeal to bilateral and multilateral funding agencies.

- Mega-cities need to address indirect CO_2 responsibility, too, as they are hotbeds of consumerism, income growth and lifestyle change. As more mega- and medium-size cities develop in Asia, this issue will increase in importance. Though it may not be possible at present to have explicit policies, indirect emissions can be addressed from other viewpoints, including waste management and the creation of a society with a sound material cycle (such as is found in an advanced form in Europe and has penetrated Japan and Korea). These steps not only reduce emissions but also reduce the consumption of precious natural resources. Policymakers, NGOs and other concerned organisations, such as the media, must run campaigns to promote awareness.
- Economically viable technologies will have a bigger role to play in the future of all mega-cities. The promotion of alternative fuel, new transportation, renewable energy, and efficient building technologies is necessary, as is the dissemination of existing high technology to developing mega-cities. Improvements in technology and its management as well as in lifestyle changes are essential for realising a sustainable future.

References

Bai, X. and H. Imura (2000). A comparative study of urban environment in East Asia: Stage model of urban environmental evolution. International Review for Environmental Strategies, Vol. 1, No. 1, pp.135-158. Institute for Global Environmental Strategies, Kanagawa, Japan.

Baldasano, J. M., C. Soriano and L. Boada (1999). Emission inventory for GHG in the city of Barcelona, 1987-1996. Atmospheric Environment, Vol. 33, pp. 3765-3775.

Bennett, M. and M. Newborough (2001). Auditing energy use in cities, Energy Policy, Vol. 29, pp. 125-134, 2001.

BMG (1999). Short-term Air Pollution Control Measures in Beijing 1998-1999. Beijing Municipal Government, Beijing.

Dhakal, S. and K. Hanaki (2002), Improvement of urban warming by managing heat discharges and surface modifications in Tokyo, Energy and Buildings, Vol. 34, No. 1, pp. 13-23.

Dhakal, S. (2002). The urban heat environment and urban sustainability. In Future Cities: Dynamics and Sustainability. Ed. by Moavenzadeh, Fred, Keisuke Hanaki and Peter Baccini, pp. 149-172, Kluwer Academic Publishers.

Dhakal, S., S. Kaneko and H. Imura (2002a). An analysis on driving factors for CO_2 emissions from energy use in Tokyo and Seoul by factor decomposition method. Environmental Systems Research, Vol. 30, pp. 295-303, Japan Society of Civil Engineers (JSCE).

Dhakal, S., Norman, G. (2003). Transitions in Urban Energy and Environment: Perspectives from the South-Asian Conference. Proceedings of South Asian Regional Conference on Transition towards Sustainable Development.

Organised by Industrial Transformation (IT) Project of International Human Dimensions Programme (IHDP) and The Energy and Resources Institute (TERI), February 10-11, 2003, New Delhi.

Dhakal, S., K. Hanaki, and A. Hiramatsu (2004). Heat discharges by an office building in Tokyo using DOE-2. Energy Conversion and Management. Vol. 45, No. 7-8, pp. 1107-1118.

ECOASIA (2001). Towards A Sustainable Asia and the Pacific. Report of ECO-ASIA (Environment Congress for Asia and the Pacific). Long-term Perspectives Project, Institute for Global Environmental Strategies, Kanagawa, Japan.

Feng, Liu (2002). Improving energy efficiency of space heating in China: lessons learned and policy implications. The SinoSphere Journal, Vol. 5, No. 2, pp. 32-40, November.

HABITAT (2001). The State of the World's Cities Report 2001. United Nations Human Settlements Programme (UN-Habitat). United Nations Publications, New York.

Hanaki, K. (2002). Integrated approach for best mix of technologies of reduction of carbon dioxide emissions - Tokyo Half Project (THP). Paper presented at IGES/APN Mega-city Project Workshop, January 23-24, 2002. Kitakyushu, Japan.

He, Kevin, Qiang Zhang and Hong Huo (2004). Integrating global environmental concerns into local environmental planning in Beijing: Policy analysis. Commissioned report prepared by authors for Institute for Global Environmental Strategies, Kanagawa, Japan.

Ichinose, T., K. Hanaki and T. Matsuo (1993). International comparison of energy consumption in urban area. Proceedings of Environmental Engineering Research, Japan Society of Civil Engineers (JSCE), Vol. 30, pp. 371-381 (in Japanese).

ICLEI and Torrie Smith Associates (1999). Just Do It! (But Count It Too!!) Local Action Plans for Greenhouse Gas Reduction and Importance of Quantification. International Council for Local Environmental Initiatives.

ICLEI (1007). Local government implementation of climate protection: case studies. http://www.iclei.org/co2/fact/cpcs97.htm (Aug. 1, 2002), 1997.

IIED (2001). Urban environmental improvement and poverty reduction. Report prepared by International Institute for Environment and Development (IIED) for DANIDA, London.

JFS (2003). Japan for Sustainability Information Centre, January 31, 2003 release. See http://www.japanfs.org

Jung, Hung Soon (2004). Current status of policy implementation by Seoul Metropolitan Government to reduce the emission of GHG. The International Workshop on Policy Integration towards Sustainable Energy Use for Asian Cities: Integrating Local Air Pollution and Greenhouse Gas Emissions Concerns, 28-30 January 2004, Institute for Global Environmental Strategies, Kanagawa, Japan.

Kates, R. W., M. W. Mayfield R. D. Torrie R. D. and B. Witcher (1998). Methods for estimating GHG from local places, Local Environment, Vol. 3, No. 3, pp. 278-298.

KEEI (1998). Yearbook of Regional Energy Statistics 1998. Korea Energy Economics Institute, Seoul.

Kim, Woon Soon (2004). Energy emissions scenario in Seoul and possible strategies for emissions mitigation. Paper presented at International Workshop on Policy Integration towards Sustainable Energy Use for Asian Cities: Integrating Local Air Pollution and Greenhouse Gas Emissions Concerns, 28-30 January 2004, Institute for Global Environmental Strategies, Kanagawa, Japan.

Lin Gan (2003). Globalisation of the automobile industry in China: dynamics and barriers in greening of road transportation. Energy Policy. Vol. 31, pp. 537-551.

Marcotullio, P. J. (2003). Globalisation, urban form and environmental conditions in Asia-Pacific cities. Urban Studies. Vol. 40, No. 2, pp. 219-247.

Marcotullio, P. J., S. Rothenberg and M. Nakahara, M (2003). Globalisation and urban environmental transitions: comparison of New York's and Tokyo's experiences. The Annals of Regional Sciences. Vol. 37, pp. 369-390.

Marcotullio, P.J., and Y.S. Lee (2003). Urban environmental transitions and urban transportation systems: a comparison of North American and Asian experiences. Proceedings of International Workshop on Policy Integration towards Sustainable Urban Energy Use for Cities in Asia, East West Center, 4-5 February 2003. Published by Institute for Global Environmental

Strategies (IGES), pp.143-177, available at http://host-3.iges.or.jp/en/ue/pdf/megacity03/html/1.html.

Matsumoto, T., Zuo. J., and X. Wei (2003). Lifestyle and energy consumption in households. 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.

McEvoy, D. W., K. W. S. Longhurst, and D. C. Gibbs (1997). A framework for the construction of local CO_2 inventories, in air pollution V-modeling, monitoring and management. Ed. by Power, H., T. Tiranassi and C.A. Brebbia, 3-13. Southampton, Computational Mechanics Publications.

McGranahan, Gordon, Pedro Jacobi, Jacob Songsore, Charles Surjadi and Marianne Kjellen (2001). The Citizens at Risk: From Urban Sanitation to Sustainable Cities. Earthscan Publications Limited.

Newman, P. (1999). Sustainability and cities: extending metabolism model. Landscape and Urban Planning, Vol. 44, pp. 219-226.

Sawa, T. (1997). Japan's experience in the battle against air pollution. Committee on Japan's Experience in the Battle Against Air Pollution, Tokyo.

OECD (1995). Urban Energy Handbook: Good Local Practice. Organisation for Economic Cooperation and Development, Paris.

Seong, Suho (2004). Korean national policy for mitigating GHG emissions. Paper presented at The International Workshop on Policy Integration towards Sustainable Energy Use for Asian Cities: Integrating Local Air Pollution and Greenhouse Gas Emissions Concerns, 28-30 January 2004, Institute for Global Environmental Strategies, Kanagawa, Japan.

SEPB (1998). Shanghai SO2 integrated pollution control planning. Shanghai Environmental Protection Bureau, Shanghai.

Shanghai (1999). China's Agenda 21: Shanghai's Plan of Action. ISBN 7-5327-2333-X/F.115. Shanghai Municipal Government, Shanghai.

Shi, Min (2004). Local energy use and air pollution policies: challenges and opportunities for tapping global environmental benefits in Shanghai. Paper presented at The International Workshop on Policy Integration towards Sustainable Energy Use for Asian Cities: Integrating Local Air Pollution and Greenhouse Gas Emissions Concerns, 28-30 January 2004, Institute for Global Environmental Strategies, Kanagawa, Japan.

Shu J., C. Li, H. Long, L. Deng, and N. Yuan (1997). On some features of the urban climate of Shanghai. International Symposium on Monitoring and Managing of Urban Heat Island, 19-20 November, Keio University, Japan.

Stubbs, Jeffry and Giles Clarke (1996). Mega-city Management in the Asian and Pacific Region: Policy Issues and Innovative Approaches. Vol. II. Published by Asian Development Bank. ISBN 971-561-083-8.

Takagi H. (2004). National Climate Policy and Roles of Local Governments: Issues and Opportunities for National-Local Interaction for Mitigating Greenhouse Gas Emissions in Japan. Paper presented at the International Workshop on Policy Integration towards Sustainable Energy Use for Asian Cities: Integrating Local Air Pollution and Greenhouse Gas Emissions Concerns, 28-30 January 2004, Institute for Global Environmental Strategies, Kanagawa, Japan.

TEW (1997). Tokyo Environment White Paper. Published by Tokyo Metropolitan Government.

TMG (1999). Waste Management in Tokyo, Bureau of Waste Management, Tokyo Metropolitan Government.

TMG (2000). Transport Demand Management Action Plan. Tokyo Metropolitan Government.

TMG (2002). Press release of Bureau of Environment, Tokyo Metropolitan Government, 20 February 2002.

TMG (2002a). Tokyo Basic Environmental Plan, Tokyo Metropolitan Government, Tokyo.

TMG (2002b). Stop Global Warming: Tokyo Challenges. Press release, Bureau of Environment, Tokyo Metropolitan Government, 20 February 2002.

TMG (2003). http://www.kankyo.metro.tokyo.jp/kouhou/english2002/index.html. Accessed on 24 December, 2003.

UN (2002). World Urbanisation Prospects: The 2001 Revision. Population Division, Department of Economic and Social Affairs, United Nations Secretariat, New York.

WDI (1992). World Development Report 1992: Development and Environment. The World Bank, Published by Oxford University Press, New York.

WDI (2001). World Development Indicators 2001 CD-ROM. The World Bank, Washington D.C.

Wu Di (2004). Energy consumption and the development of air pollution control in Beijing. Paper presented at The International Workshop on Policy Integration towards Sustainable Energy Use for Asian Cities: Integrating Local Air Pollution and Greenhouse Gas Emissions Concerns, 28-30 January 2004, Institute for Global Environmental Strategies, Kanagawa, Japan.

Yoon Eui Young and Jo Sunghan (2003a). MSW management and energy recovery from incineration heat and its effect on GHG emissions reduction in Asian mega-cities. Commissioned paper for Institute for Global Environmental Strategies, Kanagawa, Japan.

Yoon Eui Young and Jo Sunghan (2003b). MSW management and energy recovery. Presentation at International Workshop on Policy Integration towards Sustainable Urban Energy Use for Asian Cities, February 4-5, 2002, East West Center, Honolulu, Hawaii , USA.

Yoon, S. and K. Araki (2002). Scale of economy in urban energy use. Proceedings of IGES/APN International Workshop on Policy Integration and Industrial Transformation towards Sustainable Urban Energy Use for Cities in Asia, January 23-24, 2002, Institute for Global Environmental Strategies, Kanagawa, Japan.

Yoon, So-Won (2003). Analytical review on the relationship between urbanisation and environmental distress in Seoul Metropolitan Region. Proceedings of IGE-KEI International Workshop on The Role of Planning Practices toward Sustainable Urban Environment in Asia, Seoul, pp. 79-83.

Yuan, J., L. Fu, X. Yu, J. Hao, K. He (2002). Environmental effect analysis for four stage measures of short-term air pollution control in Beijing. Environment Science, 2002, Vol. 23, No. 3, pp. 9-13.

Zhou, Hongchang and Daniel Sperling (2001). Transportation in developing countries: GHG scenario for Shanghai. Report Prepared for Pew Center on Global Climate Change. Downloadable from http://www.pewclimate.org/projects/transportation_shanghai.cfm

appendix A

Urban Transportation and Environmental Management in Singapore:

Lessons for Other Cities

ABSTRACT: To combat the environmental problems and congestion which arise from urban transportation, both end-of-pipe interventions such as traffic management and tailpipe emission control and more upstream measures such as urban and land-use planning have been implemented in many cities around the world. Singapore, in particular, has achieved rare success in managing congestion and the environment amid high economic growth through integrated land use, transportation and environmental planning. This paper examines this success story in detail: the underlying situation; the major policy instruments designed to curb vehicle ownership and use, including quotas, fiscal control and road pricing; and policy impacts. 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

The use of fossil fuels is a major cause of emission from urban transportation. Cities around the world have implemented measures at different stages, ranging from end-of-pipe interventions to more upstream measures like containing travel demand, and in different forms, from command-and-control to market-based. Since containing the growing demand for travel has negative implications for economic growth, cities often focus on how to organise travel demand into a better modal structure, a step requiring the integration 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 and their corresponding social, economic and human health costs. Policy makers are concerned about the share of private transportation in both meeting demand and contributing to pollutant concentrations. End-of-pipe approaches such as setting emission standards, improving fuel quality, and implementing vehicle technology interventions are limited neither the environment nor congestion will improve as long as the number of vehicles and their use increase. While such measures are necessary there are not sufficient. A long-term solution to the environmental and congestion problems urban transportation introduces in dense Asian cities requires additional steps.

Since the country gained independence in 1965, policy makers in Singapore have shown concern about integrated urban, land-use and transportation planning (see Table A1). The major motivation for Singapore was not environmental considerations but economic prospects; it saw itself becoming a prominent manufacturing, commercial and trading centre by utilising its unique geographical location. Singapore was successful in meeting an unprecedented demand for travel while keeping congestion and environmental pollution within acceptable limits (set by the WHO and EPA-USA) and achieving economic growth from SG$ 7.5 billion in 1965 to SG$ 138 billion in 2001 (at 1990 market prices) (SDS, 2002). Singapore employs a mixture of command-and-control and market-based instruments to manage travel demand and related environmental problems. This paper discusses and analyses several policies and instruments with special attention to two: congestion pricing and vehicle ownership restrictions. This analysis of the conditions underlying the workability of these instruments is important if other cities are to be able to replicate Singapore's success in their quest for congestion- and pollution-free urban systems. The following questions are explored: How successful was Singapore's action? What was the situation underlying the city-state's opting for such aggressive policies? What kind of policies and policy instruments were implemented? What was the prevailing situation that led to the successful implementation of the policy instruments? Are there prospects for replicating one or more aspects of Singapore's experience elsewhere?

Table A.1 Key dates in transportation in Singapore

Year	Activity
1968	Ministry of Communications established, 30% import duty on cars imposed
1970	Bus service reform begins
1972	Import duty and ARF increases
1973	Singapore bus service is unified
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	ERP begins
1999	ERP extended to highways

A.2 Challenges and Strategies for Integrated Planning

The city-state of Singapore achieved independence in 1965, at which time housing shortages and unemployment were major problems. Singapore was a densely-packed settlement surrounded by shantytowns in the coastal area: the average density of the city's 400-hectare core exceeded 1,200 persons per hectare in 1959 (Willoughby, 2000). In 1965, nearly 70% of the population of 1.8 million was concentrated within a 5-km radius of the port of Singapore, the city centre (Humphery, 1985). In 1965, the newly elected People's Action Party made housing and employment a priority and the landmark land-reform legislation the Land Acquisition Act of 1966 gave the government sweeping powers to acquire land. The result was 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. Singapore's strategic location and policy of economic liberalisation attracted huge manufacturing investments after 1965, and Singapore maintained double-digit economic growth until the first global oil crisis in 1973. In the late 1960s Singapore also attracted the attention of the financial and commercial sectors. In the 1960s and 1970s, per capita car ownership in Singapore was high relative to its per capita income. In the 1960s alone, the numbers of cars doubled and that of motorcycles tripled. Income was rising steadily. The public transportation system was slow and unreliable. Traffic congestion in 1975 vehicular speeds during peak hours to an average of 19 km/hour (Phang and Toh, 1997).

Realising that land-scarce Singapore needed sound long-term city planning in order to accommodate the growing economy, the government initiated a four-year State and City Planning (SCP) Project. This 20-year conceptual plan was completed in 1971 with support from the UNDP. Unlike earlier plans, it focused on planning to accommodate four million rather than two million residents. In terms of the transportation sector, the project estimated that by 1992 it would be environmentally unacceptable and physically impossible to build road infrastructure to meet the prevailing rate of growth in numbers of private automobiles and that buses alone would not be able to meet public travel demand. It suggested easing traffic congestion within the business centre by developing a rapid transit system in addition to expressways (Fwa, 2002). Following the recommendations of SCP, the Singapore government implemented a number of measures from 1972 to 1992. They included restricting private vehicle ownership by imposing high import duties, charging additional registration fees (ARF), using a vehicle quota system VQS, restricting private vehicle use in city centres through an Area Licensing System (ALS), expanding expressway systems and constructing a 67-km mass rail transport (MRT) system. At the time, public transportation was provided by three principal groups: a large British-owned bus company, eleven smaller Chinese-owned companies and unlicensed taxis; the result was a slow, inadequate and unreliable system. To organise the system, the government forced a merger in 1973; the major market share of this single company was initially in government hands but was floated on the Singapore Stock Exchange in 1978. With the quality of public transportation improved, switching away from private cars became a viable choice for travellers.

Since appropriate land use and urbanisation influence travel demand, interventions are often limited because the government has no rights over built private property. In Singapore, however, the government's control over land rights enabled the HDB to plan housing zones and to construct high-rise and affordable housing estates in them. The government scheme was successful in moving city dwellers to newly-constructed public housing well-equipped with supporting commercial and recreational establishments. Today, 86% of the population lives in such estates (MIA, 2001). These activities followed SCP's suggestions to adopt a ring concept, in which high-density residential areas, industries and urban centres were to be distributed in a ring formation around the central business districts. A revised plan introduced in 1991 replaced the ring concept with four decentralised areas in a constellation pattern (Lye, 2002).

Despite strong economic growth and a twenty-fold increase in office space and in employment, Singapore has maintained its environmental and transportation systems under acceptable limits. In 1995, the level of motorisation was slightly over 100 cars per 1000 people, the average level of cities with an income level one-third that of Singapore. Recent data suggests that the average speed during rush hour is 20-30 kph on city roads and 45-65 kph on expressways. In addition, the concentrations of major air pollutants in Singapore are well within the limits the WHO and the U.S. Environmental Protection Agency have laid out (see Table A.2).

Table A.2 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

Pollutant type	Average time	1982	1988	1994	1999	Standard
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

* In 1982 ozone measurements were conducted using the neutral-buffered potassium iodide method; this method was subsequently replaced by the ultra-violet photometric method.

Source: Ang and Tan (2001) citing Pollution Control Department; Ministry of Environment, Singapore

Initially, it was the Ministry of Communications and Information (MCI) of Singapore that had the mandate to oversee all land transportation policies through its departments and statutory bodies. Ministerial restructuring was carried out in 1990, 1999 and 2001, and in November 2001, the department's 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 restricting car ownership and all policies and schemes curbing car use. 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 the URA jointly manage parking spaces and policies, while the LTA and the Ministry of Environment (especially the National Environmental Agency created 1 July, 2002) cooperate with the traffic police to control motor vehicle emissions. The HDB is responsible for the construction and sale of housing complexes. These agencies coordinate closely to achieve integrated land use, transportation and environmental planning.

The countermeasures in Singapore to reduce air pollution and thereby improve the environment include driving clean vehicles with emission limits, using clean fuels and controlling traffic congestion. Interventions in fuels and vehicles have had much success in cities around the world, whereas interventions in traffic congestion have not. Singapore, with its system of travel demand management (TDM), is an exception. TDM was principally achieved through four major instruments to limit the number and use of private cars: (1) fiscal measures to curb car ownership (2) a VQS (3) an ALS, which has been recently upgraded to an electronic road-pricing (ERP) system, and (4) efficient and affordable public transportation systems.

A.3 Analyses of Major Policy Instruments

A.3.1 Fiscal measures to curb car ownership

Singapore has relied upon high taxes and fees to curb car ownership. Fiscal measures include an import duty levied through the Customs and Excise Department; a goods and services tax; registration fees, including an ARF imposed by the Land Transport Authority when imported vehicles are registered; and road and fuel taxes. These measures generated a large amount of revenue, which, in turn was invested in land transportation infrastructure. The import duty was 30% of the open market value (OMV) of in 1968; it increased to 45% after 1972 but was subsequently reduced to 31% of the OMV for cars, 12% for motorcycle, 7% for taxis and 31% for buses with eight or fewer seats. On 4 May, 2002, the import duty for cars was further reduced to 20% of the OMV. In 2002, the goods and services tax stood at 3% of the cost of CIF cost plus the customs duty. The ARF was originally introduced in the late 1950s and, after several revisions, stood at 140% of the OMV from 1980 to 4 May, 2002, when it was reduced to 130%. In 1968, registration fees were SG$ 15; they had increased to SG$ 1,000 in 1980, but after the introduction of ERP in April 1998, dropped to SG$ 140. Total car registration fees, including ARF, increased 17.5 times from October 1972 to October 1983, from 10% to 175% of a car's price (Fwa, 2002). The Singapore government has also imposed high taxes on retail fuel prices. Taxes vary according to fuel grade. The best grade of gasoline is taxed at SG$ 0.44 per litre (or 35% of the pump price before a 3% goods and sales tax). The tax on diesel was lifted in late 1998. The annual road tax varies from SG$ 70 cents per cubic centimetres for cars with 1000 cubic centimetres engines to SG$ 175 cents for those with engines larger than 3000 cubic centimetres engines per year (Lye, 2002). Since ERP was introduced in September 2002, a rebate in road tax has been offered. The formula for calculating the rate of rebate for cars is given in the appendix. A preferential ARF for vehicle modernisation, in which the registration fees for new vehicles whose purchase results in the scrapping of older vehicles of the same class and size, was launched in 1975. The growing economy and rise in living standards, however, soon surpassed the economic disincentives to own a car. Despite the heavy financial burdens of owning a car, Singapore saw a 73% rise (an average of 13,000 cars a year) in the number of cars from 1977 to 1984, followed by a brief recession and again a steep rise of an average 15,000 car a year from 1987 to 1990 (Fwa, 2002). Although this increase was much less than in other similar nations, it was unacceptable for the Singapore government, which imposed a new fiscal measure to control the number of vehicles: the VQS maintains a 3% annual growth rate. In part, the preferential ARF contributed to the increase in the number of vehicles due to the continued increase in the ARF and the appreciation of the Japanese yen. Dealers marketed cars by arguing that assets would increase. Indeed, in the case of some classes of cars, older cars did increase in value over time (Willoughby, 2000).

A.3.2 Vehicle Quota System

Announced in February 1990, VQS was intended to cap the number of newly registered vehicles. VQS was an easier instrument than the ARF, a pricing instrument whose changing level was politically sensitive. With VQS, the government fixed the number of allowable vehicles but not their price, which remained determined by the market. Under this system, prospective vehicle owners obtain a certificate of entitlement (COE) making ownership of a vehicle valid for 10 years through open bidding. Bidding is opened twice a 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 the price levied on all successful bidders for 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 selling prices of cars (Fwa, 2002; Willoughby, 2000). Table 3 lists an illustration of COE prices.

Table A.3 Certificate of entitlement (COE) bidding on 20 November 2002

Category	Quota	Quota premium	Total bids received	No. 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

1) A, B and D are non-transferable categories 2) 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, including weekend cars, small cars, medium cars and taxis, big cars, and luxury cars were established at the outset. Since this system resulted in too many complexities, it was simplified in 1999. Now, only two categories exist for cars: below 1600 cc and equal to or above 1600 cc. Public and school buses, diplomatic vehicles, ambulances and emergency vehicles are all excluded from the scheme. When his ten-year COE expires, an owner has to de-register or acquire a new COE at the price of the three-month moving average quota premium in that category. Since 1999, many efforts have been made to discourage speculation and other distortions but the basic rule has remained the same (Phang, Wong and Chia, 1996; Toh and Phang, 1997; Chu and Goh, 1997). For example, when it was introduced, COEs were transferable and a speculative market soon developed. Indeed, in the first two months, 20% of COEs changed ownership. In response, the government in October 1991 made COEs, with the exception of open and goods categories, non-transferable. To soften such strict measures, which controlled demand rather than need, the government implemented relief measures such as the week-end car (WEC) scheme, which provided rebates in ARF, import duties, quota premiums and road taxes but allowed WEC use only during off-peak hours. For urgent cases, five-day-use licenses were granted when annual road taxes were paid at the cost of SG$ 20 a day. In essence, WEC was a manual road pricing scheme, although in a very primitive form.

A.3.3 Area Licensing System

ALS is a road-pricing mechanism in which each car is charged for its contribution to congestion in central business districts (CBD). Import duties, ARF and other measures such as road or fuel taxes cannot influence the use of cars once they are on the street, but ALS can. Introduced in 1975, the scheme was based on a cordon-pricing system, in which a cordoned CBD area of 5.59 km^2 (600 hectares) referred to as a restricted zone (RZ) was isolated from the rest of the city by constructing a 22-entry point (Toh, 1977). In the scheme, a license to enter a restricted zone during morning peak hours (7.30 to 9.30 A.M.) had to be purchased in advance at the cost of SG$ 3 (later SG$ 4) a day (or SG$ 60 per month; later SG$ 80). The system was paper-based and verified by observers at the entry posts. Non-complying vehicle owners had to pay a fine, about which they were notified at home through a letter. Restricted zones, times and prices 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; after 1989, they were not exempted. Also in 1989, the charge for public parking in restricted zones was raised and additional surcharges were levied on private parking operators to discourage car use.

ALS was highly successful in curbing traffic congestion during morning peak hours. By the fourth week of ALS, traffic flow during peak hours had fallen by 45.3%, the number of cars had dropped by 76.2%, and the percentage of commuters travelling by public had risen from 35.9% to 43.9% (Toh, 1977, Yap 1986). The average speed of vehicular traffic increased from 18 to 35 kph (Willoughby, 2000). Traffic was reduced by 45.3%, substantially more than the targeted 25-30%. However, ALS also increased traffic pressure just before and after restricted hours as well as on areas contiguous to the restricted zone that served as an escape corridor.

Supplemental traffic management measures were then implemented in those areas to relieve pressure. The anticipated mirror effect of less traffic during evening peak hours, did not occur. In order to make optimal use of road space and to ensure a smooth flow, several adjustments in the times and places restricted were made in later years through careful monitoring. After 27 years of ALS implementation, the inbound traffic volume in CBDs during morning peak hours was still less than it used to be before ALS implementation (Fwa, 2002). Apart from congestion, the major advantages of ALS were energy saving and air pollution reduction. Fwa and Ang's conservative estimate of energy savings with and without ALS, which was based on 1990 data on the flow and speed of traffic, suggested that savings amounted to 1.043 GJ per day in 1996. The shift from clean vehicles to a clean transportation system relieved Singapore's over-dependence on end-of-pipe measures for air pollution in CBDs.

One of the major questions regarding ALS is whether the pricing was correctly fixed with respect to the given externalities to society due to congestion and environment. In 1990, a study by the Public Works Department in Singapore revealed that in RZs the average speed during morning peak hours was higher than it was 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 pricing mechanisms varying over time and space, no price, in fact, could be optimal. Electronic road pricing (ERP), the new measure that has replaced manual ALS, may, however, with its improved technology, pave the way for a fair pricing mechanism.

A.3.4 Electronic Road Pricing

ERP replaced ALS in September 1998. Its basic idea is similar to ALS, but since it is ERP technologically sound, it can vary charges over time and spaces and reflect the true cost of vehicle use in CBDs. In this system, all 33 ALS gantries were replaced with ERP gantries for every 720 ha of core area and vehicles allowed to enter RZs were fitted with in-vehicle units (IU)—in the lower right-hand corner of windscreens of four-wheeled vehicles and on the handlebars of motorcycles. IU units read stored-value cash cards from which charges are deducted automatically using a shortwave radio frequency link as soon as a vehicle enters a RZ through an ERP gantry. Photographs of the license plate of non-complying vehicle are taken automatically for further action.

On the institutional side, four departments in the Land Transport Authority are involved in the operationalisation of ERP. The traffic management department is responsible for setting up rules and guidelines; the computer information department maintains the hardware and software, and the regulation department enforces rules and regulations and deals with violations. The vehicle engineering department also plays a role.

At the moment, pre-determined ERP charges vary each half hour throughout the day, from SG$ 2.50 during peak hours to 50 cents during off-peak hours depending on the road section. Charges are different for motorcycles, cars, goods vehicles, taxis, buses, etc., and different IU units are installed in each category of vehicle. The fundamental question is how much an appropriate charge is. Theoretically speaking, real-time pricing reflecting the cost and level of congestion and the relative contribution of each vehicle category to that 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, however, charges do not fluctuate depending on the traffic conditions in Singapore. Instead, 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 is less than SG$ 300 and for new vehicles with IU units, rebates of as much as SG$ 200 are offered on road taxes. Frequent adjustments, such as special reduced-ERP prices during school holidays when traffic is reduced, are possible and, in fact, are being carried out.

A.4 Why Did TDM Work in Singapore?

TMD has had only limited success in many parts of the world, most of which actively pursue supply side measures (such as building road infrastructure, etc.). Supply side measures, however, are never sufficient and, in fact, place a 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 resource conservation downstream as well as upstream. The fundamental question is why TMD worked in Singapore.

Integrated city planning is the key word in Singapore's success. All the measures it has introduced are a part of a comprehensive strategy and are coordinated very closely to produced a comprehensive solution. No single measure alone can work. The right to travel is a basic human right; however, government policies can offer options which encourage travellers to choose modes which are both sustainable in the long term and acceptable to residents. When ERP was implemented in Singapore, commuters had several choices: (1) pay the charges and drive smoothly, (2) change the time of travel and pay lower charges, (3) use alternative roads, (4) use public transport, and (5) use other schemes, such as park-and-ride (Menon, 2002). Singapore's success is also coupled with favourable economic, social and urban conditions. The smallness of both the land area and the population size allowed for flexible planning. As a city-state, Singapore has only a single tier of government; thus, all the complexities which arise from layers of authority and a mismatch between local and national priorities are eliminated. 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 sustainable growth in transport and concern for the environment. Unlike in other countries, where economic growth is curbed by environmental countermeasures, economic growth in Singapore was actually fostered by improvements in environment and transport. A strong government, stable and strong regulations and institutional frameworks for enforcement are other reasons why TDM worked in Singapore. From the point of view of jurisdiction, the roles and responsibilities of authorities responsible for urban and land use planning, land transport and environment were clearly demarcated. The land reform process initiated in 1967 allowed the government to acquire a most of the land and the subsequent development of housing estates on the city's periphery and facilitated the development of infrastructure suitable for sound land-use planning. The HDB, which was set up in 1960 by the British colonial government, provided housing to just 9% of the population in 1960. Because the sweeping powers of the Land Acquisition Act enabled the government to acquire private land for public housing or other development activities, today 85% of the population live in HDB housing complexes. Another reason for Singapore's success is the periodic adjustment of policies using feedback from the public and other stakeholders, which is made possible by transparency in policy formulation. Singapore has learned by doing. It recognises that policies are never perfect and provides for adjustments. For example, ERP charges are subject to review every three months, and charge structures and times change depending on traffic and economic conditions.

Another key to TDM's success has been infrastructure investment. Demand side management was supplemented by constructing additional road infrastructure, maintaining roads well, coordinating traffic light systems, and building expressways and MRT. The taxes and fees imposed on vehicles generated huge financial resources, which were invested in demand and supply side management but also applied to reducing less desirable taxes. Willoughby (2000) estimated that the annual revenue from road transportation was at least three to four times greater than road expenditure.

Some technology factors also played important roles in Singapore. ERP for example, depends on sophisticated technology that allows time-of-day pricing which reflects traffic conditions. Its prototype, ALS, was, in contrast, a non-technology measure. A computerised traffic controlling system was already in place by 1986 in CBDs (Lee, 1986). It was replaced with a more advanced automated traffic signalling system called GLIDE (green link determining system), a traffic-adaptive signal control system monitored centrally to adjust to changing traffic conditions (Lee, 1990). Efforts are now being made now to create a Global Positioning System (GPS)-based coordinated public taxi-calling system which dispatches taxis automatically from the nearest location. Individual taxi operators are already using GPS. These high-technology measures provided support to non-technology restrictions on car ownership and use. Some researchers claim that the overall effectiveness of high-technology measures is questionable (Fwa, 2002).

A final reason for the success of TDM is that Singapore is a migrant society with citizens who originated from many countries. Since most were economic migrants, their opposition to government policies was minimal. Thus, there were no barriers in the form of an organised force of resistance.

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

The big question is what lessons Singapore's experience can offer to other cities once localised favourable conditions are discounted.

Because Singapore is both a city and a nation, policies can be implemented with ease. It is possible to control the flow of goods and services in and out of the city as it is effectively an island. 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 reserved land for city planning. With the exception of cities in a few centrally-administered countries, the governments of most dense cities in Asia do not exercise similar control over land. Calls for land reform have set limits and placed constraints on the public, but the policy makers of many countries do not address land reform because it is such a sensitive issue. In densely built-up cities, some changes in land use may be possible by providing incentives to de-populate central areas; however, their effectiveness may well be nominal.

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

In general, a strong legislative and institutional framework is a prerequisite. ERP may seem a little bit too ambitious at the moment for cities in developing countries but other measures such as ALS and VQS do not need high technology and are not complicated to operate. ALS, for example, is a simple, easily enforceable measure suitable for dense city core areas in mega- and medium-scale cities which curtails emissions and congestion during peak hours. Local governments, under the self-governance acts in force in many cities, can carry out such provisions. Like parking regulations, ALS does not interfere with the national government, and the revenue generated can be used by city authorities to improve roads and signal systems and to relieve pressure on escape routes around the cordoned area. The financial burden of maintaining road infrastructure can also be relieved. ALS, in particular, has generated much interest around the world and many cities have already initiated such schemes. The Norwegian cities of Bergen, Trondheim and Oslo, for example, adopted a scheme whose area is wider than that in Singapore in 1980. High- technology options, especially ERP and Intelligent Transport Systems (ITS) have attracted attention in developed countries: Canada, Norway, and the U.S. have initiated applications, while Chile, the Netherlands and the U.K. are expected to do so (Willoughby, 2000) in the near future. London started a system similar to ALS in late 2002; entering the core area costs five pounds. In Bangkok and Kuala Lumpur, restrictions on vehicle ownership and use have been proposed several times since the late 1970s but have as yet had little success. In Manila, restrictions were proposed in 1977 (Freeman and Fox, 1977), but were dropped ostensibly because of the lack of enforcement mechanisms (Kirby *et al.*, 1986).

Most cities in Asia do not have clear functional boundaries; the fact that there are often many interactions outside of the cities poses difficulties in making effective policies. In many cities, too, the transportation sector provides employment to low-income groups through cheap travel modes such as manual tricycles (Bangladesh and India), three-wheelers (many cities in South and Southeast Asia), and the jeepney (the Philippines).

Policies need to provide viable alternatives to such groups. The root causes of policy failure in cities of developing countries are inappropriate and inadequate policies, the lack of integration of policies, the lack of the institutional capacity to enforce existing policies, problems related to the jurisdiction and coordination of authorities, and the political interests of governing parties. These are all examples of poor governance and are often associated with the lack of financial resources. Selling to the public is not easy because it directly affects the travel of each city dweller. Such measures will not be acceptable or popular unless they are part of a city's overall strategy. Regardless of the economic and social conditions of a city, a good public campaign and acceptable alternatives are essential. In particular, the development of a sound public transportation system is key to replicating Singapore's other successful measures.

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References

Singapore Department of Statistics (http://www.singstat.gov.sg/keystats/hist/gdp1.html). Accessed 25 November, 2002.

Ang, B.W. and K.C. Tan (2001) Why Singapore's land transportation energy consumption is relatively low, Natural Resources Forum, 25, pp. 135-146.

Freeman Fox and Associates (1977) MMETROPLAN: Metro Manila Transport, Land Use and Development Planning Project, Final Report, Main Volume. Manila.

Fwa, T. F and B. H. Ang (1996) Energy saving due to land transportation management in Singapore, Journal of Advanced Transportation, Vol. 30 (2).

Fwa, T. F. (2002) Transportation planning and management for sustainable development- Singapore's experience, STAP/GEF Workshop on Sustainable Transport Non-Technology Options for Engineering Modal Shifts in City Transport Systems, 25-26 March 2002, Global Environmental Facility, Nairobi, Kenya.

Humphery, J. W. (1985) Geographic analyses of Singapore population. Census Monograph No. 5, Department of Statistics, Singapore.

Kirby, R. F., M. T. Tagell and K. W. Ogden (1986) Traffic management in metro Manila: formulating traffic policies, Traffic Engineering and Control, May, pp. 262-269.

Lee, W. S. (1986) The computerised Singapore area traffic control system, Proceedings of 5th CAFEO Conference on Transportation and Communications within ASEAN Region, 22-25 October, Singapore.

Lee, W. S. (1990) Adaptive traffic control system, Proceedings of 6th Conference of Road Engineering Association of Asian and Australiasia, 4-10 March, Kuala Lumpur.

Lye, Lin Heng (2002) Environmental taxation in the regulation of traffic and the control of vehicular pollution in Singapore, Paper presented at Third Annual Global Conference on Environmental Taxation, 12-13 April 2002, Woodstock, Vermont, USA.

McCarthy, P. and R. Tay (1993) Economic efficiency vs. traffic restrain: a note on Singapore's area licensing system, Journal of Urban Economics, 34 (1), pp. 96-100.

Menon, A. P. G. (2002) Travel demand management in Singapore: why did it work? Regional Workshop on Transport Planning, Demand Management and Air Quality, Organised by the Asian Development Bank, with the support of the United States-Asia Environmental Partnership (US-AEP), Clean Air Initiative for Asian Cities (CAI-Asia), and Envirox, ADB Auditorium, 26-27 February 2002, Manila.

MIA (2001) Singapore 2000. Ministry of Information and Arts, Singapore.

Phang, S. Y, W. K. Wong and N.C. Chia (1996). Singapore's experience with car quotas, Transport Policy, 3 (4).

Phang, Sock-Yong and Rex S. Toh (1997). From manual to electronic road congestion pricing: the Singapore experience and experiment, Logistics and Transportation Review, 33 (2), pp. 97-106.

Toh R. S and S. Y. Phang. (1997). Curbing urban traffic congestion in Singapore: a comprehensive review, Transportation Journal, 37 (2).

Toh Rex (1977). Road Congestion Pricing: The Singapore Experience, Malayan Economic Review, 22 (2), October, pp. 52-61.

Willoughby C. (2000). Singapore's experience in managing motorization and its relevance to other countries, Discussion paper TWU-43, The World Bank, Transportation Division, April, Washington DC.

Yap N. C. (1986) Urban transportation planning and practices in Singapore, Proceedings of Conference on Transportation and Communications within ASEAN Region, 22-25 October, Singapore.

appendix **B**

The Role of the Government, the Private Sector and Civil 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 1,320 m above sea level and is surrounded by mountains. The topography of the city exacerbates the rising levels of air pollution and photochemical smog because wind flow is blocked. Air pollution in the Valley is increasing at an alarming rate; the concentration of pollutants, especially PM, is well above the health guidelines set by the WHO. The result has been a decrease in atmospheric visibility and an increase in asthma and respiratory-related heath problems in the last decade. The implication of air pollution is not limited to health issues: it also threatens the tourism industry, which is one of the major economic activities in the Valley. Motor vehicles are the major source of air pollution in the Valley, mostly because vehicles are old and poorly maintained, fuel is low quality and adulterated, two-wheelers and two-stroke engine vehicles prevail, congestion is increasing, and the road infrastructure is inadequate and poorly maintained.

Box B.1 Vital statistics of Kathmandu Valley

Area:	*550 km^2 (valley floor)*
Altitude:	*1350 m above sea level*
Road Length:	*535 km (2002)*
Registered number of vehicles	*171,678*
Vehicle composition:	*Car/jeep, 23.7%; bus/truck 5.2%,; 3-wheelers, 2.9%; 2-wheelers 65.3%, rest/others (2001)*
Pollutant concentrations:	*24-h average: PM_{10} concentrations are 225,135 and 126 µg/m3 in the core, sub-core and remote parts of the valley, respectively; the highest value is 495 µg/m3. TSP concentrations are 376, 214 and 137 µg/m3 in the 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*

Diesel three-wheelers imported from India in the late 1980s once produced a visible cloud of black smoke and other air pollutants over the Valley, even after new registrations were banned in 1992. In 1995, an outright ban on usage was imposed. In order to fill the vacuum, the government, the private sector and civil society (mainly NGOs and advocacy groups) worked together to promote and expand the use of battery-operated electric three-wheelers on a commercial basis. This successful introduction of zero-emission (by tail-pipe considerations) electric three-wheelers is noted as a successful practice of sustainability in many international forums, including USAID[47] and UN Sustainable Development;[48] the IPCC Special Report on Technology Transfer features a Kathmandu Valley safa

47 http://www.info.usaid.gov/countries/np/success/success2.htm

48 Success Stories Vol. 4/2000, http://www.un.org/esa/sustdev/success/PCBCP-5.htm

(clean) tempo on its cover page. Although, a single end-of-pipe solution for reducing pollutant emissions from a sectoral niche is not a solution to overall air quality problems, it does provide useful information. As a case of the successful interaction of the government, the private sector and civil society in improving urban air quality by controlling vehicular emissions and promoting clean vehicles, however, the experience is of interest to other cities in the region which rely on gasoline and diesel three-wheelers for a major proportion of their public transportation systems. Facilitation is essential if clean vehicles are to move into any market; this paper examines how it was done in the Kathmandu Valley. The introduction of safa tempos has established a new industry, invited private sector investment, created employment opportunities, and promoted the first experimentation in employing women drivers in Nepal's public transport sector.

We analyse why the introduction of electric vehicles succeeded in Kathmandu although in other cities techno-economic limitations have resulted in their failure. We also analysed the prevailing situation and the roles played by the government, the private sector and advocacy groups. The role of various command-and-control and market-based economic instruments are also illustrated. Last, the factors determining the potential for replication elsewhere are discussed and the relevance of this experience for other cities in the region is explored.

Figure B.1 A typical battery-operated three-wheeler in Kathmandu Valley

B.2 The Success Story

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

Gasoline-operated three-wheelers were introduced into the Kathmandu Valley as a cheap alternative to taxis in the late 1980's. Many cities in the Indian sub-continent had embraced this vehicle since foreign-built cars were expensive and three-wheelers serviced short commuting routes cheaply. Three-wheelers carry three or four persons, including the driver in front, and are powered by two-stroke engines. Kathmandu then saw a sudden surge in the number of larger diesel-operated three-wheelers from 1989-92; each ferried ten passengers on its narrow chassis.[49]

The vehicles plied the streets emitting thick black smoke and creating a lot of noise. At that time, there were no environmental standards for emissions from motor vehicles in the Valley. In 1992, due to the public outcry over these polluting three-wheelers, the government banned further registrations of new three-wheelers. Despite growing public awareness about air quality and pressure from NGOs and other civil groups, however, it failed to remove the vehicles from the streets altogether due to a number of local economic and political difficulties. For three years, policy makers failed to create any incentives for restricting the use of three-wheelers.

In a series of programmes designed 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 for gasoline vehicles[50]), formed the Ministry of Environment in 1995, and passed the Environmental Protection Act in 1997. Although it was announced that non-complying vehicles would be phased out within two years, by late 1998 (Budget Speech 2055/56), and a phasing-out programme was prepared by the Ministry of Environment, the Department of Transport Management, and local municipal governments in consultation with the private sector and NGO groups in early 1999, phasing out was a failure. An anti-diesel three-wheeler movement peaked in early 1999. NGOs, the tourism sector, cine-artists associations, local clubs and the public participated in street protests and road blockades of three-wheelers. Finally, in its 1999 budget (2056/57), the government provided an alternative to owners of diesel three-wheelers in the form of a 75% customs duty holiday on the import of twelve- to fourteen- passenger vans. In consequence, diesel three-wheelers were banned in the Valley from July 1999.

49 Built by Scooters India Ltd. with a payload of 1000 kg powered by a 10 HP, four-stroke, one-cylinder diesel engine.

50 This standard was later relaxed. For two-wheelers, a rate of 4.5% CO was set in early 1998.

Box B.2 Key dates

- *November 1991* — *Ban on new registrations of three-wheelers*
- *1993* — *Techno-economic feasibility demonstration of electric three-wheelers by Global Resources Institute*
- *August 1994* — *Announcement of in-use vehicle emission standards*
- *July 1996* — *Reduced import customs tariff and sales tax on electric vehicle parts*
- *July 1999* — *Ban on in-use diesel three-wheelers*
- *September 2001* — *Number of electric three-wheelers exceeded 600*

B.2.2 Demonstration of techno-economic feasibility

Interest in converting from diesel to electric three-wheelers existed in the Valley as early as 1992. 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 into electric three-wheelers. By 1995, a total of eight electric three-wheelers had been designed and tested on one of the major routes in the Valley for six months; they had carried over 200,000 passengers and travelled more than 175,000 km.[51] This pilot project demonstrated that battery-operated three-wheelers are economically feasible in the local context. Apart from designing vehicles, the initiative also created awareness among and acceptance by the government, the private sector and the public.

B.2.3 Favourable government policy 1991-2000

Since 1995, the government has consistently adopted policies which directly and indirectly facilitate the electric vehicle (EV) industry. The

51 Peter Moulton and Marilyn Cohen (1998), Promoting Electric Vehicles in the Developing World, Paper presented at International Electric Vehicles Conference, Cosata Rica, November 1998.

National Transport Policy of 2001[52] further consolidates the policy of promoting electric transportation system in the country. Indirect facilitation mainly consisted of banning diesel three-wheelers and thereby creating a market vacuum which electric three-wheelers could exploit. Direct facilitation included fiscal benefits in the form of reduced import customs tariffs and waivers on annual vehicle registration fees (annual registration fees were about 4,500 Rs/year in 2001). The 1996 budget[53] reduced customs duties on parts and accessories for electric three-wheelers to 1% and completely waived sales taxes.[54] A similar policy has continued to be implemented, thus greatly reducing the price of EVs and encouraging many private groups to invest in the EV industry. From the transportation management side, the government initially ensured EVs would have favourable routes by eliminating competition from other three-wheelers. Though this policy was later scrapped, it encouraged private sector investment. As for the fuel side, the state-owned Nepal Electricity Authority provided the electricity needed for charging batteries at low tariff rates. The EV industry began using surplus and unutilised energy during off-peak periods (at night) at low rates and the electric utility got a new market. There is currently no price difference between the rates for peak and off-peak charging although the possibility for introducing a graded system exists. Since most of Nepal's electricity is generated by run-off-river hydropower plants, battery charging is emission-free.

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

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52 National Transport Policy 2058. Available from the Ministry of Labour and Transport, Kathmandu, Nepal.

53 Fiscal year 2053/54 budget presented to the Parliament.

54 Import duty (and sales tax) was 60% for diesel three-wheelers and 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 for EVs other than three-wheelers; and a 10% duty on all complete EVs.

Table B.1 Comparison of electricity tariff rates in 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$ was about Rs 78 in 2002.

In the promotion of electric vehicles, four government bodies have played important roles: the Ministry of Environment, the Department of Transportation Management, the Ministry of Finance and Valley Traffic Police. Since it did not have jurisdiction over this area, the role of the Kathmandu Metropolitan Corporation was limited to pressuring the government and bringing stakeholders together.

B.2.4 Emergence of a new industry

The demonstration project demonstrated that battery-operated three-wheelers are techno-economically feasible in the Valley and inspired the private sector to invest. Since then, the private sector has fostered the expansion of EVs. The seven converted electric three-wheelers of the demonstration project were bought by a private company, which then expanded its fleet size to 15 vehicles and opened more routes. A total of about 500 million rupees[55] has been invested in the Valley's EV industry.[56] By 2002, over 600 electric three-wheelers had been manufactured and sold. Operated by the private sector, these vehicles ply 16 routes in the Valley and employ over 70 women drivers.

Box B.3 Performance of batteries

Type: *Trojan, US125 and Excite USA*

Cost: *Rs 60,000 per pack (12 6-V)*

Average driving distance per charge: *65 km*

Energy per charge: *15-18 Kwh*

Average cycle life: *450*

Average life: *18 months (a considerable improvement over the 9-10-month average earlier reported)*

55 On average, an electric three-wheeler costs Rs. 540,000. Investment in a charging station investment amounts to about Rs. 1.5 Mn.

56 Personal communication with the Electric Vehicle Association of Nepal.

The EV industry consists of three major groups: vehicle manufacturers, vehicle owners and charging station operators. Currently, there are about five major manufacturers,[57] 38 battery-charging centres, and many owners.[58] Each charging centre owns between five and 10 vehicles; individuals own the remainder.

Some success has been made in adapting local technology instead of relying on expensive imported technology, especially in chargers; this trend has reduced costs to some extent. The energy source for EVs, batteries, are a key determinant of whether or not EVs succeed. The cost and performance of batteries are often barriers to a full-scale diffusion of EVs in a transportation system. In the Valley, electric three-wheelers commute along short, fixed routes averaging about 10-13 km; total daily travel runs to 120 km and batteries are changed once a day. Three types of batteries are used: Trojan, US125 and Excite USA. Since their expense is a serious concern, a mechanism of battery leasing has been devised; today, 99% of all batteries are acquired from this system. A 50% down payment is made in the beginning and the remaining payments are made over several months on an instalment basis with 7% interest. This mechanism fostered the expansion of the industry.

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

B.2.5 Efforts of NGOs and of civil society

The role of advocacy and civil groups was significant in opposing diesel three-wheelers and in facilitating the introduction of electric three-wheelers in the Valley. These groups organised a number of activities that created public awareness about air pollution, the role of polluting vehicles and the need for clean vehicles. They also created a forum to stimulate discussions among the private sector, the public and the government, highlighted technical and policy debates, and lobbied for EVs. The

57 The major EV manufacturers are the Nepal Electric Vehicle Industry (NEVI) and the Electric Vehicle Company (EVCO); each has a share of about 40% in the local EV market.

58 There are about 450 owners.

major NGOs and civic groups involved in these issues included Martin Chautari, Winrock International-Nepal Office, Leaders Nepal, Abhiyan Group (a group of cinema artists), Pro-public and Explore Nepal (a group in the tourism sector). 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 the streets, demonstration and mass rallies were organised, FM radio talk programs were held, and lawsuits were filed in court against diesel three-wheelers. The role of the media was favourable: it disseminated information air pollution from diesel three-wheelers and other motor vehicles to the public. All these activities put tremendous pressure on the government to act.

B.3 The Potential replication and Significance to Other Cities

B.3.1 Local conditions

In order to assess whether Kathmandu Valley's experience can be replicated elsewhere and what significance it has for other cities, it is important to identify the local conditions under which these electric three-wheelers were successful. The phasing-out of diesel three-wheelers and the introduction of electric three-wheelers were accomplished during a period of intense objection to visible air pollution; thus, public support was easily garnered. Geography, traffic patterns, travel demand, and energy availability affect the feasibility of EVs in any urban transportation system. In Kathmandu Valley all were favourable; the main barrier was limitations in battery technology. The area of Kathmandu Valley is about 550 km^2 and the majority of the vehicles ply inside a circle about 15-20 kilometres in diameter. The top speed of traffic in the city does not exceed 30-35 km/hour, while the average speed is as low as 10-12 km/hour. Under such conditions, neither top speed nor driving distance was a serious constraint for electric three-wheelers. Since these vehicles were to run on fixed routes, battery changing would be easy to carry out once or twice a day. Nepal also has great potential for hydroelectric power. Most plants are run-of-river types, where electricity is "spilled away" if it not utilised during surplus or off-peak times. This made it possible to offer a low tariff rate for the off-peak charging of batteries. In addition, the country could save a huge amount of foreign currency (an important consideration for a trade-deficit country like Nepal) and financial resources ordinarily spent on foreign fossil fuels if a significant number of electric vehicles ply the streets. Although off-peak charging mechanisms and time-of-day tariffs were not created in the period from 1995 to 2000, the possibility of introducing them helped to create a favourable response among the public and policy makers. The interest of foreign donors was another important local factor. The roles of two donor communities, USAID (US ODA agency) and DANIDA (Danish ODA agency), was instrumental; USAID/US-AEP supported demonstration programmes and DANIDA provided support at later stages. Their interest helped to create a favourable response from policy makers.

B.3.2 Significance for other cities

Three-wheelers make up a significant part of the urban transportation systems in many cities in South Asia,[59] particularly those in India, Pakistan, Sri Lanka and Bangladesh. Three-wheelers are also popular in Chinese cities. In Bangkok, tuk-tuks are widely used for short-distance commuting. Despite their prevalence, governments in South Asia are fighting to phase out three-wheeler, which, because they run on two-stroke gasoline engines, have significantly exacerbated air pollution. Resistance, however, is high. Cheap modes of transportation like three-wheelers are closely linked to low-income groups and intertwined with urban poverty issues. Without providing an alternative to the owners, it is difficult to ban or replace polluting three-wheelers. In most cases, vehicles are being pushed out of cities rather than being phased out. Bangladesh announced a ban on three-wheelers with two-stroke engines in Dhaka City from 1 September, 2002; nearly 12,500 vehicles were affected.[60] The government of Bangladesh has permitted 5,000 four-stroke CNG three-

59 South Asia refers to Nepal, India, Sri Lanka, Pakistan, Bhutan, the Maldives, and Bangladesh (the Indian sub-continent).

60 Bangladesh Centre for Advanced Studies web-page http://www.bcas.net/. Accessed on 25 December 2002.

wheelers to ply the street to fill the gaps in travel supply which the ban created.[61] Possibilities for replicating Kathmandu's experience in Dhaka are being examined by the South-South-North Project of the Bangladesh Centre for Advanced Studies (BCAS).[62]

Table B.2 Number of three-wheelers in South Asia

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

*NA = data not available

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.*

Drawing upon what it learned from its successful demonstration in Kathmandu of converting diesel three-wheelers to electric ones, USAID went on to provide assistance to India in a programme called "India Zero Emission Transportation Program (IZET) in 1999-2003. The objective of this programme was to reduce the adverse health impacts from vehicular emissions. This demonstration program designed, tested, and assembled 1,000 electric three-wheelers in Delhi, Agra and Pune. Under this programme, seven three-wheelers were successfully field tested in the city of Agra for one year. In view of 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 US$ 3.9 million of the US$ 9.3 million programme; the remainder of the cost of investment will be borne by the private sector.[63]

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61 Bangladesh has large natural gas reserves and an extensive network of gas pipelines in Dhaka.

62 Recent BCAS News http://www.bcas.net/. Accessed on 3 January 2003.

63 For the complete project, see the web -page of the U.S. Department of Energy, Office of Policy and International Affairs, http://www.pi.energy.gov/library/EWSLindia-izet.pdf

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 a significant volume of air pollution. However, introducing EVs is limited to designing and testing vehicles; this step should be supplemented by increasing public awareness and acceptance, creating laws and regulations, government policies and incentive mechanisms which remove initial market barriers, and inviting private investment on a commercial basis. The cooperation of the government, the private sector and advocacy groups facilitates the successful introduction of EVs. It should be mentioned that three-wheelers are a low-occupancy public transport mode and that a large-scale penetration of these vehicles may slow down other forms of transport through congestion and other externalities. Three-wheelers are best suited for short commutes and full integration with high-occupancy public vehicles through well-designed transportation planning is essential.

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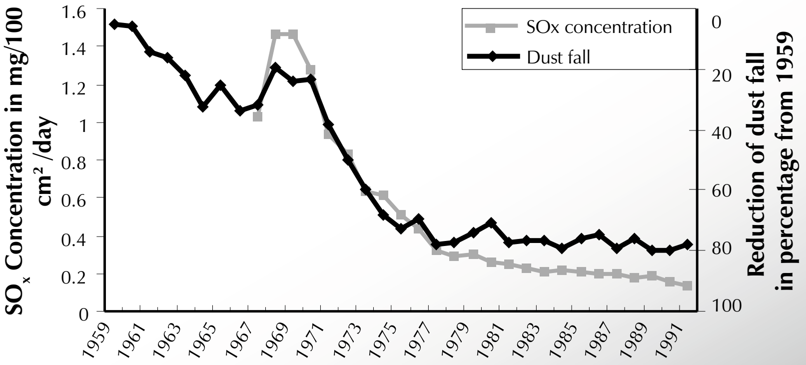
appendix C

Success in Controlling SO_x Emissions in Kitakyushu, Japan

C.1 Introduction

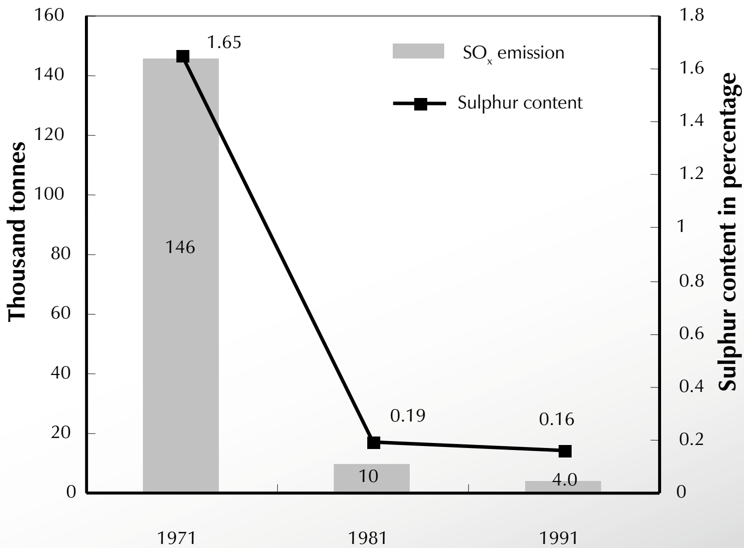
Kitakyushu was one of the most polluted cities in Japan during the 1960s and early 1970s due to industry-related pollution, such as high sulphur oxide concentrations and dust fallout. Since then, the city has taken drastic measures to improve reduce air pollution. As a result, it enjoyed both high economic growth as well as better air quality in later years. In fact, in recognition of its achievement, Kitakyushu was awarded the Global 500 Award by UNEP in 1990.

In the 1960s, Kitakyushu was one of the most industrialised cities in Japan; it was dominated by heavy industries, including paper and pulp, steel and petro-chemicals. A large quantity of energy, generated primarily by coal, was consumed. The high sulphur content of coal, the inefficient use of energy, inefficient industrial production processes, and non-utilisation of end-of-pipe technologies to reduce the emission sulphur oxides were major problems. Under pressure from residents, the government of 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 the quality of fuel, providing incentives to small- and medium-scale industries, strengthening monitoring systems and enhancing the institutional capacity of the local government.



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

Figure C.1 SO_x concentration and dust fallout



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

Figure C.2 SO_x emission and average sulphur content of fuels

C.2 Processes and Policies

The motivation for the local government to act to reduce concentrations of SO_x and dust, in particular, dates to the mid-1960's, when women's protest movements introduced the slogan "We want our blue sky back." This campaign increased awareness among people about the negative aspects of environmental pollution. Despite pressure from polluting enterprises, these women's groups petitioned and challenged the local government with their own studies on air quality. In other Japanese cities such as Kawasaki and Osaka, too, resident groups confronted polluting enterprises and the local government. The anti-pollution movement had a lot of political repercussions in those cities: local political leaders carried out anti-pollution measures partly because of the leftist party's active environmental agenda and ongoing campaigns for public awareness and environmental improvement. Polluting enterprises were urged to cut emissions significantly. Ultimately, voluntary agreements to implement pollution control measures were signed by residents, polluting enterprises (48 companies and 57 factories) and the local government in March 1972; they were renewed in January 1977.

The air pollution countermeasures implemented by the city government can be classified as follows:

- Strengthening local regulations and enhancing institutional capacity
- Improving fuel quality and encouraging fuel substitution
- Providing technical guidance and enhancement in the manufacturing process
- Changing the industrial structure
- Relocating factories away from residential areas
- Implementing financial mechanisms such as subsidies

C.2.1 Strengthening local regulations

In addition to the anti-pollution laws enforced by the national government (regulating environmental quality standards, emission standards, area-wide total pollution load control, and automobile exhaust emissions), Kitakyushu itself formulated strict laws, regulations and inspection systems, including (1) a new plant modification order, improvement order, and strict inspection of smoke and soot treatment facilities, (2) continuous pollution monitoring, and (3) emergency measures (1969-74). The emergency measures demanded that industries systematically reduce SO_x emissions by 20%, 30% and 50% during the implementation period. Local regulations also included time and quantity reductions. For time regulations, a weather information system was developed in order to issue smog warnings and special weather events that would aggravate pollution concentration. Once a warning was issued, individual industries were required to implement the designated reduction in quantity during the time period specified. The K-value[64] regulation, in which the quantity of emissions was regulated by the height of the exhaust port, was set at 1.75; this was the second strictest value in Japan.

C.2.2 Enhancing institutional capacity

In order to support these countermeasures, the institutional capacity of the environmental section was enhanced by increasing the number of qualified staff members, introducing a monitoring system and improving equipment. The table below shows the number of administrative and research staff members employed since the early 1960s.

Table c.1 number of administrative and research staff

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.*

The authority for making decisions about regulations and standards and smog warnings was shifted from Fukuoka Prefecture to Kitakyushu in

64 In K-value regulation, allowable emissions are given as n Nm3/hr = K * 10-3 * He^2, where, He = effective stack height in meters, K=1.75meters., K = 1.75 m for Kitakyushu.

1970. This transfer of authority to the local body enabled the city to act quickly and created a sense of ownership among the city council, administration, enterprises and residents. Following this step, the Kitakyushu Air Pollution Prevention Joint Council, consisting of representatives from the national government, Fukuoka Prefecture and key polluting enterprises, was established. This council played a key role in implementing a wide range of countermeasures. The decentralisation of responsibilities within Kitakyushu itself was also a key institutional measure.

Apart from the local government's actions, enterprises which met certain criteria were mandated to have pollution control managers whose job was to manage technical and managerial matters related to pollutants. Such managers had to pass a national qualifying examination.

C.2.3 Fuel substitution and fuel quality improvement

Yet another key component of the countermeasures was the type and quality of fuel used. The city government 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. As these changes were accomplished, the sulphur content per unit of energy consumption was drastically reduced. The first stage of the process involved switching from coal to crude oil (sulphur 1%) in the 1960s. This was followed by a switch to low-sulphur crude oil (0.15%) and light oil, then to LPG, LDG and finally to LNG.

C.2.4 Technology during the manufacturing process and at the end of the pipe

Efficient manufacturing processes results in large energy savings. The following technology enhancements were carried out:

- Conversion to efficient processes such as cement kilns.
- Switching raw materials. Ferric sulphide replaced sulphur in sulphuric acid plants, for example.
- Desulphurisation of furnaces.
- Phasing out of small and medium-size boilers and introducing large-scale boilers.

- Introduction of better equipment.
- Recycling of waste energy.
- Increasing the height of chimney stacks
- Introducing end-of-pipe technology, in particular, FGD (fluidised gas desulphurisation) installations

The introduction of clean production (CP) measures was successful in considerably reducing energy consumption and emissions. The figure below shows the contribution of CP to SO_x reduction.

The local government's provision of know-how and technical support to polluting enterprises by the local government was important. Local government employees, experts and other relevant persons on many occasions carried out pollution diagnoses and provided needed technical guidance to manufacturing establishments. They helped identify appropriate improvement measures and, at the same time, enhanced the degree of understanding and trust between the government and the enterprises.

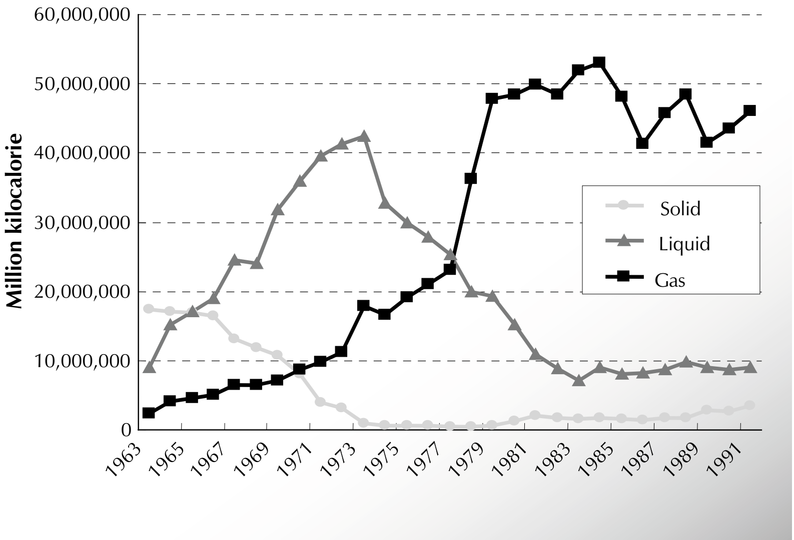
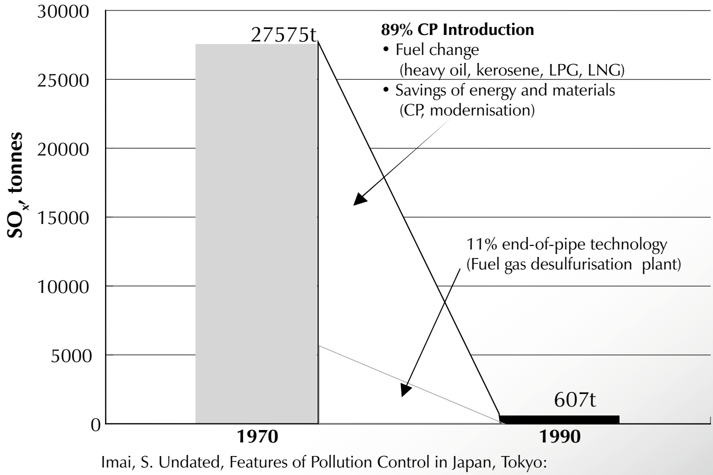


Figure C.3 Energy consumption in Kitakyushu City



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

Figure C.4 **Reduction of SO_x emissions by various means**

C.2.5 Factory relocation away from residential areas

In order to make controls effective and to reduce residents exposure to high SO_x concentration of SO_x, several factories were relocated from residential areas to industrial areas near the coastal zones. In the Okidai area, for example, approximately 100 factories were relocated to three industrial zones. Many relocated industries were steel and chemical. At the same time, residents of densely industrialised areas were persuaded to be relocated to less polluted area such as the Shiroyama area, where more than 650 households were resettled.

C.2.6 Financial mechanisms and subsidies

No activity described above would have been possible without the local government's financial facilitation of enterprises, particularly small- and medium-scale ones. Financial mechanisms consisted of (1) a public capital financing system and (2) tax incentives. The core of control measures was technological enhancements and fuel switching. The capital needed to implement technical countermeasures so that the terms of voluntary agreements and regulations could be met was provided at low interest rates. The payback period (7-20 years) depended on the type of company.

Tax system benefits at both the national and the local level were introduced to reduce the financial burden of maintaining and managing pollution control equipment and activities. This included tax exemptions and reductions on fixed assets related to pollution control facilities and equipment and the extension of the terms for repayment applied.

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

Table C.2 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 with Kitakyushu officials*

C.2.7 Future considerations for the planning process

The local government included considerations for future development in subsequent years of planning. They included planning based on the number of anticipated industrial facilities, the scientific analysis of the relationship between source and pollution distribution, support from wind tunnel tests and computer simulations, and prediction models.

C.2.8 Enforcement

Without enforcement of regulations and standards, success cannot be achieved. The inspection systems developed by the local government included 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, were fined and imprisoned.

C.3 Lessons Learned

- Promoting public awareness and ensuring political will are important for tackling environmental problems.
- Comprehensive planning based on scientific approaches can produce good results.
- Anti-pollution measures should be implemented after taking stakeholders into confidence.

C.4 Replication

SO_x emission control in an urban industrial city is Kitakyushu's distinctive feature. Most of its achievements were made by implementing technical measures, mainly, modifying manufacturing processes and improving fuel quality, coupled with effective enforcement and monitoring. The case is of interest to rapidly industrialising cities, such as those in China and others Asian countries. Some conditions in Chinese cities are similar to those in Kitakyushu, such as a rapidly growing economy, the availability of plenty of city revenue, and a coal-based economy in transition to liquid and gaseous fuels. The experience of the local government of Kitakyushu in making a significant achievement in CP techniques by taking industry into its confidence might be useful for cities in Southeast and North Asia. Since technology, time and approaches have changed in recent years and since only a few aspects of the successful experience in one city can be transferred to another due to local conditions, caution must be taken in any attempt at replication.

Cities in rapidly industrialising regions of Asia are confronted with multiple tasks for economic development and environmental protection. They tend to give priorities to immediate and local issues, and consider global warming as a far-away 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 brings multiple benefits to the community. It helps to solve air pollution and traffic congestion, and also facilitates the reduction of CO_2 emissions.

Energy management at city level was neither a priority nor an important issue until recently because energy related decisions are made at the national level. These days, city policy makers are under growing pressure to incorporate greenhouse gases, especially CO_2 emissions into consideration while planning. But 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. Therefore, efforts should be directed towards providing support to cities in generating knowledge and in building their capacity to understand the problem and to find possible measures for implementing policies. The prerequisite for systematic action is the analysis of CO_2 emission budgets of cities, their drivers and associated policy analyses.

In this context, ***Urban Energy Use and Greenhouse Gas Emissions in Asian Mega-Cities: Policies for a Sustainable Future*** aims to quantify CO_2 emissions from energy use and analyse their driving factors for selected Asian Mega-Cities—Tokyo, Seoul, Beijing and Shanghai. It presents discussions on the nature of future challenges. Further, it highlights the needs for taking into account the overall energy and CO_2 "footprint" of cities. Finally, it presents policy directions, policy challenges and identifies major opportunities and barriers for integrating CO_2 considerations into local environmental policies.

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