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

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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.

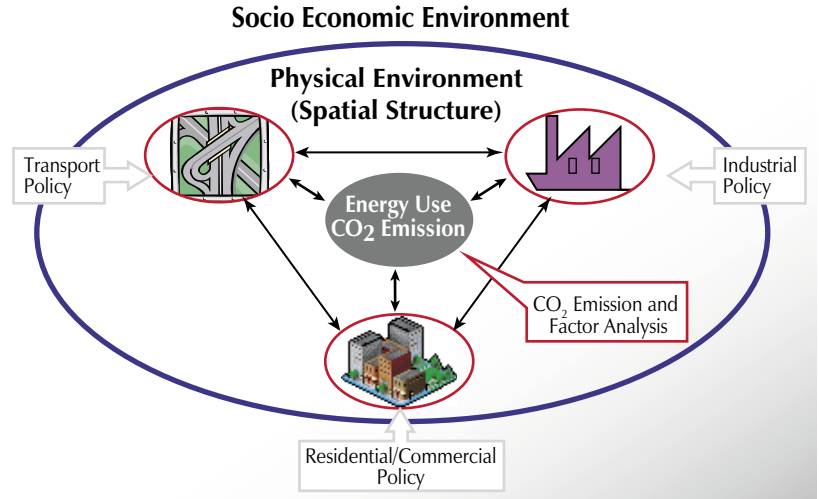
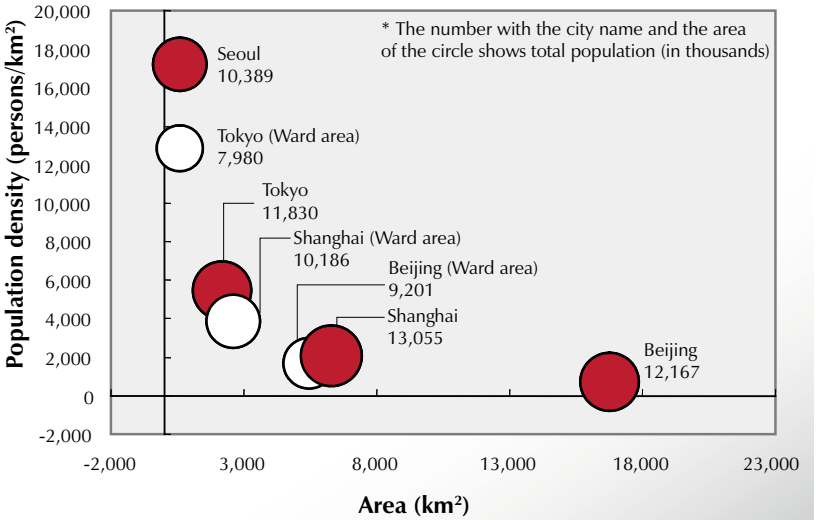


Figure 1.1 Analyses framework

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.