#2000-18 Urbanisation, Industrial Transformation, and Environmental Change

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FULL REPORT

PREFACE

The international global change research community is striving to answer three questions of great scientific and policy importance:

1) Precisely what are the global environmental impacts of human activities, what are the mechanisms by which these impacts occur, and what are likely to be the long-term effects of environmental changes on humans and ecosystems?
2) What can humans do to mitigate the impacts of human activities on the environment, and what would be the environmental and economic benefits and costs of those mitigating actions?
3) If some human impacts on the environment cannot be mitigated, in whole or in part, how might humans adapt to environmental changes occurring at the local, regional, and global scales?

In October 1999 APN initiated a new way of addressing these questions. It noted that the majority of the world's population was urbanized and that urbanization was proceeding in Asia at the most rapid rate known to history. These observations, coupled with the rapid rate of economic growth throughout the region, elevated to a new level of scientific interest the cities of today and tomorrow in the Asia-Pacific region. APN made it possible for social and natural scientists and engineers to discuss whether a profitable focus for APN might be on the interactions of cities with their environments as one of a number of APN programs. These cities can reasonably be predicted to contribute significant shares to environmental changes, as cities have throughout the world and throughout history, but Asia's new and growing cities also offer the opportunity to take advantage of urban efficiencies and economies of scale. Rather than being ecological hazards, Asia's cities might be constructed and operated as ecological devices to mitigate the human impact on the environment.

APN convened a small scoping meeting to identify the research questions that need to be asked about how cities affect their environments, how the production and consumption processes that sustain life in cities might be transformed so as to mitigate the human impact on the environment, and how the populations and economies of Asia's growing cities might adapt to environmental changes.

The small October 1999 scoping workshop identified two priority areas for research, which were then developed into concrete research proposals at a July 2000 workshop. One area focuses on urban gases and particulates, and the underlying energy generation, industrial production, and transportation processes that account for a large fraction of urban gases. The other area focuses on human uses of water, the impacts of environmental changes on the sources of that water, and the discharge of water (after use by humans) into seas, ecosystems, and reservoirs. Each focus relates strongly to APN's identified scientific priorities. Those four APN priorities, and their connections to these two areas, are:

- Changes in Atmospheric Composition: Both urban greenhouse gases and short-lived gases and particulates account for a major proportion of observed changes in atmospheric composition. This occurs at local, regional, and global scales; for example, it is believed that much of the pollution observed in the INDOEX results is attributable to urban sources. These atmospheric changes may be substantial enough to change the hydrological cycle on a regional scale and contribute to various forms of air pollution.
- Changes in Coastal Zones and Inland Waters: Much of the urbanization in the Asia-Pacific region is along the coastal margins. Through outflows of contaminated water (from storm runoff as well as from sewer systems and industrial discharges), these cities are already affecting the coastal zone. Inland waters, including lakes and river systems, provide much of the water for Asia's cities, as well as the water for the agriculture that sustains those cities. Climate change would impact both sources of water: inland sources through changes in the hydrological cycle and coastal sources through rising water tables, soil salinization, and saltwater intrusion into coastal freshwater sources.
- Climate Change & Variability: Urban greenhouse gases account for what is believed to be a significant proportion of all greenhouse gas emissions, a proportion that is likely to increase as urban populations grow and as urban economic activity increases. The potential for climate change and increased climate variability has major implications for the hydrological cycle and thus upon the sources of water used by humans.
- Changes in Terrestrial Ecosystems & Biodiversity: The expansion of cities throughout the region is changing land use, land cover, and habitats, both directly by the conversion of land to urban uses and indirectly through the conversion of land to agricultural uses. The extent to which this will occur will be a function of the design of tomorrow's cities, with the sprawling city types common in the West probably having the greatest impacts on terrestrial ecosystems and biodiversity. Conversion of wetlands depletes biodiversity and often degrades water quality. Cities designed to "sit lightly upon the land" will have smaller impacts upon both air quality and water quality and abundance.

Each project team has designed a research agenda that will develop substantial new information about how cities relate to their environments. Comparative within each project, these inquiries will help to build an understanding of how and why cities differ among themselves. If Asian cities show the same degree of differentiation as is observed in North America, these differences will be large and complex. Policies to deal with the impact of cities upon the air and upon the water must take account of those differences; it is highly unlikely that one solution will apply throughout Asia and the Pacific. Although the projects are not now designed to be comparative across the teams (one may need a different sample of cities to understand their water use than one needs to understand urban gases), some degree of consolidation of the samples may prove wise in terms of conserving project resources. And the envisioned large-scale projects to result from these two proposed APN pilot projects, it is inevitable that many cities will be shared across the two research foci.

These projects have been designed to meet APN criteria for interdisciplinarity, international scope, capacity building, policy relevance, and integration of the findings of natural science with social and economic factors. Each is intended to serve as a means of leveraging a relatively small amount of APN funding into a large-scale externally-funded research project that will still operate under the APN umbrella and strive to contribute to other APN projects.

This report includes the overall agenda for the July 2000 scoping workshop, a full list of participants, and the separate agendas for the projects on water and urban gases (a third, smaller workshop on transportation has not yet yielded a successful proposal). A report prepared after the urban gases workshop, and a paper prepared for the water workshop are also included. The urban gases team now has a Web page at http://www.iges.or.jp/ue/kaneko/APN/Toppage.htm, but it is accessible only by members of the team.

APN Workshop Agenda
Urbanization, Industrial Transformation and Environmental Change
(12-14 July, 2000, Kobe, JAPAN)

Wednesday, 12 July

0900-1000	**Registration- 5th Floor, IHD Building, APN Center**
1000-1045	***Plenary- Opening address by Dr. Ryutaro Yatsu, APN Director Introductions by Richard Rockwell and GHG and Water Group Leaders**
1045-1100	**Coffee Break**
1100-1230	***Group Session**
1230-1330	**Lunch- IHD Building, Hygeia Restaurant**
1330-1530	**Group Session**
1530-1545	**Coffee Break**
1545-1700	**Group Session**
1830-	**Reception- New Otani Hotel, Kobe**

Thursday, 13 July

0930-1045	**Group Session**
1045-1100	**Coffee Break**
1100-1200	**Group Session**
1200-1300	**Lunch**
1300-1500	**Group Session**
1500-1520	**Coffee Break**
1520-1700	**Group Session**

Friday, 14 July

0930-1045	**Group Session**
1045-1100	**Coffee Break**
1100-1200	**Group Session**
1200-1300	**Lunch**
1300-1500	**Group Session**
1500-1520	**Coffee Break**
1520-1700	***Plenary/Report Meeting**

***Plenary -**	**3rd Floor, Conference Hall, IHD Building**
***Group Session -**	**GHG, 3rd Floor, Conference Hall, IHD Building Transport, 3rd Floor, Conference Hall, IHD Building. Water, 5th Floor, APN Secretariat, IHD Building**

APN Workshop
Urbanization, Industrial Transformation and Environmental Change
(12-14 July, 2000, Kobe, JAPAN)

The List of 26 Participants

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Workshop Agenda for GHG Budgets for Selected Megacities in Asia

Wednesday, 12 July – Friday, 14 July, 2000

1. Opening statement--- Prof. Imura and Dr. Mitra
2. Introduction of the participants
3. Draft Research Plan --- Prof. Imura

4A. Review of the Relevant Works --- H. Imura
(1) Existing Studies on Municipal GHG Budgets for Japanese Cities
(2) ICLEI's Project on Municipal GHG Budgets
(3) Others

4B. Review of the Relevant Works --- A.P. Mitra

5. Preliminary Study Information
Seoul--- Dr. Tae Young JUNG, Dr. Euiyoung YOON and Dr. Sunghan JO
Tokyo --- Dr. Shinji KANEKO
Beijing (1) (Commercial and Residential Sector) --- Prof. Zhihong WEI and Dr. Deliang TONG
Beijing (2) (Urban Transport Sector) --- Prof. Kebin HE
India and Southeast Asian Cities --- Dr. Sharma (Delhi) and Mr. Dasgupta (Calcutta)
6. Analysis Framework and Data Collection
A proposal of a possible analysis framework --- Dr. Tae Young JUNG
Proposals and suggestions on data collection
Comments and free discussion
Wrap-up and summary
7. Revised Research Plan and Future Schedule
Discussion and approval
8. Closing

14th July 2000 (Draft)

APN Workshop on Urbanization, Industrial Transformation and Environmental Change

Rapporteurs' Report on Group session on GHG emissions and mega-cities

C. Sharma

The group session began with opening remarks of Prof. Imura who apprised about the various components of this project, which is being formulated to account for the first time the embodied emissions also besides direct GHG emissions. He also proposed the tentative approach and time lines for discussions by the participants. Dr Mitra emphasized the need to take into account other urban pollutants like CO, NOx & SOx besides particulate matter as those have great impacts on health as well as climate and are associated with the sources responsible for greenhouse gas emissions. He pointed out that during the forthcoming discussions, there will be need to address questions like the definition and geographical boundaries of the mega-cities which are increasingly becoming epicenter of urbanization of surrounding erstwhile non-urban areas. It will also be needed to identify suitable time periods to enable development of future scenarios based on past history of growth rate besides incorporation of various socio-economic (consumption pattern) factors.

After lunch, Prof. Imura apprised about the ICLEI's project reports and pointed out that there is not so much information available for the developing world. He also informed that about 20 cities have joined ICLEI's to reduce their CO2 emissions by 20% by 2010.

Following this, Korean, Japanese, Chinese and Indian groups made presentations and apprised about the kind of data available for Seoul, Tokyo, Beijing, Delhi and Calcutta. These groups also presented studies carried out so far, which have relevance with the present effort and have already generated quite useful database and information.

While it has been realized that lot of data already exists which can be used in this project but substantial efforts would be needed to put all the data in usable format and for their quality control & quality assurance analysis. Another significant information emerged about the importance of different sectors in different mega-cities e.g. in Seoul, it is the building sector which is important, in cities like Tokyo and Delhi, transport sector is important. It was also decided to accelerate efforts about the database generation for Shanghai and Manila.

Later on Dr Jung made presentations on the `approach of possible analysis framework' and `data-base construction' for primarily Seoul, Tokyo & Beijing. But it was agreed upon that for Delhi, Calcutta and Manila, efforts would be made to use such approach with or without modifications. Dr Yoon made a brief presentation about his research efforts in waste sector in Seoul.

After that, participants discussed about the future strategies for the development of the pilot pre-proposal to be submitted to APN before the September 2000 deadline. Various issues about the feasibility & viability of such proposal, components, selection of mega-cities, time frame, approach to be undertaken, embodied emissions, deliverables etc were discusses in great length and finally a consensus has emerged. It has been decided to concentrate efforts in seven mega-cities in Asian region namely Tokyo, Beijing, Seoul, Shanghai, Manila, Delhi and Calcutta. However, participants are welcome to incorporate other cities too.

The group had advantage of interacting with the members of transportation group and noted the apparent overlapping in the two group's efforts. However, it was made clear that this group's objectives are different than that of transport group's objectives and, therefore, approaches of the two groups will be very different. This group will be doing the more microscopic studies which would be very different from the transport group's efforts. But a close interaction will be established with transport group to get maximum benefit from their efforts.

It was decided to prepare following:

1. Draft version of -1**st** ORDER DOCUMENT by the afternoon of 14th July 2000 comprising of data and analysis presented during the meeting.
2. -1**st** ORDER DOCUMENT by December 2000. The contents and format of this proposed documents have been agreed upon and annexed here. It has been realized that at the moment, all data for all the sectors may not be available but this exercise will lead to identification of gap areas and form basis of inter-comparison and prioritization of issues.
3. Preparation of PROPOSAL for pilot study for submission to APN before September 15, 2000 seeking about US$ 80,000 per year for two years in two phases. This will include elements like inter-comparison of different mega-cities, projections for future using four different scenarios built upon past history and policy implications. It has been realized that this proposal has significant policy implications and provide information to adopt proper mitigation approaches in mega-cities which would have long term as well as short term advantages of reducing GHG emissions but also reducing air pollutants. Therefore, both climate change as well as well health related aspects would be addressed.

4. This exercise will facilitate the eventual formulation of a mega-project for submission to other international funding agencies like GEF etc by the year 2002-2003.

All the data presented during the deliberations were distributed among the group members. All of the participants resolved to continue and enhance mutual collaboration.

Annexure

The GHG Budgets and Future Projection Scenarios of
Selected Mega-Cities in Asia

"- 1 Order Report" : Table of Contents

* All time series data for (1970), 1980, 1990, 1995, (2000)
* The first focus is on energy consumption and CO2, CH4, air pollutants
* Projection is not included. It will be conducted in Pilot Project (2001-2003).

1. Background Information
   - Geographical areas (built-up areas, administrative areas, larger cities, etc.)➔ Maps
   - Population (geographical distribution, age structure, ...)
   - Climate conditions
   - GRP
   - Land use patterns (Built-up areas, ...)
   - Basic Environmental Parameters
   -
2. Aggregate Energy Data
   - Energy Balance Table
   - Energy Sources (Coal, Oil, Gas, Hydro, Nuclear,...)
   - Sectors (Industry, Construction, Transportation, Residential, Commercial (Service), Conversion, ...)

3. Specific Sector Data

3-1 Household
   - Household size
   - Urban vs. Rural
   - Income groups
   - Sample Surveys (Household expenditures (electricity, gas, water, food, transportation, communication, education, cloth,...)
   - Buildings and houses (room size, physical structures,...)
   - Electric home appliances (number, size, energy efficiency, ...)

3-2 Commercial and Industrial Establishment, Service Establishment (e.g., hospitals)
   - number of establishments by type
   - floor space
   - energy consumption per floor space

3-3 Transportation
   - Vehicles (population, category, vintage,...)
   - emission factors

- fuel economy
- fuel consumption (gasoline, diesel, gas)
- average mileage
- road (structure, length)
- public transportation (railways, subways, buses, taxi)
- number of turnover (freight and passenger)
-

3-4 Energy embodied in materials

- Steel, cement, bricks (building materials), chemicals, food, water,...
- Consumption volume

3-5 Infrastructures (ecological devices)

- sewerage system
- waste disposal
- transportation system
- etc.

3-6 Waste

- Municipal solid waste (landfill, incineration)
- Domestic and commercial waste water
- Industrial waste water
- Emission factor (CH_4 from landfill, CO_2 from incineration)
- Resource recycling and recovery

3-7 Agriculture

- Land use (paddy field - CH_4, agriculture soils - N_2O)

Outline for the Workshop on Climate Change and Water use in Asian-Pacific Cities

Richard Berk
Meg Keen
Chris Cocklin

June, 2000

Attached is a draft of the concept paper written by Richard Berk and Meg Keen to conduct research on climate change and water resources in Asian-Pacific Cities. The premises of this concept paper are important. All follow from the "mission-oriented" nature of the proposed work. In particular, there are important empirical questions to be answered about climate change and water use that will require a wide range of expertise, technical skills, and backgrounds. It follows, therefore, that the interests and concerns of natural scientists, social scientists and policy makers will be linked in manner that will be highly interdisciplinary. In the same spirit, there will be the need for some collaborators who have in-depth knowledge about particular research sites and for some collaborators who are generalists. Likewise, both "hard" and "soft" data will be required. Finally, the proposed research is organized into phases because there will be the need for refinements as the enterprise proceeds. This workshop is the initial refinement exercise.

While the agenda for the workshop is subject to revision, especially during the workshop itself, listed immediately below is a set of topics that will need to be addressed, organized in approximate chronological order. The order is similar to the order of topics in the proposal. The "deliverables" at the end of the workshop will be 1) a series of concrete suggestions for revising of the concept paper and 2) a set of specific activities for implementing the pilot study, 3) suggestions for possible organizational structures in which to house the proposed research.

I. Overview of the Concept Paper (Wednesday --- 11:00 – 12:30)
   A. Theme – integrating human activities into the natural water cycle in the context of climate change
   B. Policy Concerns – water sustainability
   C. Staging
      1. Development
      2. Pilot Research
      3. Full Scale Research,
      4. Dissemination
   D. Research Design
II. Nature of the Research and Policy Problem (13:30-15:30)
   A. Current Issues in Water Resources in Asian-Pacific Cities
   B. Possible Impacts of Climate Change
III. Integrated Assessment as an Organizing Framework (15:45–16:15)

A. Integration of causal processes involving physical, biological and human processes
B. Integration over temporal and spatial scales
C. Integration across traditional academic disciplines
D. Integration of research and policy concerns
E. Immediate application: linking climate, hydrology, water supply infrastructure, water demand, water use, and water disposal
    1. where both the quantity and quality of water are important
    2. where there are quality of life implications (e.g., public health, regional economic health)
    3. where there are implications for wildlife and ecosystems

IV. Climate Models and Future Climate Scenarios (16:15-1700)
A. Modeling outputs: temperature and precipitation on a regional scale
B. Ideally, by season.
C. Ideally, estimates not just of average tendencies, but variability and extreme events.
D. What is likely to be available in practice?
E. Links to temporal and spatial scales of other processes (hydrology)

V. Research Design (Thursday, all day: 9:30-10:45 11:00-12:00, 13:00-15:00, 15:20-1700)
A. Data Requirements
    1. What needs to be measured, in principle?
    2. Temporal and spatial scales, in principle
    3. Practical and cost constraints
B. Potential Data Analyses
C. Site Selection
D. Time and Costs

VI. Pilot Study over the next 18 Months (Friday --- 9:30-10:45, 11:00-12:00)

VII. Staffing the Pilot Study (13:00-15:00)

Climate Change and Water Use in Asian-Pacific Cities

Richard Berk
UCLA

Meg Keen
Australian National University

December 10, 1999

Abstract

Of the potential effects of climate change, the implications for water resources are among the most important to society. An adequate supply of potable water is essential for human habitation. In many parts of the Asia Pacific, the demand for consumptive (e.g., water supply) and non-consumptive (e.g., navigation, hydroelectric power generation, industrial cooling, instream flow) uses of fresh water is barely balanced by sustainable surface and groundwater. Cities such as Jakarta and Bangkok may not be able to meet water demand by early next century (Dupont 1998); and as many as 300 cities in China are estimated to suffer already from water shortages (Postel 1996). In addition to issues of supply, issues of urban water quality are profoundly affecting the health and well being of urban populations. At present, many cities in the Asia Pacific suffer from inadequate sewage connections, storm water drainage, water supply networks and waste removal, which contribute to an increased incidence of flooding, water borne diseases, and ground and surface water contamination (Appan 1998; Elliott 1998; WRI 1996). To achieve better urban water management in the face of global climate change, a greater understanding of water hydrology and water demand in cities is required (Lettenmaier et al. 1999). In this document, we briefly describe the kinds of research that could inform such adaptations to climate change. The key idea is to "follow the water."

C. Introduction

There is increasing consensus that greenhouse gases produced by human activity are affecting the global climate, and that there is no way to quickly alter existing social and economic institutions so that the release of greenhouse gases can be dramatically reduced. It appears to be both reasonable and prudent, therefore, to begin preparing for a world that will have to adapt to relatively rapid climatic change. And in this world, how cities respond will be critical (Rockwell, 1999).

There are a large number of potential climate change impacts on humans in cities that will necessarily involve policy-makers and stakeholders of various kinds. These include the following (Watson et al. 1996):

1. Storm Damage
2. Sea Level Rise
3. Landslides/Erosion
4. Photochemical Smog
5. Wildfires
6. Energy Demand for cooling
7. Changes in location of Disease Vectors
8. Loss of Ecological “Services”
9. Changes to the Quality and Quantity of Water Resources
10. Salinization of groundwater from sea level rise
11. Increasing incidence of flooding

While all of these effects, and others that have not yet been anticipated, are grounds for serious concern, we focus here on water resources. Simply put, without adequate supplies of potable water modern, cities cannot exist.

In this proposal, the research issues pertain to water resources for Asia Pacific cities in the context of a number of climate change impacts. Adaptations to alterations in historical patterns of precipitation and temperature will need to address the demand for potable water, the flow of water through cities, and the disposal of wastewater. Demand must be understood not just so that water supplies can be improved, but so that the management of demand is a viable policy option. An understanding of water flows is vital to the better planning of infrastructure and policy to deal with: the increasing incidence of urban flooding in Asia Pacific cities; the contamination of urban groundwater and water courses; and, the sustainable extraction of groundwater given the increasing occurrence of subsistence and salt water intrusion. Better data on how waste water is being disposed will allow authorities to consider alternatives to such common practices as coastal and groundwater disposal, which have resulted in contaminated water supplies, human health threats, and fisheries degradation (ADB 1993).

The present trends in urban areas appear to be adding to, rather than reducing, pressures on water resources (Postel 1993; WRI 1997). For example, ground water in Jakarta, Manila, as well as Dailan, Qingdao, Yantai and Beihai in China are all suffering from saltwater intrusion, while cities on river deltas such as Bangkok are threatened with a salt front (Elliott 1998). Water pollution is escalating in nearly all Asia Pacific cities with very few exceptions. The increased demand for finite water resources is in part being affected by changing consumption patterns (i.e. to water intensive agricultural and industrial products) and poorly managed water supply in urban centers. It is estimated that urban leakages may account for up to 50% of water in urban distribution systems (Golubev 1993); figures for Southeast Asia have been estimated to range from a low of 6.5% in Singapore to 58% in Manila (Appan 1998). These leakages not only waste water but also can contribute to urban water pollution through the contamination of ground water and soils with sewage and industrial pollution. In some countries, the lack of suitable wastewater disposal facilities has resulted in the degradation of coastal, estuarine and ground water supplies. Changing climatic conditions coupled with land use changes can significantly affect the hydrology of urban areas and further exacerbate this degradation. Thus, for example, increased rainfall contributes to urban flooding, transport of urban pollutants into coastal and river environments, spread of water borne diseases, and stress of infrastructure capacity and functions.

2. A Scientific Context for Studying Water Resources in Cities

The proper study of water resources in cities begins with an appreciation of the natural water cycle. Physical, biological and cultural processes combine to produce and reproduce the water that humans consume. One key implication is that cities are in an important sense inserted into the natural water cycle altering the flow, location, and quality of water. Indeed, was this not the case, there would be no need to worry about the impact of climate change on water resources.

For the water cycle to be more than a metaphor, however, research on climate change and water resources needs to build on data from the relevant physical, biological/ecological, and human processes and models that link the three. These links must be made at the right spatial and temporal scales. For example, there is research already underway at UCLA in which climate models downscaled to a regional level are being used to study the impact of Pacific storms on runoff in the Los Angeles Basin. That runoff, in turn, affects water amounts and quality not just for human consumption but ecosystems in the watershed. Such models can then be used to help anticipate how the demand for water may need to be altered in response to the timing and amounts of rainfall that might come with global climate change. We briefly describe later how similar research might be done on Asian-Pacific cities. But the key idea is to "follow the water" as it enters cities, is used within cities, and leaves cities.

3. Proposed Research

While there are a number of places to start a research program on water resources and climate change in Asian cities, it perhaps makes the most sense to "build out" from human water use. From a scientific perspective, human water use is "dropped" into the natural water cycle and fundamentally alters it. As a result, the flow and quality of water is altered with impacts not just on humans but on local topography and ecosystems. Thus, the scientific question is to understand the current water cycle as a hybrid of natural and anthropogenic processes.

In addition, if human water use is not reasonably well understood, it will be almost impossible to develop practical adaptations to climate change. Moreover, if human water use is accurately comprehended, one can begin to develop policy instruments in anticipation of what the future climate might bring, and even make changes that would be desirable under almost any circumstances. For example, it is hard to imagine a climate change scenario in which the more effective control of water borne diseases would be detrimental. But to design and implement better controls on water borne diseases requires information on how human water use relates to the major flows and reserves of water.

We are proposing to study human water use in a set of Asian Pacific cities. We see the project as moving ahead in several phrases. Phase I would determine for the selected cities what information on water use exists, and what would need to be collected. Phase II would involve collecting data to fill whatever gaps were found in the available information, and then constructing comparable measures across sites. In phase III, analysis of the data would lead to conclusions about human water use in those cities and about the policy instruments that might be implemented. Insofar as output from regional climate models are available (or could be made available), those policy instruments would be evaluated in the context of regional climate change scenarios.

3.1 Information to Be Collected

It is both important and obvious to begin with information on water supplies in the relevant spatial and temporal units. Such information would describe the "input" and make a direct link between human needs and what nature can provide. But water supply is only part of the story. To follow the water, one would need information on city infrastructure and data on urban residential, industrial, commercial, and governmental water users, organised by the relevant unit (e.g. household, factory, retail store) and by time (e.g., per day, per month). And ideally, one would also need information on local ecosystems that might be involved.

While the details would depend on local circumstances, (e.g., groundwater data will typically be difficult to obtain), the following list illustrates the kinds of information one might seek on both the natural world and the human world.

5. Local Climate.
6. Structure of the water distribution system, both natural and human-constructed.
7. Key characteristics of local hydrology and geology (e.g. soil permeability, groundwater recharge rates, heat island effects, etc.).
8. The location and functioning of local relevant ecosystems.
9. Water quality at various points in the distribution system
10. Uses of the water by humans (e.g. personal hygiene, washing computer chips, automotive servicing, food processing, industrial cooling systems, etc).
11. Water use technology and infrastructure (e.g. kind of toilets, cooling mechanisms, sewage treatment).
12. Human behaviors relevant to water use (e.g. baths versus showers).
13. How water is obtained (e.g., local wells, private sector water purveyor).

14. If, and how, water use is officially monitored.
15. If water must be purchased, what the price structure is.
16. Local demand management practice (e.g. through water metering, building codes, pricing structures, regulations, education).
17. Institutional arrangements affecting water supply and quality.
18. Cultural factors affecting water use and water quality.
19. Available human resources to affect change in the water sector.

Data Collection

Depending upon the particular kind of information required, a combination of several data sources would be used. A key distinction would be data that could be collected from existing sources and data that would have to be collected directly. For example:

F. Scientific documents and official statistics where available, could be used to in part characterize present climate and hydrology (e.g., precipitation, temperature, groundwater volumes, groundwater recharge rates, and land surface changes). But such information might be supplemented by new data collection were practical (e.g., adding more rain gauges at higher elevations).
G. In many cities, there will official/archival data on water use and quality from administrative records (e.g. meter data, population data, survey data). A key question is how complete these data are likely to be.
H. Official documents supplemented by interviews with local informants would be useful for understanding local water infrastructure, local ordinances and regulations relevant to water use (e.g. water delivery systems, building codes, sale of water).
I. Official documents supplemented by interviews with local informants would help document local policies and practices of water suppliers (e.g. metering, price structure, demand management practices)
J. Interviews with representative samples of water users would be essential to learn how and when water is used.

All five of these sources have been used successfully in the United States (see for example Berk et al. 1981; 1993), and research instrumentation, including questionnaires, are available. However, the mix of sources and details of research approaches would vary across the Asian settings. For example, in some locales there will be little comprehensive official records of water use. In those settings, more of the burden would be carried by new survey research.

3.3 Future Climate Scenarios

Data on the current context and situation are necessarily inadequate for projecting the implications of future climate change. We propose, therefore, to establish a working relationship with a world-class climate-modelling group who would be able to provide regional scale climate change scenarios, including consequences for the natural water cycle. In this regard, we have spoken with officials at the National Center for

Atmospheric Research (NCAR) in Boulder, Colorado. Their Climate System Model (CSM) will have added to it over the next 12 months a module to capture the natural hydrological cycle, and in particular, precipitation and soil moisture. One of us (Berk) is a member of the Advisory Board for the CSM and has been assured that the climate scientists at NCAR would be delighted to provide the regional information we would need. The climate scenarios along with information on the natural hydrological cycle could then be used to consider the implications for Asian Pacific cities of changes in precipitation amounts combined with where and when it fell. Note that timing and location are as important as amounts. For example, a shift of just a few degrees in the angle at which storm fronts approach coastal mountains can mean that precipitation supplying one watershed may now supply another watershed. Likewise, an alteration in the timing of the monsoon season could have critical implications for water quality and flooding. In short, the climate modelling forecasts will provide information on the renewable water resources with which Asian Pacific cities will have to manage. This information will provide vital inputs to our analysis of water use and allow us to work through a wide variety of "what-if" adaptations.

3.4 Choice of Sites

Ideally, one would collect data from a large set of Asian cities, perhaps even the entire population of cities above a certain size. But this is clearly impractical. Rather, we propose an incremental choice of sites in which later sites are chosen based on the insights gained from earlier sites. We propose to begin with one city in a highly developed country such as Japan, Singapore or Korea and one city in a developing country such as China, Thailand or Vietnam. The goal would be to refine the research design and data collection instruments in settings that might begin to represent the range of sites ultimately to be studied. For example, when there is no central water purveyor, there will likely be no centralised records of water use. A key question then becomes how can urban water use be effectively assessed to inform urban planning and decision-making? It may be necessary under such circumstances to help local water purveyors design and implement special procedures to routinely record the water amounts provided to different users.

Based on the experience with the initial two cities, it might then make sense to design a larger scale study of perhaps five cities. The goal would be less to generalize to some population of Asian cities (with a sample size of five that would be silly), but instead to develop a methodological framework which could be used to assess urban water use in Asia Pacific cities, and to begin to document the range of water use practices and policy responses in the Asia Pacific. Therefore, the design would call for cities that are very different from one another. Finally, one could imagine implementing a water use study on a large and representative sample of Asian cities. But such a study would be undertaken only after the two smaller studies were completed.

We appreciate that the choice of sites in which to conduct the initial pilot research is crucial to the success of the study. At the present, we lack the information needed to choose intelligently. Moreover, even if we had such information, the data collection would almost certainly fail without the assistance of colleagues at each of the sites. We cannot say at this point how our data collection strategies will likely fare in cities that are somewhat different from cities in the United States, Australia and Europe, where much of the experience with water use data has been acquired. The issues will differ dramatically in different Asian cities. We would need advice and assistance in selecting potential sites. We recommend that a scoping workshop for this project be organised, with APN assisting us to ensure that appropriate expertise from the region is adequately represented. This workshop could be used to: refine the research proposal; to build collaborative networks with colleagues working in the cities selected for water use research; and to involve other colleagues from Asia Pacific cities for which the research has relevance.

3.5 Examples of Policy-Relevant Questions that Could be Addressed

The literature on water use is filled with examples of the kinds of policy-relevant questions that could be addressed by this type of research, which combine concerns about climate change with urban water use. Some illustrations include the following, all of which would be addressed in the present and under the most plausible climate change scenarios.

1. What are the peak use periods during the course of a day/year, and how are these likely to be affected by climate change? This information is critical because the supply of water has to match peak load demand, not average demand.
2. Which household activities are the most water intensive? Clearly, these are the activities in which it may be most cost-effective to intervene.
3. What are the local possibilities for water use substitutes and/or use of reclaimed water (e.g. sanitation)?
4. Where are the opportunities for rapid and effective top down interventions (e.g. water metering, building codes)?
5. How can greater community involvement address water quality and demand issues (e.g. pooling of community resources to build water infrastructure for poor localities)?
6. Which industries are especially water intensive/polluting and where in their operations are cost-effective changes most effectively made? (This information can be used to develop targeted policy incentives through cleaner production programs or financial incentive programs).
7. What aspects of urban form contribute to the degradation of water or the over-consumption of water? (e.g. mixing industrial and domestic waste water; building based heating and cooling systems)
8. What policies implicitly contribute to high levels of water consumption or degradation (e.g. industry subsidies, differential water rates)?
9. How adequate are water drainage networks, sewage treatment plants and other water infrastructure given projected climate change coupled with projected population growth and industrial transformation?
10. What are the impacts of local water quantity and quality on the ability of wetlands to provide their usual "ecological services?"

4. The Next Step

The next step is to receive feedback on this "pre-proposal" and then to rewrite and expand the content accordingly. However, many of the key details cannot be determined without selecting the initial two cities for the pilot study. Consequently, before the revision is undertaken, it is essential to begin a discussion with experts associated with APN, who are knowledgeable about cities that might serve as the two initial research sites. In addition, contact with local experts at those sites (i.e. both local scientists and local policy makers) is vital. In other words, some discussion with potential collaborators is necessary before a full proposal can be written. This could occur optimally in a workshop, or alternatively, through e-mail discussions/internet conferencing.

Once the pilot cities are selected, it would also be extremely useful to have "site visits" to see first hand what kinds data might or might not be available. Given the international nature of the proposed research and the considerable potential for incomplete communication, there is really no substitute for face-to-face discussions at each of the potential research sites. One research associate familiar with the data needs of the methodologies to be applied could do these site visits. Advice on appropriate funding bodies and the full support of APN would also be required.

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<u>Agenda for Transportation Workshop</u>

Wednesday

0900-1000	**Registration**
1000-1100	**Plenary**

Transportation Group Session

1000-1130	**Self introductions**
1130-1230	**Overview of research questions**
1200-1300	**Lunch**
1330-1700	**Specification of critical research questions**
1830-	**Reception**

Thursday

0930-1200	**Status and scope of current research on urban transportation and its impacts**
1200-1300	**Lunch**
1300-1500	**Identification of questions not being adequately addressed for the region.**
1500-1700	**Preliminary design of an APN research program**

Friday

0930-1200	**Concrete proposals for APN research program**
1200-1300	**Lunch**
1300-1500	**Report(s) written**
1500-1700	**Next steps**

The GHG Budgets and Future Emission Scenarios of Selected Mega-Cities in Asia (APN 2000-18)

Final Activity Report

March 15, 2001

Hidefumi IMURA

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PART I

IMURA Group

(Tokyo, Seoul, Beijing and Shanghai)

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1 The Outline of the Activity

1.1 Meeting and Workshop

a. Group Session in APN Workshop held in Kobe on 12-14 July, 2000

Title: Group Session on GHG emission and mega-cities of APN Workshop on Urbanization, Industrial Transformation and Environmental Change

Objective:

As this was the first opportunity for the participants to get together, the meeting mainly aimed at sharing a common understanding of the objectives of the project, formulating the personnel organization, and elaborating the initial plan for the submission of the pilot pre-proposal for APN before the September 2000 deadline.

Participants:

- ✓ Prof. H. Imura (Nagoya University) /Japan
- ✓ Dr. A. P. Mitra (National Physical Laboratory) /India
- ✓ Dr. T. Y. Jung (IGES) /Japan
- ✓ Dr. S. Kaneko (IGES) /Japan
- ✓ Dr. C. Sharma (National Physical Laboratory) /India
- ✓ Prof. K. He (Tsinghua University) /China
- ✓ Prof. Z. Wei (Tshighua University) /China
- ✓ Prof. E. Yoon (Hyupsung University) /Korea
- ✓ Dr. D. Tong (Beijing Municipal Institute of City Planning & Design) /China
- ✓ Dr. S. Jo (Korea Energy Economics Institute) /Korea
- ✓ Dr. L. Bin (Tsinghua University) /China
- ✓ Mr. Dasgupta (National Physical Laboratory) /India

Summary:

The group session began with opening remarks of Prof. Imura. Prof. Imura apprised about the various components of the project which is being formulated to account for the first time the embodied emissions besides direct GHG emissions. He also proposed the tentative approach and timelines for discussions by the participants. Dr. Mitra emphasized the need to take into account the other urban pollutants like CO, NO_x & SO_x besides particulate matter as they have great impacts on human health as well as the climate. Dr. Mitra mentioned that they are associated with the sources that are responsible for greenhouse gas emissions. He pointed out that during the forthcoming discussions, there is need to address questions such as the definition and geographical boundaries of the mega-cities which are increasingly becoming epicenter of urbanization of surrounding erstwhile non-urban areas. It will also be needed to identify suitable time periods to enable development of future scenarios based on past history of growth rate besides incorporation of various socio-economic (consumption pattern) factors.

After lunch, Prof. Imura apprised about the ICLEI's project reports and pointed out that there is not so much information available for the developing world. He also informed that about 20 cities have joined ICLEI to reduce their CO_2 emissions by 20% by 2010.

Following this, Korean, Japanese, Chinese and Indian groups made presentations and informed about the kind of data available for Seoul, Tokyo, Beijing, Delhi and Calcutta. These groups also presented studies carried out so far which have relevance to the present effort and it was found that they have already generated quite useful database and information.

While it has been realized that lot of data already exists which can be used in this project but substantial efforts would be needed to put all the data in usable format and to insure their quality. Another significant information emerged from the importance of different sectors in different mega-cities e.g. in Seoul building sector is important, in cities like Tokyo and Delhi transport sector is important. It was also decided to accelerate efforts for generating the database for Shanghai and Manila.

Later, Dr Jung made presentations on the “approach of possible analysis framework” and “data-base construction” primarily for Seoul, Tokyo & Beijing. But it was agreed that efforts would be made to use such approach for Delhi, Calcutta and Manila with or without modifications. Dr Yoon made a brief presentation about his research efforts in the waste sector in Seoul.

After that, participants discussed about the future strategies for the development of the pilot pre-proposal to be submitted to APN before September 2000. Various issues about the feasibility & viability of such proposal such as the components, selection of mega-cities, time frame, approach to be undertaken, embodied emissions, deliverables etc were discusses in great length and finally a consensus was made. It was decided to concentrate the efforts in seven mega-cities in Asian region namely Tokyo, Beijing, Seoul, Shanghai, Manila, Delhi and Calcutta. However, participants were welcomed to incorporate other cities too.

The group had advantage of interacting with the members of transportation group and noted the apparent overlapping in the two group's efforts. However, it was made clear that this group's objectives are different than that of transport group's objectives and, therefore, approaches of the two groups will be very different. This group will be doing the more microscopic studies which would be very different from the transport group's efforts. But a close interaction will be established with transport group to get maximum benefit from their efforts.

It was decided to prepare following:

1. Draft version of -1st order document by the afternoon of 14th July 2000 comprising of data and analysis presented during the meeting.
2. -1st order document by December 2000. The contents and format of this proposed document was agreed and is annexed here. It has been realized at the moment that all data for all the sectors may not be available but this exercise will lead to the identification of data gap and form the

basis of inter-comparison and prioritization of issues.

3. Preparation of proposal for pilot study for submission to APN before September 15, 2000 seeking about US$ 80,000 per year for two years in two phases. This will include elements like inter-comparison of different mega-cities, projections for future using four different scenarios built upon past history and policy implications. It has been realized that this proposal has significant policy implications. This provides information to adopt proper mitigation approaches in mega-cities which would have definite advantages in long term as well as short term for reducing GHG emissions and air pollutants. Therefore, both climate change and human health related aspects would be addressed.
4. This exercise will facilitate the eventual formulation of a mega-project for submission to other international funding agencies such as GEF and others by the year 2002-2003.

b. Meeting of IMURA group held in Seoul on 13 December, 2000

Title: Work Plan for the Second Phase Project of IGES-UE/APN Project -Study on Urban Policy Integration for Energy Related Issues in Selected Asian

Objective:

The major objective of this meeting was to discuss and agree on the working plan for next phase activity particularly focusing on the model development. Prior to the discussions on the job allocation and time schedule, the model design/structure including sector disaggregation, data availability, and final and intermediate goals were discussed.

Participants:

- ✓ Prof. H. Imura (Nagoya University) /Japan
- ✓ Dr. T. Y. Jung (IGES) /Japan
- ✓ Dr. S. Kaneko (IGES) /Japan
- ✓ Prof. K. He (Tsinghua University) /China
- ✓ Prof. E. Yoon (Hyupsung University)/Korea
- ✓ Prof. C. Moon (Hanyang University) /Korea
- ✓ Prof. K. Lee (Dongguk University) /Korea
- ✓ Prof. D. Lee (Sangmyung university) /Korea
- ✓ Dr. S. Jo (Korea Energy Economics Institute) /Korea

Summary:

The one-day meeting was composed of two parts: the presentations in the morning and the discussion in the afternoon. The meeting began with opening remarks by Prof. Imura who made a brief explanation of the objectives of the meeting as well as the entire project and participants reconfirmed the prehistory and the progress of the project. Following this, Dr. Kaneko who is in charge of coordinating IMURA group proposed the outline of the model including the model structure, job allocation, schedule and expected outcomes. After that, the respective experts made the three presentations on the methodological issues for designing sector specific modules, namely transportation sector by Prof. He, waste management sector by Prof. Yoon, and macro economic sector by Dr. Jung.

The major points and agreements in the discussion lead by Prof. Imura and Dr. Jung can be summarized into four categories including data issue, job allocation, methodology and scheduling or assignment.

1. Data issue

A) Statistical Data: 200 ~ 300 variables will be included

- Make common format for aggregate data (Dr. Jung & Dr. Kaneko will do as soon as possible)
- Make data list (finish at end of Jan. 2001)

B) GIS Data

- Tokyo data is too much detail and need to be aggregated (Dr. Kaneko can access Tokyo data)
- Tokyo data is the benchmark of other cities.
- Professor Lee, D.K. has Seoul data (GIS data).

C) Information for the future plan

- Need common format: translation to English (documentation in local language).
- Need check point (what kinds of information should be collected and summarized).

D) Other issues for database

- How to integrate the old data.
- Which years: time series (from 1980 ?). need to check the availability
- How to dis-aggregate if there is no regional data.
- Need meaningful scenarios
- To make data format (urgent issue): data depend on the methodology but methodology also depends on data. (Dr. Jung & Dr. Kaneko will do as soon as possible)
- Energy data is really important (particularly for Beijing and Shanghai)
- Need micro level data (March, 2001): transportation mode data (bus, subway, etc.), population data, commercial sector (categorized by business-floor space, types of business, business hours, etc.)
- Need household energy consumption data (home appliances, heating/cooling, hot water supply, etc.).
- Professor Lee K. J. will develop the efficient way of data management.

E) Base year issue:

- Year 1995

- 1998 or 1999 is preferred to 1995, but 1995 is easy to connect the other data like I/O table

2. Job Allocation

A) Sub Team

- Macro Analysis (top-down, economy data): Dr. Jung T. Y.
- Transportation (4 Cities): Professor He.
- Waste Management: Professor Yoon
- Residential/Commercial Sector: not decided yet
- Data Management: Dr. Kaneko

B) Other Activities

- Data Management system development: Professor Lee K.J.
- Material flow: Dr. Dhakal.

C) Proposal

- Each sub team leader should make the proposal and submit to Dr. Kaneko by the end of Feb. Dr. Kaneko is going to integrate and make complete final plan.
- Proposal contains:

Background

Objectives

Methodology

Scenarios, etc

3. Scheduling

A) Proposals: Jan 2001

B) Meeting: April or May 2001

- First meeting: IGES
- Second meeting: Shanghai

C) International Conference in Brazil (IHDP): Sept. 2001

- Urban Sustainability: Presentation (4 Sub groups, APN funding)

D) Basic Analysis of Data and Summary of Methodology will be published by IGES (July 2001)

4. Other Issues

A) I/O Table

- Check the regional I/O and National I/O.
- 3 nations have 95 national I/O tables.
- Need city level I/O table

Shanghai (95) Dr. Kaneko needs to check.

Beijing (85) Prof. He needs to check.

Tokyo(?) Dr. Kaneko needs to check.

Seoul(?) Prof. Moon needs to check

B) Regional Data: Macro, Consumption, etc

- Check to the governmental statistic office.
- Contact Dr. Tong for Chinese data.

C) Human Resources

- Hire students for computer work
- Find the proper expert from Shanghai and contact with him/her as soon as possible

1.2 Other Activities

- ✓ Dr. S. Kaneko (IGES) and Dr. T. Y. Jung (IGES) made a business trip to Seoul to discuss and initiate the database development with Prof. K. Lee in June 2000. The related expenses of Dr. S. Kaneko were covered by IGES.
- ✓ Dr. T. Y. Jung and Prof. K. Lee made a business trip to Beijing to explain database development and initiate the data collection for Beijing with Prof. K. He in September 2000. The related expenses of Dr. T. Y. Jung were covered by IGES.
- ✓ IGES commissioned Prof. K. He to prepare three manuscripts entitled "Overview of Energy Related Issues in Shanghai", "Overview of Urban Transportation and Environmental Issues in Beijing" and "Proposal on the Model Development of Urban Transportation Sub-module and its Related Researches" respectively.
- ✓ IGES commissioned Prof. E. Yoon to prepare two manuscripts entitled "Overview of Waste Management and Energy and Material Consumption in Seoul" and "Proposal on the model development of waste management sub-module and its relevant research".

2 Major Findings

2.1 Introduction

This study aims to collect GHG budget data of some mega-cities in Asia and to present future scenarios of GHG emissions and carbon cycle of the cities up to 2020. It will also lead to the generation of inventory of various associated short-lived gases like CO, NO_x, SO_x and particulate matter (PM). The study will focus on sectors and activities for which cities can manage to implement some effective countermeasures by adopting locally operational policy instruments. Thus, it will give special consideration to transportation, residential and commercial sectors, buildings, urban infrastructures, and citizens' lifestyles where it needs detailed investigation and analysis. Key areas are household energy consumption for heating/cooling, cooking, electrical appliances, etc., and vehicular transportation including gasoline and diesel driven cars and motorcycles. Cities usually have factories, power plants and other industrial establishments. The study intends to account both for the direct emissions and the embodied emissions, which is a new concept and needs formulation of suitable methodology.

As a first step toward the above-mentioned final goals, the major findings of preliminary studies conducted by the members of IMURA group from July 2000 to March 2001 are summarized in this report. The selected sectors in selected mega-cities that are covered in this report are shown in **Table 1**.

Table 1 Selected Cities and Sectors Covered in the Report

	Basic Information	**Transportation sector**	**Residential sector**	**Commercial sector**	**Waste management**
Tokyo	√	√	√√		
Seoul	√	√		√√	√√
Beijing	√	√√			
Shanghai	√	√	√	√	

Note: √: Brief introduction, √√: Detail information

2.2 Urban Transportation and Air pollution in Beijing

a. General Description of Urban Transportation Issues in Beijing

(i) Present Situation

Beijing City development plans change almost every month and a new map is therefore required to reflect the final status of development, housing, and road network. There are five ring roads that contain Beijing's urban area. First ring road encompasses Beijing's downtown area. Second, third, and fourth ring road areas are referred to as urban core, urban area and built urban area respectively. Beyond the fifth ring road are Beijing's suburban and rural areas (small parts of suburbs are included in the fifth ring area). New housing is under construction around the fifth ring road area and 14 satellite cities are built in the suburban and rural areas. Due this new settlement patterns and due to government policy of "one child only" being implemented more strictly in the urban area, most of the population increase in the future is expected to occur in the suburban areas. People will want to move to the suburbs to get out of the city's pollution and get bigger houses for cheaper prices. This will result in an increased demand of transportation.

Compared to developed cities Beijing has less automobile usage, very little rail-based transport (subway and light rail), and much more non-motorized vehicle usage (mainly bicycles and walking). At this moment, the share of air pollutant emissions from the mobile sector is lower compared to Mexico, Santiago, and São Paulo. Main reasons for this are that, industries/ stationary sources are located in the suburb areas for these cities whereas they are still scattered all over the whole area of Beijing. Stationary sources burn coal which is a main source of pollution in Beijing. But this will change because of Beijing's plan of decentralization, pushing the industries outside the fourth ring road area, and high growth rate of the transportation sector.

In 1995 there was slightly more than 850,000 vehicles in Beijing and cars made only a small percentage of this (12.4%). The model's projections show a large increase in the number of cars, from around 231,000 in 1998 to more than 4 million in year 2020, reaching almost a 60% of the total number of vehicles in Beijing. The other mode of transportation that shows a large increase is the LDV mode, arise from slightly above 350,000 to more than 2.1 million from 1995 to 2020. There has been a large number of motorcycles in the past but the future share of motorcycle population will decrease due to the policies that the government is implementing against these vehicles (motorcycles are not allowed to run within the five ring road areas, these regulations being enforced more strictly within the first 3 ring roads area).

(ii) Problems

Since the 1980s, road construction and traffic management in Beijing have made great achievements. Nevertheless, because of historical and realistic reason, traffic demand and supply are not balanced in terms of total amount and structure. This imbalance is getting more and more serious. As a result, traffic jams occur in wide area. The direct reasons for the above are as follows.

(1) The development of vehicle traffic loses control. Road construction is difficult to suit the increasing demand.

In recent 15 years, the number of vehicles in Beijing has increased by 15 percent per year, while the road length has increased by only 1.2 percent and road area by 3.7 percent on average per year. As a result, the vehicle traffic demand exceeds the capacity of road network in the city proper. Besides, a large number of bicycles and vehicles run on the same road, making traffic jams more serious.

(2) Irrational road network structure and passenger and freight traffic structure make traffic jams more serious.

Viewing from the existing road network structure in proper Beijing, the No. 2 and No. 3 ring roads have already been renovated as semi-closed express roads. Part of the No. 4 ring road has been constructed. Nevertheless, as there are not enough link roads between ring roads, it is difficult to form a network. It is also difficult for a large number of vehicles running in express road network to leave there through link roads. This situation makes the traffic load and traffic jams on arteries and express roads more serious. Once a traffic accident or vehicle's breaking down occurs, it is very easy to cause traffic jams.

In recent years, as urban passenger traffic structure is not rational, buses and trolley buses have lost attraction gradually. The passenger carrying has been about 3 billion per year with 40 percent of passengers coming from other provinces. At the end of the 1970s, about 70 percent of residents traveled by buses or trolley buses. But at present, this rate has reduced to only less than 40 percent. That is to say, a large number of passengers who used to travel by bus or trolley bus have now traveled by car (including taxi, private car and vehicles own by units). As a result, the cars occupy 77 percent of the loading capacity of the road network in the proper city. But they only carry 12 percent of the whole passenger traffic volume. This situation, in turn, makes the distribution of road capacity seriously lose the balance. Therefore, traffic jams become more serious.

Because the freight traffic market is not properly managed and the readjustment and control of freight traffic policy do not work properly, many units and persons manage freight traffic by themselves. As a result, socialized professional freight traffic withers continuously. In the early 1980s, the socialized professional freight traffic carried 40 percent of the whole freight traffic volume. But at present the rate has decreased 4.7 percent. This not only causes surplus of social freight traffic capacity and a waste of fixed asset (including a waste of energy and environmental pollution), but also makes the efficiency of freight traffic resource distribution decrease to the lowest point. In addition, because the unsocialized freight traffic modes are not efficient with high deadhead operation rate, large amount of inefficient trip volume increases, occupying the insufficient road resource and making traffic jams more serious.

(3) In the proper city, the contradictions between the intensity of land development and the capacity of its traffic environment increase gradually.

Since the 1980s, part of land use structure and the intensity of development in the city center have been development to the direction not favorable to ease traffic pressure. The contradictions between the intensity of development and the capacity of traffic environment become increasingly acute.

It should be agreed that the application of the principles of land rent at different classes to attract funds and to develop the city center in more rational way is necessary. But if what has been done go beyond certain limit, it will cause a series of side effects. According to statistics, from 1991 to 1995, the newly built, proposed, renovated and extension projects (The floor area if a single building exceeds 10,000 square meters.) in proper city had a total floor area of 28 million square meters with 70 percent distributed in the city center. Also, most of the structures are public buildings which generate and attract streams of people and vehicles. If the spatial distribution of these buildings with high FAR is not appropriate, it will produce greater pressure to the arteries and commercial streets where traffic jams have already occurred very often.

(4) Parking space and facilities are in great demand. Vehicles are often parked in disorder.

Because of some historical and realistic reasons (For example, early city planning, especially transport planning did not pay much attention to parking problems. The planning, design and construction of a number of large or medium sized public buildings do not abide by the stipulations concerning constructing parking facilities. Some indoor parking facilities have been converted to other uses. At present, parking fee and management policies could not repay the investors, etc..), parking facilities are in great demand not only in center but also in the periphery of the proper city, the units and residential districts. As a result, vehicles are parked in disorder, affecting the appearance of the city, occupying large road space, making traffic jams more serious and threatening residents' calm living environment.

(5) The source of urban traffic investment is single. It is difficult to suit the present and future need for development.

The construction and management of urban transport need a huge investment. But according to the existing transport policy, the outcome after investment is mainly reflected as social benefit (excluding outbound commercial passenger and freight traffic). Therefore, it is difficult to realize rational repay and increase in value. This investment system does not have the ability to solve the transport problems left over by history and ease the present transport contradictions between supply and demand. It is more difficult to suit the need for huge funds in the future development of urban transport.

To sum up, as Beijing's modernization, urbanization and motorization are entering a new stage of development, transport demand is in the state of exceeding normal growth. This situation, therefore, causes the imbalance of traffic demand and supply, leading to traffic jams in large areas, and lowering the efficiency of urban activities. This is the crux of urban transport development issue for Beijing.

b. Current State of Energy Consumption of Urban Transportation in Beijing

Tables 2 and **3** show the fuel efficiency and energy consumption of urban transportation in Beijing in 1995 and 2000.

Table 2 Energy Consumption per km in Beijing

	Occupancy	FE (1995) (km/lt) or KWh/km)	MJ/km	MJ/pass-km
Cars	2.5	7.69	4.21	1.6823
Taxis	3.6	8.00	4.04	1.1230
Buses	50	4.00	8.53	0.1706
LDV	3	6.67	4.85	1.6163
HDGV	2	3.57	9.06	4.5298
HDDV	2	3.33	10.77	5.3862
MC	1.2	28.57	1.13	0.9434
Subway	220	3.65	13.14	0.0597
light-rail	120	5.62	20.23	0.1686

Table 3 Fuel Use by Different Transport Modes in 1995 and 2000 in Beijing

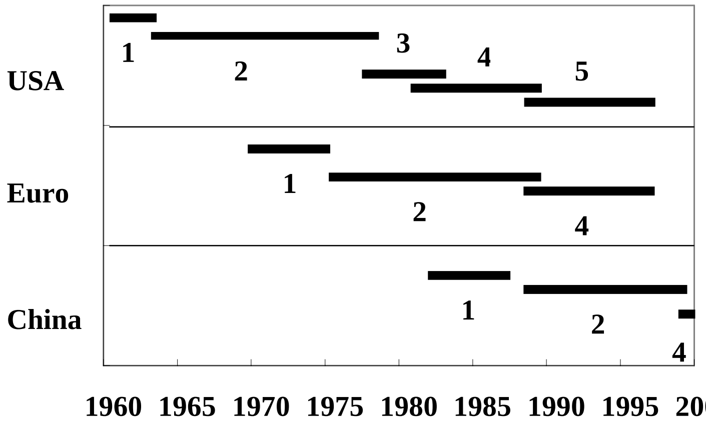
	Gasoline (million liters)		Diesel (million liters)		Electricity (million KWh)	
Vehicle	1995	2000	1995	2000	1995	2000
Cars	407.80	1,356.10				
Taxis	549.43	563.10				
Buses	42.47	59.65	42.47	59.65		
LDV	1454.82	2,373.70				
HDGV	398.58	672.99				
HDDV			282.24	325.52		
MC	77.35	140.01				
Subway					146	146
Total	2,930.45	5,165.55	324.71	385.17	146	146

c. Current State and Countermeasures of Vehicular Air Pollution in Beijing

(i) Emission factors and control level

Most of China's vehicles still use carburetors and there is no after- treatment of exhaust. For most of the domestic vehicles, the old engine modes are conductive to high fuel consumption and emissions. The control level of the average emission is still low (**Figure 1**). From the emission factor comparison shown in **Table 4**, we can see that the present level of vehicle emission control in China is similar to that of USA in the 1970's.

In addition, inadequate Inspection /Maintenance (I/M) program lead to high failure rate under lenient standards and higher emission from in use vehicles.



1: PCV, 2: CCS& EGR, 3: OC, 4:TWC+EFI, 5:Hybrid and Fuel battery

Figure 1 Development of Vehicle Emission Control Technologies

Table 4 Comparison of Vehicle ZML between China and USA

Vehicle type	HC (g/km)	CO (g/km)	NO_X (g/km)	similar US model year
LDGV	4.3	43.0	1.3	71
Mini Bus	5.7	25.3	2.1	74-78
Jeep	6.2	33.5	3.2	74-78
LDGT	9.5	51.7	4.6	71-74
HDGV	29.6	164.6	17.3	70
MC	2.0	14.4	0.1	85-88

(ii) Vehicular emissions and air quality

Figures 2 and **3** show the annual concentration change of CO and NO_x in different areas of Beijing.

From **Figure 2**, it can be found that the average level of NO_x is two times higher than the national standards in the whole urban area. The average concentration is increasing steadily, compared with TSP and SO_2 which have been controlled. So, NO_x pollution is the pollutant of greatest concern in the city.

The CO pollution (**Figure 3**) is not as serious in contrast with NO_x. The average CO concentration does not exceed national standards throughout the city. But in the areas with heavy traffic, the concentration of CO exceeds the standards frequently. Therefore, it is also important to control the CO emissions.

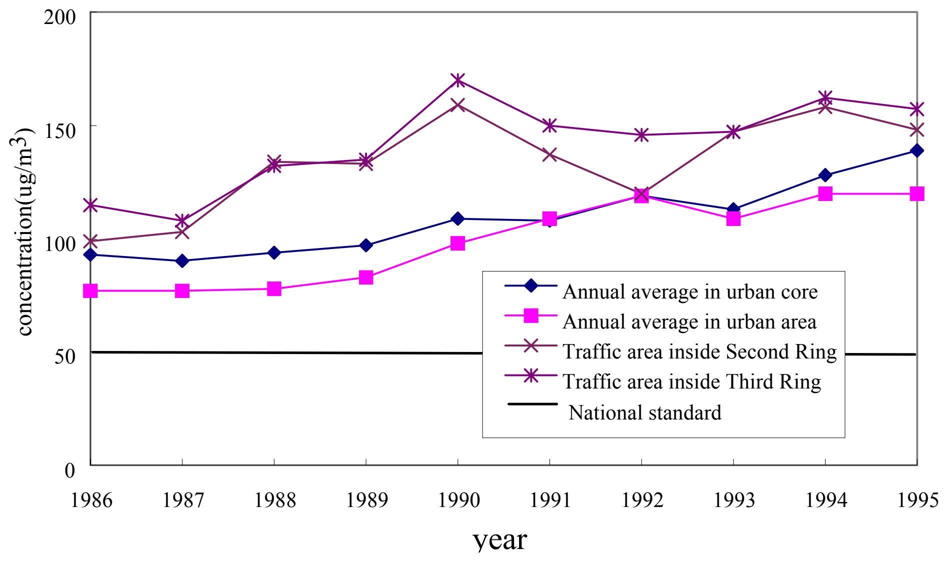


Figure 2 The concentration changes of NO_x in Beijing

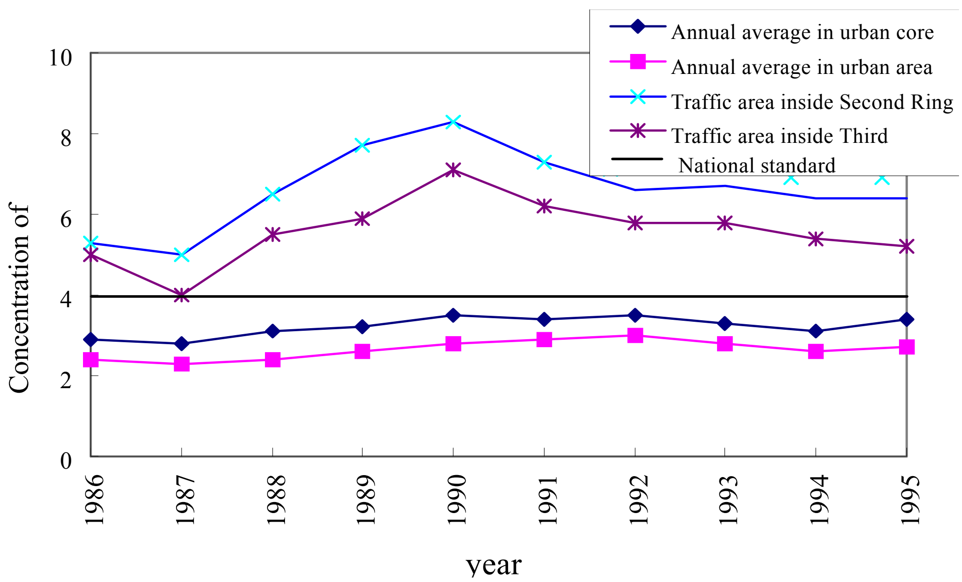


Figure 3 The Concentration Change of CO in Beijing

Further, the above figures indicate the different characteristics of the two pollutants. As shown in **Figure 2**, the concentration of NO_x in the main traffic area inside the third ring is higher than that in the whole urban area, however, the average NO_x concentration in the urban area is still high, indicating that the air pollution of NO_X occurs throughout the city. The sources of NO_x in addition to vehicles (stationary sources) cannot be neglected, and some of them may be more important than mobile sources. On the contrary, the difference of CO concentration between the whole urban area and main traffic area is very distinct. This is because vehicle emissions are the major causes of CO pollution.

Vehicle emissions such as HC, NO_x CO oxidizes into ozone and other strong oxidants. According to monitoring data, the days of O_3 concentration exceeding national standards have increased. The trend of O_3 exceeding the standards is shown in **Table 5**. Ozone exceeding phenomenon have increased from an average 48 days in 1986-1990 to over 53 days in 1991-1995. It means that the secondary pollution (O_3) has increased and photochemical smog become worse with the increase of vehicle population and vehicle emissions. However, the spatial distribution of secondary pollutants is distinct from that of primary pollutants. In the urban core, the days that exceed the standard are less than 20 on the average and there is no increasing trend. In contrast, in the suburban areas, the number of the days that the standard is exceeded is 40-50. Hence, secondary pollution occurs in the suburbs. Since the suburbs have a lower population density, the exposure of the population is less.

Table 5 The Days of O_3 Exceeding Standards in Beijing

	1986-1990	1991	1992	1993	1994	1995	1991-1995
Urban core	129	16	23	30	24	13*	106
Suburban area	239	44	51	61	75	38*	269

* faults in the monitoring apparatus

d. Future Plans and Policies of Related Issues in Beijing

(i) Future trend of emissions

The rapid increase of vehicle population necessarily adds to vehicle emissions. If we are thinking of the business-as-usual scenario, the emission factors will remain constant (same as 1995). The calculated emission amount for Beijing will increase sharply, **Figure 4** shown the results, which reveals that if no control measures are adopted, CO emission will increase more than three times from 1.39 million tons in 1995 to 6.92 million tons in 2010. NO_x emission will nearly triple from 0.11 million in 1995 tons to 0.32 million tons in 2010. If pollutant concentration is directly proportional to emissions, by 2010, CO concentration will exceed the third level of the national standard, and NO_x will exceed the standards by 3-4 times. Such a situation would be more serious than what took place Mexico City in 1992 with serious implications to the human health.

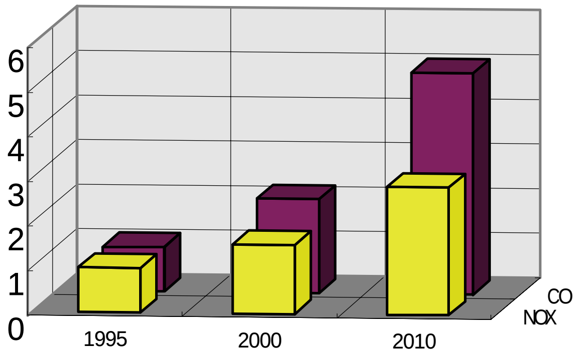


Figure 4 The Increase Ratio of Emissions for Beijing under Business-as-usual
(The emission in 1995 is regarded as 1.0)

(ii) Control target for vehicular emission

According to the international experiences, vehicular pollution control must be carried out with a certain target so that the optimal control route can be found out through the selection of technologies. According to the China's National Ninth Five-year Plan and the Perspective Objective in 2010, the ambient air quality should meet the secondary national standard in important cities in 2010. Based on this requirement and the prediction of pollution without additional control, the control target of pollutant emission from vehicles in the objective year can be calculated by assuming that the regional concentration of environmental pollutant is directly proportional to the emission and the reduction of mobile sources is synchronous with that of fixed sources. The results are shown in **Table 6**.

It can be seen that, in light of urban air quality, the current emissions of NO_x and CO are already higher than the control target in the two cities. What should be highlighted is that, due to the unevenness of spatial and diurnal distribution of vehicular pollution, the exceeding frequency and concentration of NO_x and CO are more severe than the urban average level in some areas with heavy traffic. Therefore, if we focus on these areas, the control target should be even more stringent.

Table 6 The Control Target of Vehicle Emissions in Beijing

	Emissions in1995（10^3 tons）	Control target（10^3 tons）
CO	1,392	1,201
NO_X	115	88

(iii) Technical Strategies for Vehicle Emission Control

Based on the investigation, selection, analysis and evaluation of the modern commercial technologies for emission control in the world, some technical plans which accords with the situation of Beijing are optimized in these research to achieve the target that controlling vehicle emissions economically and effectively. In selection strategies to be adopted, several factors were taken into account, including following:

- ✓ Air quality needs
- ✓ Potential effectiveness of the measure
- ✓ Cost of the measure, including hardware, maintenance and fuel economy
- ✓ Overall cost-effectiveness
- ✓ Technical feasibility
- ✓

(1) Technical control scenarios for new vehicle emissions

New vehicle emission control is mainly established by establishing a series of standards to strengthen the requirement of vehicle emission control in step by step so as to achieve the emission control target. Each issue of a new standard corresponds to the adoption of some new technologies. Four emission control scenarios for new vehicles were studied, which were designed basically following the European standard system but adjusted by intermediate implementation steps and time span. Beijing was taken as the example to carry out the total cost-effectiveness analysis for each respectively. The basic ideas of those four scenarios are shown as follows:

Scenario1: A comparatively lenient strategy, carried out basically according to the control steps in Europe.

Scenario2: Omitting certain intermediate steps, such as R15-04.

Scenario3: The standards are the same as that in Scenario 2, but the times for implementation are delayed.

Scenario4: The most rigorous strategy, adopting the strictest active standards in Europe directly.

The emission reduction potential can be described as the emission change before and after a control measure to be adopted. From the analysis of reduction potential, the following results have been found:

- ✓ The reduction of each pollutant is different under different control strategies. Each strategy is effective for emission reduction of CO and HC but only the rigid one has preferable potential for NO_x. Since NO_x emission is very high at present, rigid strategy should be selected to ensure that the urban air quality not deteriorate any more.
- ✓ There is a time-delay to reduce vehicle emission by strengthening the standards for new vehicles. The control countermeasure will not be effective until 2000. So, standards should be adopted as early as possible.
- ✓ New vehicle emission control contributes a lot to improve the status of vehicle emissions. If the most rigid active standards in Europe are adopted (Scenario 4), the vehicle NO_x emission can be limited to 114,000 tons in 2010, which is nearly the same as that in 1995 and indicate that new vehicle control plays very important role in emission reduction. But what we should

notice is that even if Scenario 4 is adopted, there still is a gap between the emission control target and emissions. So, while rigid standards for new vehicles are actualized, the adoption of appropriate control technology for in-use vehicles should be considered simultaneously. Since the lenient strategies (Scenario 1 and Scenario 3) are not useful for NO_x control, if these scenarios be adopted, the target for environment protection can not be fulfilled even additional control measures for in-use vehicles are adopted.

- ✓ At present, there are still some further research is required focusing on the strengthening of emission standards in developed counties to reduce vehicle emission. Taking into consideration that the requirement of environmental quality and the condition that the control target can hardly be achieved with even the rigid control strategy, further study on the advanced technologies for vehicle pollution control should be carried out. And the standards should be strengthened continuously according to the actual situation of Beijing.

Regarding the emission reduction potential, and the cost-effectiveness analysis for vehicles emission control technology, Scenario 2 and Scenario 4 are basically feasible.

(2) Emission control strategies for in-use vehicles

Compared with new vehicle emission control, there is not a uniform technical strategy for in-use vehicle emission control in national level. Local EPA can establish their emission control strategies according to the current situation. The following principle and basic method for controlling emissions from in-use vehicles are presented to Beijing EPB.

<u>Inspection/maintenance (I/M)</u>

Based on the experiences, the emissions from about 15% vehicles could contribute about 50% of the total emissions, these vehicles are deteriorating rapidly or tempered by some auxiliaries because no effective I/M program have been conducted. Therefore, there is a great reduction potential to conduct the strict I/M plan with advantageous testing methods. In this project, the reduction potential and cost-effectiveness of the strict I/M in Beijing were analyzed, which reveals that

- ✓ The cost-effectiveness is good

It can be seen from the calculation that the cost-effectiveness ratio of enhanced I/M program is ideal for three type of pollutant. The reductive cost of NO_x is only 334.1 USD/ton, which is close to that of the best control Scenario for new vehicles.

- ✓ The investment for hardware is very low

It is cheaper to establish the enhanced I/M programming (about 8 dollar per vehicle) than to reconstruct the productive technology for manufactories for more strengthened standards. In this view of point, the I/M programming is more feasible.

- ✓ I/M plan can reduce the vehicle emissions rapidly

Compared to the control of new vehicles, there is no time-delay for the I/M program. Once the I/M programming is actualized, the emission of all in-use vehicles covered by the program could be reduced and the environmental quality could be rapidly improved.

Following proposals are presented for Beijing:

- ✓ The close-loop three-way catalytic technology will be used in new vehicles after 2000. The present I/M program based on idle methods can not meet the requirement of inspection. Therefore, the enhanced I/M program and advanced inspecting type such as the ASM inspection must be adopted as early as possible.
- ✓ The I/M station must provide data of inspection to the local EPB for analyzing the implementation of the I/M programming and the emissions from vehicles.
- ✓ As the emission standards become more and more rigid, the EPB should adjust the standards of the I/M examination continuously according to the current situation so as to ensure that the well maintenance of all vehicles are carried out.

Retrofit of in-use vehicles

The retrofit of in-use vehicles mainly focuses on some specified vehicles with terrible emission. By retrofitting them, the emissions can be reduced and the ambient quality can be improved. The technologies currently adopted in China include adding catalytic cleaning equipment, improving the ignition system, and developing the alternative fuel, etc.

Because of the diversity of the retrofit technologies and the complexity of treated object, the local EPB must choose acceptable control technologies and implemente strategies suitable to local conditions. In order to get favorable effects of the retrofit plans in each area, the nationwide statutes for retrofit must be formulated through the aspects mentioned as following:

- ✓ Introduce the applicability and the limitation of each usable technology to assure that the retrofit programs being introduced over the country are adequately considering important factors. For example, the lead-free fuel must be available before the use of exhaust clean installation.
- ✓ Determine the technical target of these usable technologies, and authorize the local EPB to supervise the implementation whenever necessary so as to assure the target would be achieved.
- ✓ Establish the regulation system for management of the productions of vehicle emission cleaner.

Enhanced scrapping

- ✓ The vehicles with emissions exceeding the National Emission Standards should be scrapped. The environmental departments of different levels should work out the feasible standards for the scrapping according to the principles mentioned above so as to improve the scrapping of the vehicles with high emission level.

Improvement of fuel

Following items must be paid attention while the fuel developing plan is formulated:

- ✓ The emissions of vehicle may be influenced by some features of fuel, such as saturated vapor pressure, sulfur content, and aromatic content, etc. Thus, they must be limited when the standard of fuel quality is formulated.
- ✓ Statutes must be formulated to ensure the reliability of fuel transportation, store, markets, and other steps, and to avoid the emissions caused by some mistake in such steps.
- ✓ With the popularization and utilization of the unleaded gasoline, the responsible regulation for the additive, especially the fuel detergent should be issued to prevent the jamming of the jet of the electric engine, so that the new technical vehicle could be used normally and the harm to the environment would be reduced.
- ✓ Responsible rules for the utilization of the Oxygen-contained Compound such as MTBE and methanol mixed fuel should also be regulated by considering the local situation.

<u>Flexible fueled vehicle</u>

It is sure that the vehicle fueled with CNG or LPG can emit very few HC and CO than that by gasoline fueled vehicles without cleaning system, also the fuel consumption economic is better. Thus retrofitting the vehicles to double-fueled vehicles could reduce the emissions of HC and CO notably. However, some limits and circumstances should be taken into account when working out the retrofit plan:

- ✓ There are some limits in the travel scale of the alternative fueled vehicles because of the limit of the fuel support system
- ✓ Using flexible fueled vehicles are not very useful for controlling NO_x emissions
- ✓ More attention should be given to the endurance of the security characters and reliability of the technologies
- ✓ The sources and price of the alternative fuel should be taken into account according to the local situation.

(iv) Government actions in Beijing

(1) Emission standard for new vehicle

In January 1998, Tsinghua research group announced that the most effective way to control vehicular emissions in Beijing is to adopt more stringent emission standards for new vehicles. In March 998, Tsinghua group proposed to tighten emission standard in Beijing. In June 1998, Beijing EPB decided to take the suggestion to develop local emission standard. In July 1998, Tsinghua group drafted the new emission standard for light-duty vehicle (based on scenario 2 and scenario 4) and a meeting was held to discuss it with the experts from the industry. Proposed date of implementation was July 1,1999. In August 1998, the new emission standard is officially accepted and approved by the municipal government (No.: DB11/105-1998), and date of taking effect was set at January 1, 1999 by the government.

(2) Emergency measures for air pollution control

In December 17, 1998, BMG issued emergency measures (phase I) for air pollution control, which include 18 measures and 8 of them were related to vehicle emission control. In March 11, 1999, emergency measures (phase II) for air pollution control was issued which presented 28 items with 7 of them relating vehicular air pollution control. These measures focused on enhanced scrapping, I/M, transportation limitation for high emission level vehicles, alternative fuel, and new emission standard for agriculture vehicles, heavy-duty vehicles and diesel vehicles. So far, there are emergency measures of air pollution control adopted in five phases.

e. Concluding remarks

Along with the rapid economic growth in Beijing, the frequency of social contact and business activities in urban area are increasing. The quick increase of passenger and goods capacity as well as transport modes promote urban development while at the same time pose a serious threat to the quality of urban environment and result in traffic jams.

A series of technical and administrative strategies so far have been presented to Beijing Municipal Government, and some of them have been accepted and implemented, including lead free gasoline, new emission standard for exhaust pollutants from light-duty vehicles, enhanced I/M program, enhanced scrapping, and alternative fuels, etc. However, there are still some difficulties, such as the retrofit of in-use vehicle, which have strong influence on reaching environmental target, especially the ambient NO_x standard.

The key problem to be solved in urban transport development strategy is to deal efficiently with the relation between the increasing demand for urban transport and the limited supplying capacities. This includes transport facilities, environmental capacity, land resource and energy supply. The integrated analysis of those factors for a sustainable urban transportation is a weak point for the research in this field.

2.3 Overview of Energy Related Issues in Shanghai

a. General Description of Urbanization in Shanghai

(i) Municipal and Population

Shanghai is China's largest port trade center and major open city, also is one of the cities with highest population density in China. The total area is 6,340.5 km^2, with the urban area of 3248.7 km^2, accounting for 0.1% of the whole country.

By the end of 1998, Shanghai had a population of 13.07 millions, accounting for 1% of the whole country. The city's average population density was 2,061 persons per km2, with the figure in the urban area standing at 3,296 persons per km2, Nashi Districts reported the highest population density reached about 60,000 persons per km^2.

Even though the population growth rate has remained negative since 1993, with higher level of urbanization, the population from outside the city remains about 50,000 persons per year, the population of the whole city still increased smoothly.

(ii) Gross Domestic Product

Thanks to its advantageous geographic location, the level of Shanghai's social and economic develop is higher than that of the nations. From 1978 to 1989, the average annual growth rate of GDP indices remained 8%. From 1990 to 1998, attained above 10%. Since several years, the GDP of Shanghai make up about 4% of the national total GDP, of which the industrial output value accounted for about 6% of the nation's, financial revenue accounted for 13% of the nation.

Shanghai's total gross domestic product in 1998 reached 368.82 billion RMB, of which the output value of primary, secondary, tertiary industry was 7.85 billion RMB, 184.72 billion RMB, 176.25 billion RMB respectively. The city's average GDP per capita first crossed 20,000 RMB in 1996, and then in 1998 reached 28,200 RMB.

(iii) Industrial Structure

Since 1980's, through transformation of municipality functions, the production with high energy consumption and low added value have been progressively phased out, the percentage of output value of services industry in GDP have gradually raised, and the industrial structure have been readjusted. In 1978, the proportion of the output value of primary, secondary, tertiary industry in the GDP were respectively 4.0%, 77.4%, 18.6%, while in 1998 shift to 2.1%, 50.1%, 47.8%.

(iv) Industrial Economy

(1) Industry Composition

There are over 22,000 enterprises in Shanghai, of which 1482 factories were classed as large and medium. According to subordination, they are grouped to eight categories including central, city, district, county, neighborhood, town, country, and village. According to registration, they are grouped to three categories including domestic investment, HK, Macro and Taiwan funded, foreign funded, of which domestic investment are grouped to eight categories including state-own, collective-owned, share holding, joint owned, companies with limited liabilities, sticking holding companies with limited liabilities, and private.

In 1998, the industry output value of domestics investment enterprises accounted for 53% of the city's total, enterprises funded by HK, Macro and Taiwan accounting for 15%, and foreign funded accounting for 32%. The ratio in the gross output value of industry of domestic investment enterprises to foreign funded enterprises was 1.12:1. The proportion of domestic enterprises among the gross output value of industry was slightly more than that of foreign funded enterprises.

(2) Industry Category and Pillar Industry

The industry categories in Shanghai is diverse, ranging from food production, textiles, petrol processing, chemical production, rubber products, plastic products, Smelting and processing of metals, machinery manufacturing, transportation equipment manufacturing, iron and steel, household appliance.

The city's six pillar industries namely auto, electronic telecommunications equipment, iron and steel, household appliances, power plant equipment, petrol-chemicals, fine chemicals and modern medicine manufacturing, reported a total output value of 244.74 billion RMB in 1998, accounting for the 41% of the city's total.

(3) Industry Production and Annual Output

With readjustment of the industrial structure, the production of light industry have been decreased progressively since 1990, the production of pillar industry products increased gradually.

(v) Transportation

(1) Freight Transport

Cargo transport in 1998 totaled 462.3 million tons, of which goods and commodities handled by the railway system amounted to 52.92 million tons, that by the highway system amounted to 263.52 million tons, that by the navigable inland waterway system amounted to 96.85 million tons, that by ocean shipping system amounted to 48.44 tons, that by the airway amounted to 0.57 million tons. The turnover volume of freight traffic by the railway in the year totaled 11.7 billion tons*km, handled by the highways system were 4.9 billion tons*km, handled by the navigable inland waterway system were 87.1 billion t tons*km, handled by the ocean shipping were 379.4 billion t tons*km.

(2) Urban Transportation

By the end of 1998, the city had 0.583 million motor vehicles, of which excluding scooters and mopeds with "C" license plate. The possession of motor vehicles in Shanghai was less than the other cities with the same scale in the world. Though recently new progress have been make in the city's road traffic, and the average road area per capita have gradually increased, owing to trading and dwelling highly density, the traffic in the core of city still was crowded.

Of the total motor vehicles, heavy duty vehicles accounted for 17.4%, light duty vehicles for 53.3%, motorcycles for 24.1%, motor vehicles of consulate and foreign funded enterprises respectively accounting for 1.0%, off road vehicles for 0.5%.

(3) Living Standards

According to statistics from a sample survey, the average annual income per capita among urban residents increased from 2198 RMB in 1990 to 8825 RMB in1998. Among the farmers, raised from 1990 RMB in 1990 to 5965 RMB in 1998. The top three of the city's expenditure was food, education, housing, respectively accounting for 42-51%,11~12%,10~21%.

The possession of durable consumer goods per 100 urban households, for example, electric fan, TV set, washing machine refrigerator, air conditioner, microwave oven, and water heater, all were over 50. The possession of personal computer continue to increase by a wide margin.

b. Current State of Energy Supply in Shanghai

(i) Energy Inflow and Outflow

Shanghai is a municipality with the lack of energy resources. Its economic development mainly depends on energy delivered from other provinces of China. In accordance with Year Book of Shanghai, in 1998 the volume of energy delivered from other province was 1806 PJ. 383 PJ was transported to other province. The total volume of usable energy was 1436 PJ.

(ii) Energy Inflow and Composition

According to the energy resources in China, the main energy supplied in Shanghai is coal and then crude oil, while the secondary energy constitutes the minority.

In reference with statistic material for 1995~1998, coal accounts for 56~62% of total energy supplied, of which raw coal and coking coal constitutes 39%~43% and 17%~19% respectively, while crude oil accounts for 24~27% of total energy supplied. The primary energy and secondary energy account for 80%~89% and 12%~20% of total energy supplied.

(iii) Energy Outflow and Composition

Energy outflow in Shanghai is 268-382 PJ per year for 1995~1998, of which finished oil (gasoline, kerosene and diesel) and other petro-product account major proportion followed by raw coal, other coking product and fuel oil rank.

Primary energy outflow accounted for 7%~11% of the total energy outflow during 1995~1998, of which raw coal outflow accounted for 6~11% (with increasing trend) and crude oil was scarcely delivered to other provinces (expect for year 1995). Secondary energy outflow accounted for

89%~92%, of which finished oil accounted for 39%~49% (with increasing trend), fuel oil accounted for 5%~11%, other pero-product accounted for 16%~26% (with decreasing trend) and electricity accounted for 4%~6%.

(iv) Usable Energy

According to the Year Book, the total volume of usable energy was 1436 PJ in 1998, 10% higher than that in 1995 (1313 PJ), of which coal inflow and crude oil accounted for 69% and 30% respectively

(v) Energy Processing

(1) Electricity Production

Capacity of Power Plant

The total capacity of power plants in Shanghai increased with years for 1995~1998. By the year 1998, there were 16 power plants in Shanghai of which the total capacity reached 83710MW. Among these 16 power plants, Shidongkou power plant, Wargaoqiao power plant and Huaneng Shidongkou No.2 power plant have the highest capacities of 120 10MW, Wujing heat and power plant and self-provided power plant for Bao Steel have the capacity of 95 and 85 10MW respectively, the other power plants have the capacity of less than 40 10MW.

Electricity Production

Electricity production increased with years together with the development of economy and improvement of living standards. Electricity production increased by 6.4% every year for the period 1990~1998. Electricity production reached 482.2 100Mkwh.

Energy Consumed in Power Generation

According to the statistics of energy consumption for 1995-1998, raw coal consumption for power generation accounted for 57%~59% of usable raw coal in Shanghai. Energy consumption in power generation reached 445 PJ, of which raw coal consumption reached 393 PJ and other secondary energy consumption reached 52 PJ.

According to the statistics, energy consumption per unit electricity production decreased with year. It was 348 g SCE/k Wh in 1990 and 334 g SCE/k Wh in 1998.

Efficiency of Power Generation

According to the statistics of power generation efficiency for 1990~1998 from Planning Committee, the efficiencies for 1990, 1995 and 1998 are 365, 37% and 38% respective. The efficiency of power generation increased with years.

(2) Heat Production

There are 6 heat and power plants in Shanghai including Yangshupu, Nanshi, Wujing, Jinshan, Gaoqiao and Xinghuo plant. The total capacity of heat generation for 1995 and 1998 were 103.7* 10^4

kW and 11.67*10^4 kW, the quantity of heat generated were 45.6 PJ and 41.7 PJ. Energy consumption per unit heat production were 39~39 kg SCE/MkJ.

(3) Coke and Gas Production

Coke Production

According to the statistics for 1995~1998, coking coal consumption in the coke production increased with years. The total coking consumption in 1998 was 252 PJ, with which 246 PJ of secondary energy was produced. The secondary energy included 186 PJ of coke, 44 PJ of coke-oven gas and 16 PJ of other coking production. The ratio of output to input kept at 0.96~0.98.

Gas Production

Energy input for gas production was 51 PJ in 1998, of which the consumption of raw coal, coking coal coke-oven gas fuel and heat were 12 PJ (23%), 21 PJ (41%), 8.3 PJ (16%), 8.9 PJ (17%) and 1.3 PJ (2.5%) respectively. The amount of secondary energy produced in gas production was 43 PJ, of which coke, gas, other coking product accounted for 9.5 PJ (22%), 29 PJ (68%) and 4.5 PJ (10%). The energy production efficiency kept up 80% despite its instability.

(4) Oil Process

Crude Oil Process

The amount of crude oil processed was 428 PJ in 1998. The crude oil is mainly used in oil process and production. At present, the main crude oil processing enterprises are Shanghai Oil Factory and Shanghai General Oil Chemical Factory etc. The Overall oil products was 418 PJ, of which petrol, diesel, kerosene, fuel oil, LPG, dry gas and other products accounted for 22%, 23, 5%, 2%, 7% and 35%.

c. Current State of Energy Consumption in Shanghai

(i) Primary Industry

Primary energy consumption was at 15~22 PJ for the period 1996~1998. Energy consumption of primary industry accounted for 2% of the total end-energy consumption in Shanghai in 1998, of which raw coal, petrol, kerosene and electricity accounted for 12%, 36%, 36% and 15%. The primary energy consumption decreased especially, the electricity consumption (it decreased from 28% in 1995 to 12 in 1998).

(ii) Secondary Industry

The secondary industry includes industry and construction industry according to the statistic method in China. Great adjustment of industry structure had been taken place in 90's of 20 century, i.e. change to "tertiary, secondary, primary " trends. Therefore, the energy consumption of secondary industry has been a great change accordingly. It's proportion in the total energy consumption decreased from 78.9% in 1995 to 70.5% in 1998. However, the secondary industry is still the major energy consumer.

(1) Energy Consumption of Industry

The end-energy consumption of industry decreased from 789 PJ (78%) in 1995 to PJ (70%) in 1998.

(2) Energy Consumption of Construction Industry

Construction industry developed rapidly for recent years. The energy consumption of construction industry increased during the period 1995~1998. It increased from 8.2 PJ (0.8%) in 1995 to 18 PJ (1.6%) in 1998, i.e. increased by 1.2 times. The main energy carries consumed are diesel and electricity. The consumption of these two carries are 8.3 PJ and 2.6 PJ, which accounted for 47% and 15% of total energy consumption in construction respectively.

(iii) Tertiary Industry

The tertiary industry includes transportation, storage, postal and telecommunication, retail and wholesale business, and catering trade. Energy carries consumed in transportation are mainly petrol and diesel, consumed in postal and telecommunication and retail and wholesale business etc. are mainly electricity, and consumed in catering trade are mainly gas, electricity and raw coal. Storage is the largest energy consumer within the tertiary.

Energy consumption in tertiary industry was 199 PJ in 1998, which accounted for 18.3% of the end-energy consumption in Shanghai and increased by 6.1% as compared with 1995 (12.2%). The main energy carries consumed in the tertiary industry for 31%, 22%, 14%, 12%, 11% and 3% respectively. While the consumption raw coal accounted for 1.5%

(iv) Energy Consumption for Living

Energy consumption for living was 99 PJ in 1998, which accounted for 9.2% of end-energy consumption in Shanghai and increased by1.8% compared with 1995 (7.4%). The main energy carries consumed are raw coal, gas, LPG and electricity, which accounted for 46%, 8%, 10% and 16.5 respectively.

Per capita energy consumption was 7609 MJ in Shanghai in 1998 which was 1.3 times as that in 1995 (5721 MJ). Per capita electricity consumption for living in 1998 was 348 kWh which was 1.5 times as that in 1996 (233 kWh). Per capita energy consumption for cooking (gas and LPG) was 2090 MJ.

The total electricity consumption in Shanghai (including urban and rural area) was $45.5*10^8$ kWh. Electricity consumption of urban and rural households was $38.9*10^8$ kWh, which was 1.6 times and

1.2 times as compared with those in 1995 ($24.9*10^8$ kWh and $5.37*10^8$ kWh).

(v) Energy Consumption in Transportation

(1) Vehicle Population and GDP

The vehicle population was 1330,000 in 1998, according to the World Bank – Shanghai Municipality Transportation Project "Reduction strategy of vehicle emission in Shanghai" (1996), Shanghai Sciences and Technology Committee "control target for vehicle emission in Shanghai" (1997.5), Shanghai Steering Group for Comprehensive Control of Vehicle Emission "comprehensive prevention and control plan for vehicle emission in Shanghai" (2000.2) and Shanghai Environment Protection Bureau "Pollution sources investigation and contribution ratio study for NOx in Shanghai" (2000.4) ect.. The population of on-road and off-road vehicles vehicles were 1320,000 and 10,000 respectively of which heavy vehicle, light vehicle, off-road vehicle accounted for 6.9%, 23.4% and 0.7% respectively, while the amount of motorcycle, motor scooter and moped accounted for 70%.

According to the statistics, the increment of vehicle population synchronized which that of GDP for the years past.

(2) Energy Consumption in Traffic

With reference to the oil consumption per 100 km and miles of various kinds of vehicle, the fuel consumption of on-road vehicles were 63 PJ and 78 PJ for 1995 and 1998 respectively. The consumption of petrol and diesel were 42 PJ and 11 PJ.

The energy consumed in traffic accounted for 6.3% and 7.1% of the total amount of end-energy consumption in Shanghai for 1995 and 1998.

d. Current State and Countermeasures of Air Pollution in Shanghai

(i) Emissions

(1) SO_2 Emission

Shanghai energy balance and SO_2 emission calculation results of each energy-consuming sector indicate that SO_2 emission of whole City in 1998 is 580,000 tons. In which, SO_2 emission of power plants is 290,000 tons, heating production system 32,000 tons, gas making 14,000 tons, industry 160,000 tons, tertiary industry 40,000 tons and residential energy consumption 36,000 tons.

According to the contribution of SO_2 emission, SO_2 emission of secondary energy processing transfer occupies 58 percent of the whole city, in which, power plant occupies 50 percent, heating production system 6 percent, gas making 2 percent. SO_2 emission of end energy occupies 42 percent, in which, industry 27 percent, tertiary industry 7 percent, residential consumption 6 percent, agriculture 1 percent and construction 1 percent. Power plant and industry sectors are still the major

SO_2 emission sources.

(2) NO_x Emission

NO_x emission calculation results of different energy consuming sectors in the whole city indicate that NO_x emission in 1998 is 400,000 tons. In which, NO_x emission from power plant is 170,000 tons, and heating production system, coke making and gas making, industry emission, transportation (includes train, steamship and airplane) is 18,000 tons, 2600 tons, 94,000 tons, 3,999 tons, 8,000 tons, 82,100 tons and 15,200 tons, respectively.

In NO_x emissions, NO_x emission from secondary energy processing transfer occupies 48% of the whole city. In that, power plant occupies 43%, heating production system 4.4%, coking and gas making 0.7%. NO_x emission end energy occupies 27%, in which, industry 24%, tertiary industry 0.8% residential consumption emission 2%, agriculture 0.8 and construction 0.8%. NO_x emissions from transportation occupy 24.5%, in which, motor vehicle emission 21%, non-road transportation 4%.

According to NO_x emission of the whole city in 1995-1998, motor vehicle presents increasing trend. Major NO_x emitting sources are power plant, industry and transportation.

(3) CO_2 Emission

The calculated results indicate that Shanghai CO_2 emission calculated by different methods has produced a little differences in results. As a whole, CO_2 emission increases year after year. CO_2 emission contribution from coals burning is down to 66 percent in 1998 from 79 percent in 1980. Oil consumption emission contributed 34 percent in 1998 from 21 percent in 1980.

CO_2 emission in 1998 was 12.4 million to 13,2 million tons. In which, power plant occupies 20~31 percent, heating production system 3~3 percent, coke making 1~2 percent, gas making 1 percent, oil refining 10 percent, agriculture 1 percent, industry 45 percent, tertiary industry 6-9 percent, residential consumption 5~6 percent.

(ii) Ambient Air Quality

(1) SO_2 Pollution

Over the past several years, yearly concentration of SO_2 has been reduced in Shanghai through pollution control over pollutant from fuels and control over coal-burning. The yearly concentration of SO_2 of Shanghai in 1998 was 0.25 mg/m3, 11% lower than that of 1995, and only 0.5% samples failed to meet with daily concentration standard of SO_2. The yearly concentration of SO_2 in the downtown are was 0.52 mg/m^3, a little bit lower than that of 1995, and 1.3% samples failed to meet with the daily concentration standard. Regards the daily concentration of SO_2 for whole Shanghai it was 59% lower in 1998 than that of 1996, and for downtown area it was 61% lower. Concentration of SO_2 has been in compliance with Class II of national standard for the whole city while it meets with Class I standard in the rural area.

(2) NO_x Pollution

Polices and measures for energy and environment mainly focus on coal-burning, and in terms of NO_x pollution they are ineffective. Daily concentration of NO_x in the downtown area from 1986 to 1998 has the deteriorated from 1995 by 0.07 mg/m^3.

Daily concentration of NO_x of downtown area in 1998 is 0.10 mg/m^3, meeting with Class III of national standard. It was 0.028 mg/m^3 higher than that of 1995, and 38% samples failed to meet with the daily concentration standard. For whole Shanghai, the daily concentration NO_x in 1998 was 35% higher than that of 1986, and for downtown area, it was 54% higher.

With decreasing fixed industrial pollution sources, motor vehicle has become the major contributor to NO_x pollution since 1995, particularly during October to December.

(3) TSP Pollution

It can be illustrated that with some effective environmental polices, such as popularization of town-gas, establishment of smoke control zone etc., concentration of TSP has been dramatically decreased.

Concentration of TSP of Shanghai in 1998 was 33% lower than that of 1990, and in the downtown area it was 40% lower. TSP concentration for the whole city can meet with Class II of national ambient air quality standard, while for the downtown area it is closing to the Class II standard. High TSP concentration mainly focuses in Luwan, Nanshi and Huangpu District and concentration of TSP has an increasing tendency in the rural area.

e. Future Plans and Policies of Related Issues in Shanghai

(i) Policies on Energy Supply & Consumption

During 1980's to 1990's energy consumption was dramatically increased in line with a high economic growth, causing scarcity in energy and power supply. Coal contributed 75% of the primary energy consumption which caused unbalanced energy consumption and serious air pollution of SO_2 smoke and dust from coal-burning.

To improve the air quality, a new concept of coordinated development of energy and environment was put forward in 1995. It was aimed at reducing air pollution from coal-burning with improving energy supply and consumption, e.g. reduction of coal-consumption, balanced use energy, improvement of energy efficiency, etc.

Thanks to this policy, burden of energy supply has been alleviated since 1996 and proportion of coal in the primary energy supply was reduced. However, total amount of coal consumption was still increased, SO_2 emission reached to 510,000 ton/a. Therefore, in 1996 strategy of sustainable energy development was put forward. Meanwhile, more measures were taken, such as the exploration of natural gas from East China Sea Oil Field, replacement of coal-burning boilers with cleaner fuels, development of clean energy and renewable energy, and using electricity from other provinces, etc.

To improve energy efficiency, a local regulation on energy-saving was issued in 1997 to promote the sustainable development of energy and environment. In this year, natural gas project from East China Sea was formally started.

In 1998, an action plan on sustainable development of energy and environment was prepared. Policies on balanced use of energy, development of renewable energy, and improvement of energy planning and management were listed as three major issues for the sustainable development of energy, environment and society of Shanghai.

(ii) Policies on Environment

Controlling air pollution has been started since 1970's in Shanghai. In 1980's policy "Polluter should be responsible for treatment" was put forward which was aimed at reducing the popputants from coal-burning and setup "no black smoke zone" in Shanghai. Three industrial sectors, power plants, metallurgy and cement were regarded as major pollution sources. During 1980's a series of local regulations on smoke and dust control in Shanghai (1988), pollution fee collection and fines (1984), policies on improving management on pollution treatment facilities (1989) and standard on industrial emissions were issued.

With using of some dust-removal facilities, popularization of town-gas and district heating, industrial dust from kilns, power plants and metallurgical industries were reduced.

Since mid 1980's, domestic balanced use of energies has been improved, meanwhile major tasks for industrial pollution control were shifted from black-smoke control to smoke-and-dust control. Rehabilitation of some heavy-polluted areas like Hetian Road, Xianhua Road, and Taopu industrial areas were listed as top agenda.

Since 1990's, with restructuring of urban layout and industrial sectors, air pollution control in Shanghai was shifted from previous point-source focused to rehabilitation of heavy-polluted areas, meanwhile, rehabilitation of urban environment was strengthened, and target for total load control of SO_2 was put forward.

In late 1990's based on the national planning of controlling acid rain SO_2, a strategy of setting up "no coal-burning area" was put forward in Shanghai. Measures on sustainable development of energy and environment, and cleaner production have been implemented. Pollution control have been gradually shifted from end-of-pipe treatment to whole-process control. Coal-burning as well as petrol-combustion have been paid attention to. Strategies of pollution control have been focused on regional pollution control, comprehensive rehabilitation of urban.

f. Concluding remarks

Energy consumption in Shanghai is increasing annually along with the high economic growth. In 1998, the per capita energy consumption in Shanghai was 110 GJ, 1.17 times as much as that of national level.

Coal is the major energy source accounting for 70% of the primary energy.

Air pollutant emissions in 1998 in Shanghai were 488,900 ton SO_2, 170,000 ton for particulate, about 400,000 ton for NO_x, and 132 million ton for CO_2.

Due to the effectiveness of current energy and environmental policy, air pollution from coal combustion has been basically curbed, pollution exposure level of SO_2 has been declining annually, However, current energy and environmental policies are ineffective in controlling NO_x emissions.

2.4 Overview of Waste Management and Energy and Material Consumption in Seoul

a. Current State of Municipal Waste Problem in Seoul

Industrialization and urbanization have greatly contributed to our modern societies through economic growth and new pattern of lifestyle. Such contribution, however, has adverse effects on our environment by demanding increasing amount of natural resources and as a result generating a lot of waste. It is known that every ton of consumer goods requires over 8 tons of original materials inputs and OECD countries have generated increasing amount of municipal waste from 410 kg/person/year in 1980 to 510 kg/person/year in 1995 (Brandsma, 1997).

Developing countries such as Korea (became OECD member in 1996) and China followed such patterns of consumption and waste generation during the period of economic growth. Since the 1960s, population in Seoul increased by about 3 times and waste generation increased by 14 times. **Figure 5** clearly shows the correlated pattern of changes in urbanization and waste generation in Seoul for the last 4 decades, especially a sharp upward trend until 1991 and downward movement after 1992. The reason for a sharp decrease in waste generation between 1991 and 1992 in **Figure 5** is because different measures were used before and after 1992: until 1991 data was based on cubic ton of the garbage truck and after 1992 a weight tonnage of the truck was used for the data. Nonetheless, the figure shows that less municipal wastes have generated over time since 1992.

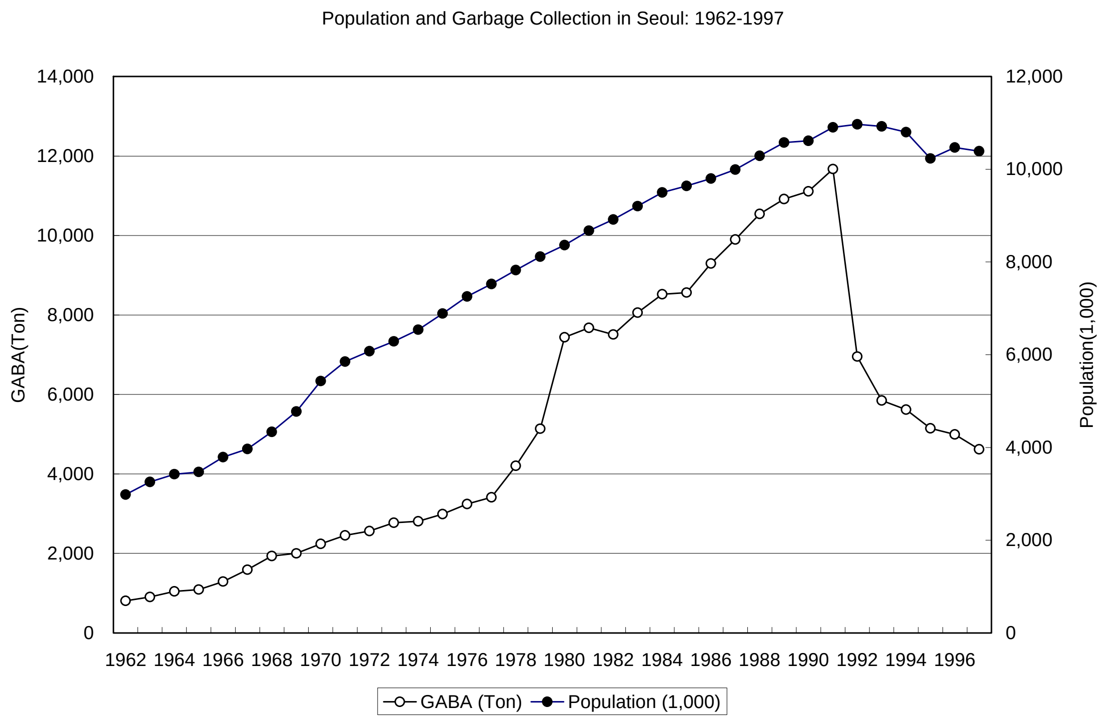


Figure 5 Population and Garbage Collection in Seoul: 1962-1997

In addition to the increased amount of waste, the city government also faced waste treatment facility problem in the late 1980s as the existing landfill (Nanjido landfill) reached the capacity, which was the only landfill treating all the garbage generated in the capital region since the 1970s. Seoul city government initiated to develop a new landfill (Kimpo landfill at the western seashore 40km from Seoul) with cooperation of Ministry of Environment of the national government and Inchon city. However, the city government met with a brand new obstacle such as intergovernmental conflicts and local resident opposition near the proposed landfill site, which is called NIMBYs(Not-In-My-Backyard syndrome). NIMBY opposition became intense over time. In addition, it was expected that the Seoul city government had to pay more waste transportation costs to Kimpo even if the new facility is successfully constructed and operated. The city government had to search for a more effective way to tackle the waste treatment problem.

In 1991, the Seoul city government changed policy direction from landfill to incineration by which each of 22 (now 25) local autonomous districts (e.g., Gu) had to construct incinerator for the treatment of local waste generated in their jurisdiction. However, this 'do-it-yourself-principle' faced mounting local opposition. As a result, as of 1999, only one facility was newly constructed (Nowon incinerator) and the existing one (Mok-dong incinerator) was expanded its capacity. One more incinerator was newly constructed in Kangnam-Gu in September 2000, but it is not operating because of resident opposition. Some others are now on the process and all the others planned in the early 1990s were canceled or postponed, resulting in the waste treatment policy deadlock and the war on waste in Seoul. These circumstances accelerated the city government to search for a more comprehensive and effective waste management strategy on one hand and contributed to enhance the public's understanding of the seriousness of waste problem on the other hand.

Since the early 1990s, the Seoul city government has initiated a variety of policy tools to address waste problem. Regarding waste management, Seoul Green Vision 21 established four action plans as follows:

- ✓ Reduction of Waste Generation at Source: Disposable goods substitution; Reusable shopping bags; and Food bank participation.
- ✓ Efficient Treatment of Food Wastes: Construction of food waste processing facilities.
- ✓ Expansion of Recycling: Volume-based charging system and Expansion of recycling centers and financial support for recycling business.
- ✓ Sanitary Disposal of Wastes: Construction of more incinerators with advanced technology.

Statistics presents that a total amount of waste generation in Seoul was decreased from 19,055 tons/day (or 1.74 kg/person/day) in 1992 to 10,972 tons/day (or 1.06kg/person/day) in 1999. (Seoul Statistical Yearbook, 1997; http://green.metro.seoul.kr/waste/main.html) One of distinguished devices to reduce waste generation is volume-based charging system which started to work since 1995. By the system, every household has to buy plastic bag to put garbage to be collected. This system worked to reduce the volume and amount of garbage and to encourage recycling. **Table 7** shows changes in waste generation and waste treatment types in Seoul since 1962. Statistics of **Table 7** shows dramatic increase in recycling and sharp decrease in landfill disposal and increase in incineration rate.

Table 7 Waste Generation and Types of Treatment in Seoul

	Population (Th.)	Waste (Th. Ton)*	Landfill (%)	Incineration (%)	Recycling (%)
1962	2,983	807	100.0	0.00	0.0
1972	6,076	2,562	100.0	0.00	0.0
1982	8,916	7,510	100.0	0.00	0.0
1991	10,905	11,672	93.6	0.43	6.0
1992	10,970	6,955	84.1	0.79	15.0
1993	10,925	5,848	80.7	0.94	18.4
1994	10,799	5,620	78.6	0.88	20.5
1995	10,231	5,147	70.2	0.51	29.3
1996	10,470	4,995	68.1	2.30	29.5
1997	10,389	4,622	61.9	4.60	33.5
1998	10,321	3,929	56.8	5.10	38.2
1999	10,260	4,005	41.0	5.00	41.0

*: Data until 1991 are based on cubic tons of garbage truck, and from 1992, weight tonnage of the truck.

b. Challenge to the Current Waste Management System

According to the statistics presented above, Seoul city government's efforts to reduce municipal wastes and recycling policy have been successfully implemented. However, it is unfortunate that such efforts are now being challenged in several ways. For example,

- ✓ Recycling policy is facing limit. It is well known that economic benefit of recycling is greater than incineration and/or landfill, but much of the collected wastes are not put into the recycling process. The main reason for that is that recycling is no more profitable for private recyclers as the supply of recycling materials exceeds the demand of recycled products.
- ✓ Incineration policy is also challenged by local opposition. A newly constructed incinerator failed to even pilot operation due to resident opposition.
- ✓ No effective method is developed to treat kitchen garbage which is about 27% (e.g. 4,150 ton/day) of total household waste. Meanwhile, Residents Committee of Kimpo landfill

announced that all food wastes would be rejected to be disposed to the landfill from June, 2002.

- ✓ The volume-based charging system has contributed to waste prevention and promotion of recycling. However, collection rate of recyclable waste is decreasing over time (Korea Environment Institute, 1998) and thus this method should be supplemented.
- ✓ There is no systematic policy of encouraging and promoting reuse. In economic and environmental terms, reuse is better than recycling since unlike recycling we need no energy for reuse.
- ✓ Waste regulatory agency pays less attention to non-household wastes. There are more than 500 thousands of public and private sources such as markets, schools, business offices, medical institution, manufacturers, hospitals and government institution. A total length of 7,600 km of road also generates great deal of wastes, but they are not properly treated. Much of radioactive wastes from hospitals also still illegally go to landfill.
- ✓ Citizen participation is very important factor for successful waste policy as successful implementation of waste policy depends largely on citizen behavior. There is variation from one district to another in the effect of citizen participation and a more effective citizen participation program is needed.
- ✓ One of the reasons that the city government adopted incineration policy was to avoid environmental hazards posed by landfills. However, it seems both solutions of landfill and incineration has failed in that incinerators pollute the air while landfill threatens groundwater. Solution to this dilemma is needed.
- ✓ Effective waste-to-energy strategies are useful way of addressing waste problem and this issue will be dealt with in a separated chapter.

c. Waste-To-Energy

(i) Value of Waste-to-Energy

"Waste-to-Energy" is valuable method in coping with waste problem. By utilizing garbage to energy, it can greatly contribute to reduce waste generation and environmental hazards and mitigate local residents' opposition.

Therefore, waste-to-energy is not only environmentally sound approach, but it is also politically acceptable alternative to the current practice of waste management.

(ii) Sources of Waste-to-Energy

There are various sources of municipal waste-to-energy, such as incinerators, landfills, and food wastes. Large portions of wastes from these sources are in fact unused energy.

(1) Scope of Waste-to-Energy Sector

Scope of waste-to-energy sector of the study consists of 3 items.

- ✓ Landfill Gas (CH_4)-to-Energy
- ✓ Incineration Heat-to-Energy
- ✓ Food waste-to-Composting and Foddering
- ✓

(2) Waste Treatment Facility in Seoul

Currently, there are 3 incinerators, 1 landfill, 2 composting facilities, and 3 foddering facilities in Seoul (see **Table 8**).

Table 8 Waste Treatment Facility in Seoul (As of 2000)

	# of Facility	Capacity	Construction
Incinerator	3	550 ton/day	Mar. 1996
		800 ton/day	Jan. 1997
		900 ton/day	Sep. 2000*
Landfill (Nanjido)	1	Size: 577,000 pyong** Capacity: 92m^3 (mil.) Height: 94-98 m	1978 - 1993
Composting Facility	2	10 ton/day	1996
		30 ton/day	1997
Foddering Facility	3	40 ton/day	1998
		20 ton/day	1999
		50 ton/day	1999

* : The 3rd incinerator was constructed in Sept.2000, but it is not operating yet, because of strong resident opposition near the facility.

**: 1 pyong = 3.3 m^2

(3) Waste-to-Energy Practice in Seoul

Landfill Gas-to-Energy

The only landfill in Seoul is Nanjido landfill which treated all municipal wastes generated in Seoul for 15 years, from 1978 to 1993. In fact, until the 1980s, landfill was a solution to garbage crisis in Seoul, but it is problem today. It causes nearby groundwater pollution and produces huge amount of methane gas.

Scientific evidence says that CH_4 has 20 to 30 times more negative impact on global warming than CO_2. Seoul city government is now trying to use the landfill gas as heating energy by providing heat to 2002 Worldcup complex and residential area near the landfill. It is also expected that "the landfill gas-to-heating energy plan" contributes to reduce air pollution as well. However, there is doubt about the feasibility of the plan.

Incinerating Garbage-to-Energy Plan

Incinerating garbage produces heat and steam and in turn they can be used to generate electricity. The Seoul city government's incineration policy in the early 1990s intended to provide the neighborhood with cheap heat and electricity from burning garbage. However, the plan was not successfully implemented. There are two main reasons for that. Firstly, in order for the incinerator to be productive, the capacity must be pretty large and thus the facility was designed for that. For example, Nowon incinerator was designed to treat 800 ton/day. However, much less amount of waste are being collected, partly because of increased recycling and other reasons. Secondly, tons of wet kitchen garbage (mostly food garbage) still go to the facility, thereby reducing heat efficiency of the facility.

By the city government's 'do-it-yourself principle,' every local autonomous district has to develop its own facility to treat waste generated in the jurisdiction. Therefore, it is important job to search for more feasible and effective way to get the "Burning Garbage-to-Energy" project work.

Food Waste-To-Energy

In Seoul, 27% of total municipal wastes are food waste, so how to reduce and utilize the food waste is a big question to be answered. General methods the Seoul city government uses include composting and foddering. Foddering can contribute to waste source reduction, and composting can be a kind of waste-to-energy strategy. Current practices of 5 these facilities will be reviewed and feasible and more effective way of food waste-to-energy will be studied. In food waste, not only domestic but enterprise sector (restaurants, hotels, etc) also will be analyzed.

2.5 Diffusion of Home Appliances in Tokyo

a. Energy consumption of residential sector in Tokyo

In Tokyo, the residential sector is one of the sectors in which the energy consumption has substantially increased in the past 25 years together with the commercial sector. According to the estimation of Tokyo Metropolitan Government (TMG), the energy consumption of residential sector has increased 2.26 times, from 17,600 Tcal in 1970 to 39,800 Tcal in 1995, and contributed about twenty percent of the total energy consumption.

Since neither population nor the number of households has changed very much, another factors are assumed to contribute to such rapid increase in energy consumption of the residential sector in Tokyo. In fact, compared to the energy consumption of in other sectors, the residential sector exhibits the largest increase during the period of 1970-1995. More specifically, it can be divided into three groups according to the changing patterns of unit energy consumption.

The first group includes residential energy consumption per household and commercial energy consumption per floor space where they have increased 1.5 times during last 25 years. The second group includes passenger vehicle energy consumption per vehicle kilometer traveled (VKT) and motor truck energy consumption per ton kilometer where they have little changed. The third group includes passenger railway energy consumption per passengers carried and industrial energy consumption per production value where they have greatly improved.

The change of the residential energy consumption by energy sources in Tokyo is briefly reviewed. As Figure 6 shows, The share of electricity and town gas in total residential energy consumption has increased from 80% in 1970 to nearly 90% in 1995. This gain of 10% is exclusively due to electricity, whereas town gas had little increase during this period. The loss of corresponding share is kerosene. Moreover, The share of LPG increased in the 1970s and 1980s, but has gradually declined since the early 1990s.

The stocks of consumer durable goods in house can to some extent explain these structural changes in residential energy consumption. Based on this understanding, the diffusion of major durable goods in Tokyo is reviewed in this section. It should be noted that in order to elucidate the relationship between residential energy consumption and

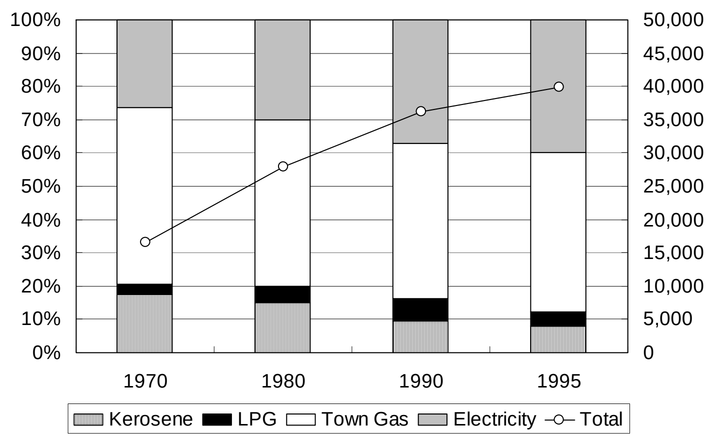


Figure 6 Total Energy Consumption of Residential Sector (Tcal) and its Composition by Energy Types (%) in Tokyo

Data Source: Bureau of Environmental Protection of TMG, 1998 consumer durable goods deeply, the performance and energy efficiency of individual instruments and frequency of their usage should be examined.

b. Air-conditioning and heating

Concerning air-conditioning and heating at household level, there are four major appliances: air-conditioner, oil stove, gas heater, and electric heater. In general, the energy demand of air-conditioner is closely related to local climate condition in Tokyo (very hot and humid and mild winter).

In addition to the traditional Japanese heating equipment, "Kotastu", there are other heating equipment that are mostly used for room heating or direct heating in the small area. Among them, oil stoves fueled by kerosene have been sharply decreasing since the early 1980s (see **Figure 7**).

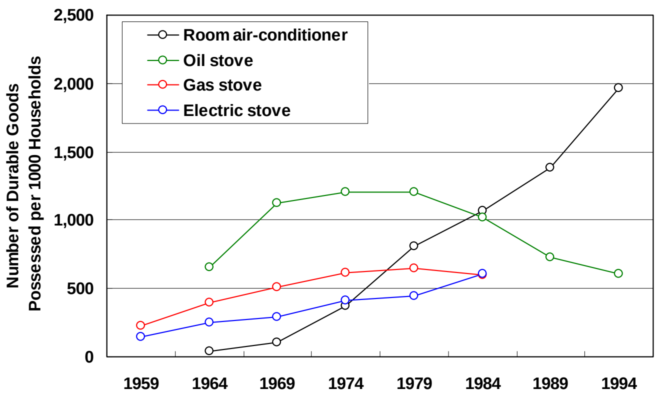


Figure 7 Diffusion Pattern of Air-conditioning and Heating Appliances in Tokyo

Data Source: Statistical Bureau of Management and Coordination Agency of Japan, 1959, 1964, 1969, 1974, 1979, 1984, 1989, 1994

On the other hand, due to very humid summer in the city, air conditioner has become very popular since the early 1970s. In the mid-1990s, every household is equipped with more than two air conditioners.

c. Entertainment

The electronic appliances used for entertainment such as television, videocassette recorder, and personal computer, considered the major appliance with regard to the energy consumption of residential sector (see **Figure 8**).

Color TV sets had been widely spread across the country

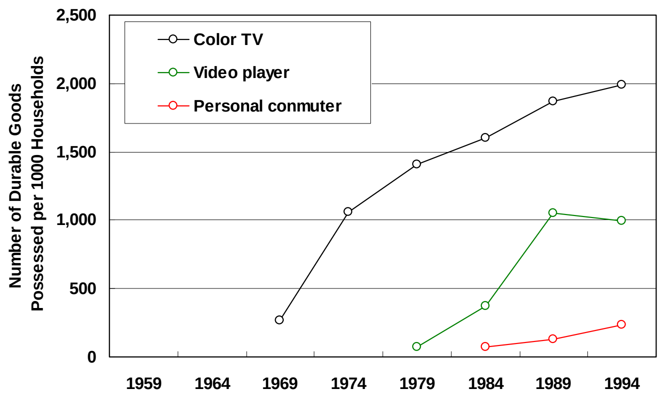


Figure 8 Diffusion Patterns of Entertainment Appliances in Tokyo

Data Source: Statistical Bureau of Management and Coordination Agency of Japan, 1959, 1964, 1969, 1974, 1979, 1984, 1989, 1994 in the late 1960s and early 1970s. As of 1974, every household in Japan owned one or more color TV sets and has now multiple sets of color TV at their home. Recently, along with technological progress, the television sets with larger and wider screen are available at lower price for consumers. In contrast, the diffusion level of video cassette player (VCR), which had become popular since the late 1970s, remains one unit per household during the last decade. With respect to the electricity demand, these home appliances create energy demand only when people use them, the continuous demand for leaving the TV on even when people is not watching or standby power requirements is increasing to non-negligible level.

Another significant changes in home appliances are recent increase of personal computers. The diffusion of personal computer has just gotten underway and largely depends on the provision of network infrastructure with reasonable price. The increase of heavy users of the Internet creates new demand of regular electricity since most of computers are always used on-connection.

d. Kitchen

In **Figure 9**, the kitchen appliances, including electric refrigerator, microwave oven and dishwasher, are seen the major electrical household appliances in terms of the energy consumption at household level. Electric refrigerator, the most prominent home appliance, is becoming larger in terms of size and containing capacity, but the energy consumption remain stable due to the improvement of energy efficiency.

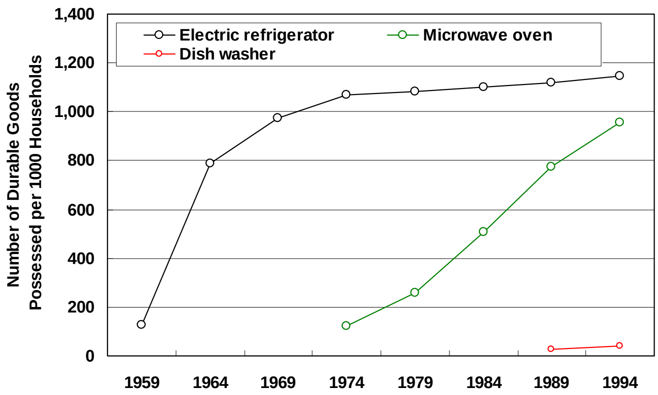


Figure 9 Diffusion Patterns of Selected Appliances in Kitchen in Tokyo

Data Source: Statistical Bureau of Management and Coordination Agency of Japan, 1959, 1964, 1969, 1974, 1979, 1984, 1989, 1994

Microwave, which has been saturated since 1994, has steadily increased since the early 1970s. The changes of dietary style and the widespread of ready-cook items are expected to increase the demand of this kitchen appliance in the future.

Although dishwasher is not popular in Japan so far as shown in **Figure 9**, the number of companies, which launch the new model of dishwasher is increasing. They are competing in price-cutting, space-saving, energy-saving and improvement of detergency.

e. Other domestic duties

Besides the major home appliances mentioned above, other home appliances, including washing machine, cloth-dryer, and electric vacuum cleaner, have been widely used for domestic duties (see **Figure 10**). The number of electric cleaner per household has grown steadily even after they reached at 100% of saturation level in 1974.

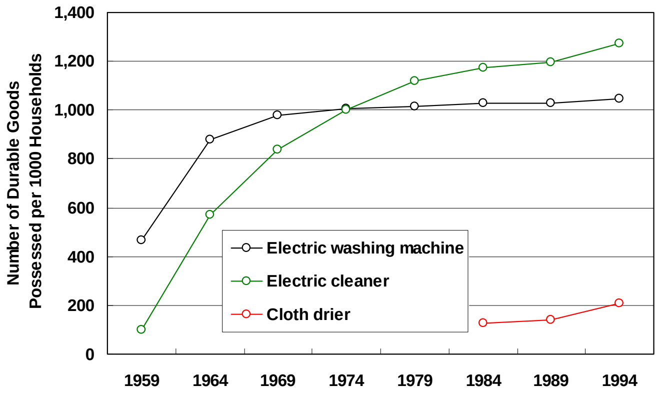


Figure 10 Diffusion Patterns of Selected Housekeeping Electric Appliances in Tokyo

Data Source: Statistical Bureau of Management and Coordination Agency of Japan, 1959, 1964, 1969, 1974, 1979, 1984, 1989, 1994

Washing machine has little increased since the early 1970s, while dryer has a slower increase during recent decades. In fact, one washing machine seems to be enough for each family. So far, the cloth-drier has not been popular in Japan simply because Japanese people prefer to dry clothes outside.

With the latest integration of washing machine and cloth- drier, the demand of dryer is likely to increase in connection with the increase of the requirement for streamlining the domestic affairs. In short, there is a great potential that the washing machine with cloth-dryer will widely spread, if they are provided at reasonable price.

2.6 Selected Indicators for Four Mega-Cities in East – Asia Tokyo, Seoul, Beijing and Shanghai

a. Scale of the City

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

Concerning the administrative boundary, **Figure 11** shows the current urban scales of Tokyo, Tokyo ward area, Seoul, Beijing, Beijing ward area, Shanghai and Shanghai ward area in 1997. Except for Seoul, there are two kinds of administrative boundaries of the whole city and ward area (central part), and statistical data is available for either both or one of them. This figure allows us to comprehend accurate statistical values with regard to urban scale of these four cities. Furthermore, the figure provides the future perspectives on how the transportation systems as a whole should be formed in these cities, especially in Beijing and Shanghai. In addition, it enables us to avoid misunderstanding of the definition of built-up area among these cities. More specifically, the boundary of the core ward areas (build-up areas at the center of ward areas) in Beijing and Shanghai is more comparable with Tokyo and Seoul, although the boundary is consistently changed over period and the data availability

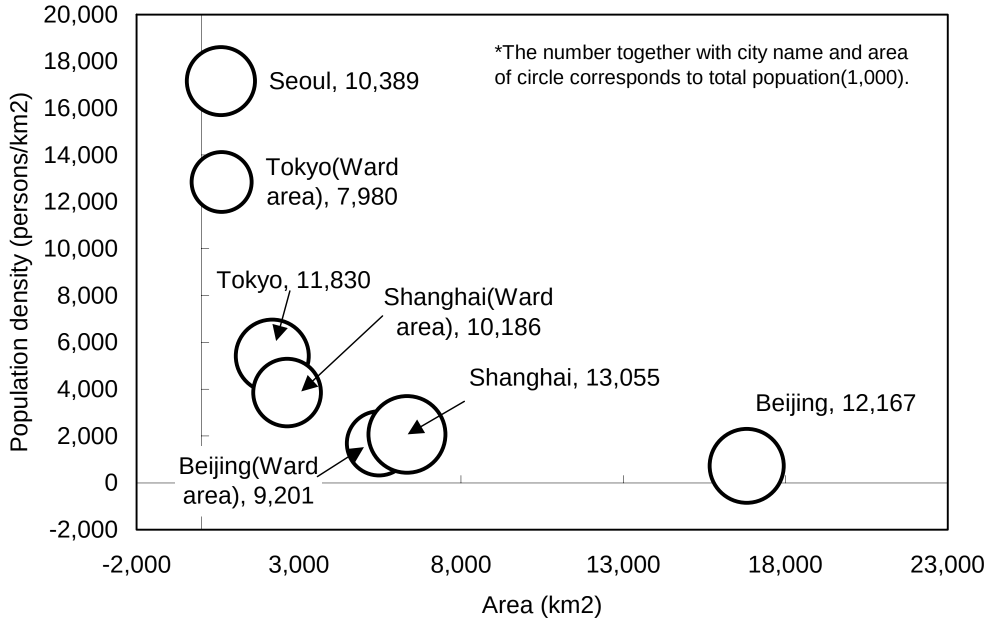


Figure 11 Urban scales of four mega-cities

Data Source: China State Statistical Bureau, 1990-1998; Ministry of Environment of Korea, 1990, Data Source: China State Statistical Bureau, 1998; Ministry of Home Affairs of Korea, 1997; Tokyo Metropolitan Government, 2000.

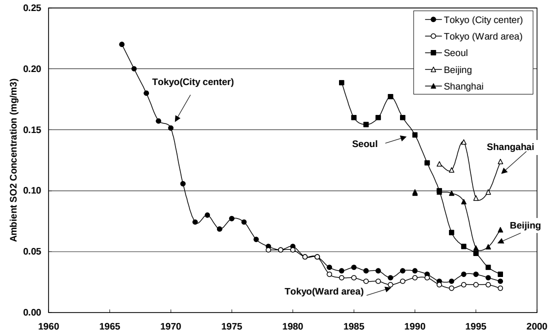
is much lower.

b. Ambient Air Quality

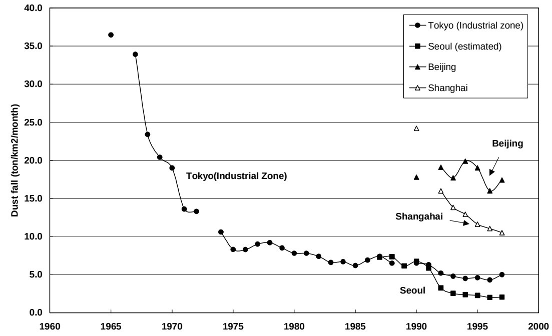
Among various urban environmental issues, air pollution is a major challenge for many cities in East Asia. Public concerns over air quality increases with the rising standard of living as it exhibits direct risks to human health. Major sources of air pollution in large cities are automobiles, although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

In all of the four cities, despite the government's efforts against the degradation of air quality, the emission of air pollutants from mobile sources is one of the most urgent challenges. The comparison of the ambient concentration of major air pollutants in the cities shown in **Figure 12** confirms that the NO_x concentration, largely discharged from automobile exhaust gases, still remains at a substantial level, while other air pollutants have to some extent decreased for the past several decades. As compared to the industrial air pollution that has recently been improved by various measures focusing on stationary source of air pollution, the future prospects on the improvement of mobile air pollution in these cities is not optimistic. The underlying reason is attributed to the existing situations in the case-study cities. Concerning urban transportation, it is expected that these mega-cities face the growing transportation demand from both freight and passengers that depends to a great extent on road transportation. Yet, considering the existing conditions in these Asian mega-cities, including rapid increase of automobiles and strong preference of private cars, the improvement of current road transportation system is so far very limited.

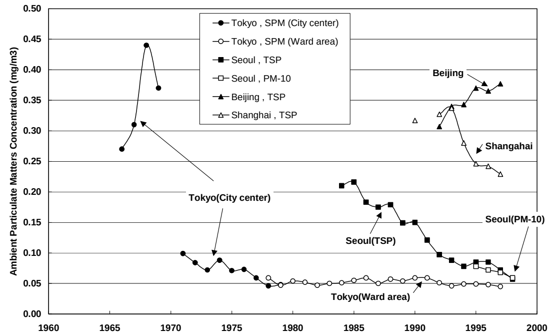
Indeed, the municipal governments made great efforts to reduce the use of private passenger cars, while they encouraged people to use public transportation modes. However, as seen in other regions, public transportation policy measures have a limited impact on the change of modal choice and trip behavior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



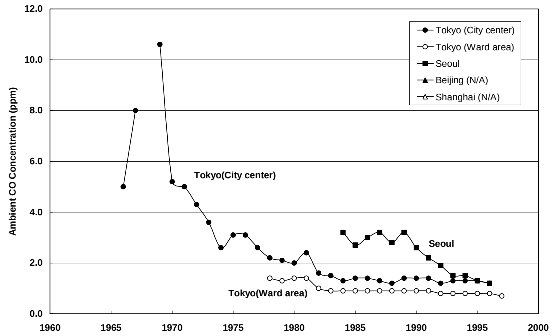
(A) Ambient SOx concentration (mg/m^3)



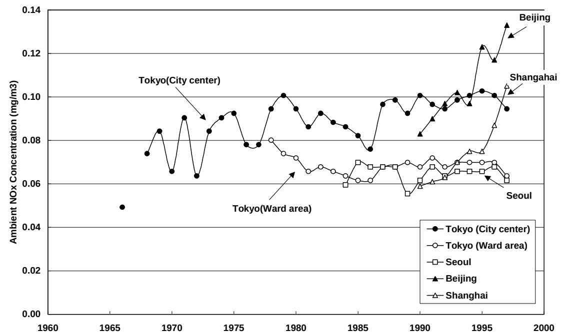
(B) Dust fall (ton/km^2/month)[1]



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



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



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

Figure 12 Comparison of the trends in major air quality indicators in 4 mega-cities

Data Source: China State Statistical Bureau, 1990-1998; Ministry of Environment of Korea, 1990, 1998; The Tokyo Metropolitan Research Institute for Environmental Protection, 1996; Tokyo Metropolitan Government, 2000.

Note

1. Data on total emitted amount of TSP is used for the estimated dust fall of Seoul.
2. SPM for Tokyo and PM-10 for Seoul include by definition every particle 10 micrometers **and** smaller. TSP for Seoul and Chinese cities include by definition every particle 100 micrometers and smaller.
3. Data on NO2 is used for NO_x of Tokyo and Seoul respectively.

c. Transportation

(i) Vehicle Population

Although the motor vehicle fleet is not exactly the same as the frequency of their use, it is one of the reliable indicators to explain motorization. **Figure 13** shows the trends of registered motor vehicles in Tokyo, Tokyo ward area, Seoul, Beijing and Shanghai, respectively. The registered vehicles are categorized into two groups, namely, passenger cars and trucks. While buses belong to the passenger car group in China, they belong to trucks in the other cities.

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

The rapid motorization in Seoul has occurred since the early 1980s. Without any discontinuity, the passenger vehicle fleet of Seoul has risen steadily and grew to 1.8 million in 1997. As a result, the past

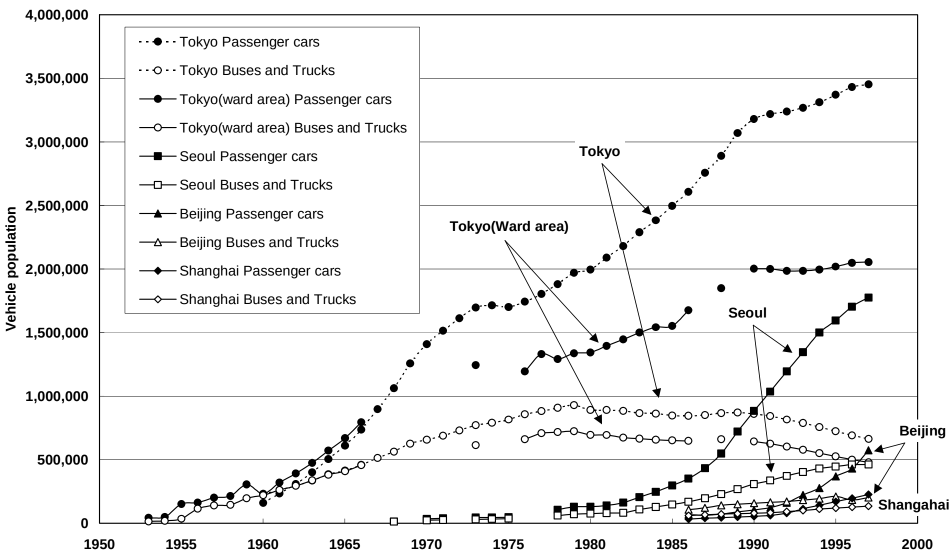


Figure 13 Vehicle Population

Data Source: China State Statistical Bureau, 1987-1998; Ministry of Home Affairs of Korea. 1969, 1971-1977, 1979-1997; Tokyo Metropolitan Government, 1962-2000; Council for Large City Statistics of Japan. 1952-2000.

trend of passenger vehicle fleets in Seoul shows a logistic curve known as typical diffusion pattern of durable consumer goods in the market. Since 1995, there have been signs that the rapid increase of passenger vehicle ownership is approaching its limit. Considering that the scale of Seoul is quite similar to Tokyo ward area, the upper limit of registered passenger vehicles in Seoul will be around 2 million, as large as the current level for the Tokyo ward area.

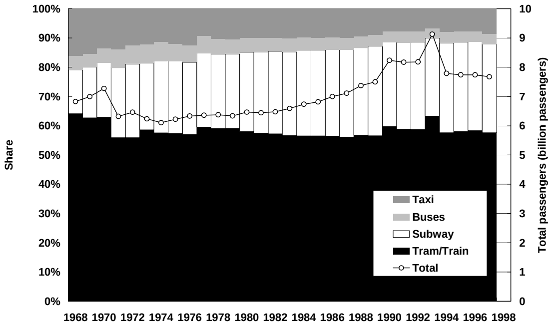
Compared with Tokyo and Seoul, on the other hand, the total number of passenger vehicles in Chinese cities is relatively small, where privately owned passenger vehicles have yet to be popularized among citizens. As of 1997, the number of passenger cars in Beijing was only 16.6%, 28.0% and 32.3% as many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

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

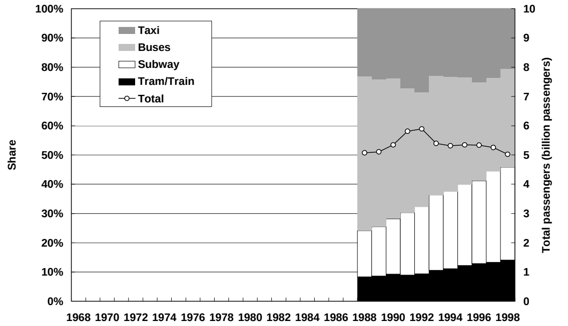
(ii) Public Transportation

Of generated trips and transportation demand, how much can be absorbed by public transit is very important for minimizing the use of private passengers. Whether public transit can provide attractive services or not is the key. **Figure 14** presents the total passengers of public transit and their modal splits. Among these four cities, there are apparent differences in characters of transit mode shares.

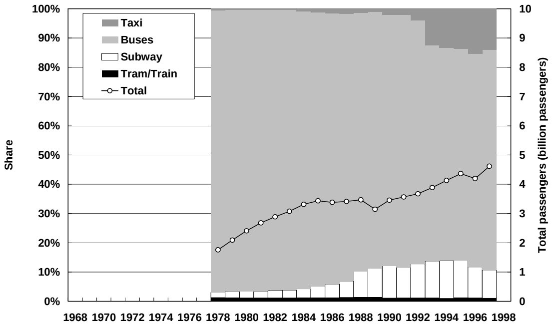
In Tokyo, total passengers have increased steadily since 1974 and peaked at 9 billion in 1992. Railway network systems including surface rails and subway lines in Tokyo are one of the most sophisticated one in the world. The surface rail networks in Tokyo developed before the motorization that came out behind the rail transportation system. As a result, the shares of on road public transit such as buses and taxis have remained small from the beginning. The surface trains have been keeping more than 50% of total share throughout the periods from 1968 to 1997. This is the result of the private sector involvement. When Tokyo experienced urban sprawl, many private rail companies constructed railways from the city center to the peripheral area. Since the government allowed them to make profits on the sale of real estate in order to recover the huge initial investments of railway constructions, they usually formulated the corporate groups with construction and real estate agencies. They newly constructed shopping centers and residential areas around each station contributed to the development of satellite cities and suburb areas. This enables them to provide better services of



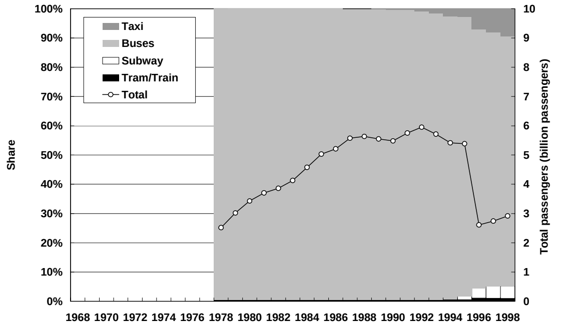
(A) Tokyo



(B) Seoul



(C) Beijing



(D) Shanghai

Figure 14 Trends in Public Transit Modes

Data Source: Shanghai Municipal Statistic Bureau, 1998, 2000; Beijing Municipal Statistic Bureau, 1999, 2000; Ministry Construction & Transportation of Korea, 1999; Council for Large City Statistics of Japan, 1952-2000.

railway transits with lower fares. Subways run by public organizations expanded their share in passengers of public transit from 15% in 1968 to 30% in 1997.

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

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

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

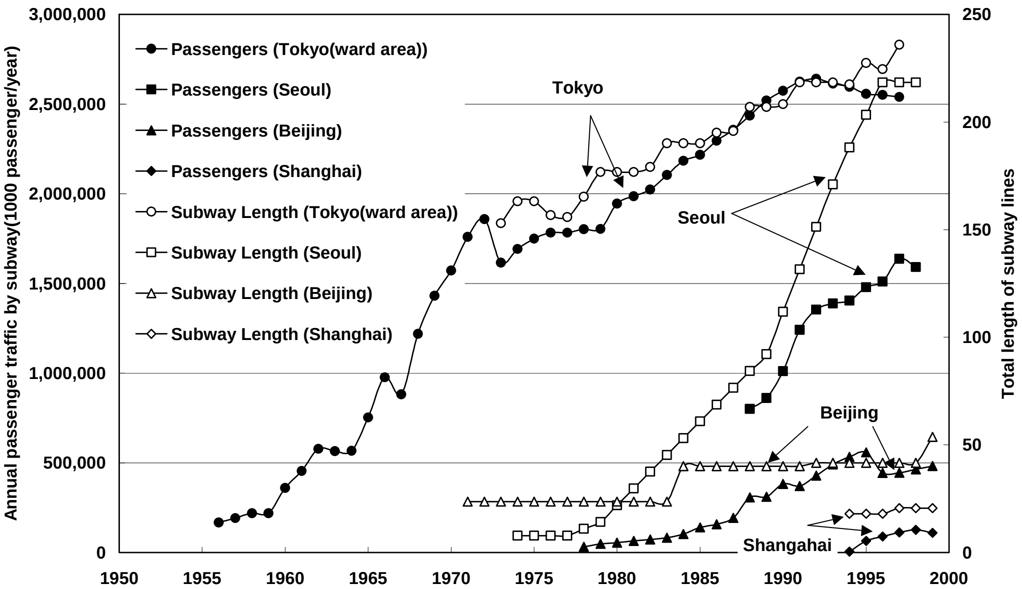


Figure 15 Subway System and Passengers

Data Source: Shanghai Municipal Statistic Bureau, 1998, 2000; Beijing Municipal Statistic Bureau, 1999, 2000; Ministry Construction & Transportation of Korea, 1999; Council for Large City Statistics of Japan, 1952-2000.

d. Hourly Load Curves of Buildings

In the total energy consumption profile in mega cities, the share of commercial building is quite important. Especially, the energy consumption patterns of commercial buildings in the cities like Tokyo and Seoul, which do not have many activities of manufacturing sector, rather have more service related activities. It is also worthwhile to note that the energy consumption patterns of commercial buildings are quite different from the activities of those buildings. **Table 9** below shows the results of actual survey conducted in specific buildings in Seoul in 1992. This table indicates the major specifications of buildings, which are related to energy consumption. This survey is the results of one-year measurement of actual electricity and heat consumption. There are four categories of commercial buildings; Hotel, Hospital, Department Store and Office. The first two types are more or less operating for 24 hours, while the last two types are used mainly for business hours. The energy consumption patterns are quite different, depending on the activities of buildings. Therefore, it is critical to consider the load patterns of energy consumption for the commercial buildings.

Table 9 Basic profiles for buildings to be surveyed in 1992

Data Source: Roh, Dong S., KEEI

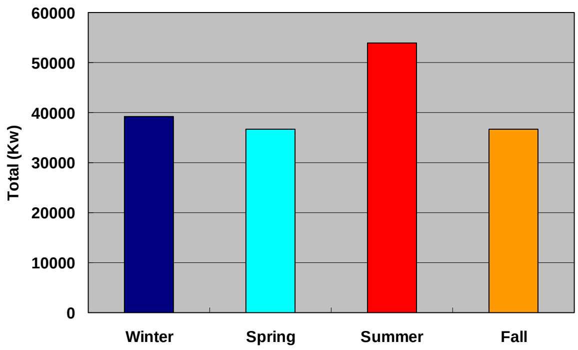
	Hotel	Hospital	Department Store	Office
Floor Space(m2)	176,786	129,273	64,440	299,753
Heating Space(m2)	105,443	102,702	26,411	196,695
Cooling Space(m2)	105,443	95,977	26,411	195,312
Floors	38	16	12	54
Heating/Cooling Method	Central	Central	Central	Central
Capacity of Heating(T/H)	24	40	15	36
Capacity of Cooling (R/T)	4,058	3,005	2,250	6,300

(i) Electricity

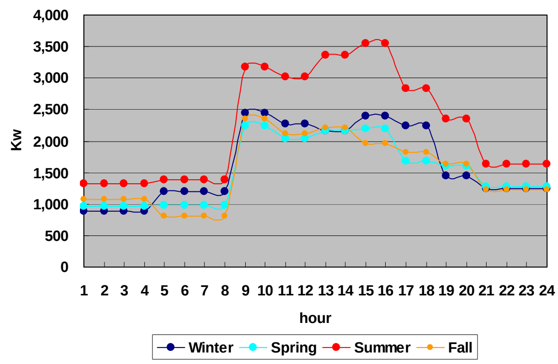
The electricity consumption in commercial buildings shows common and distinct characteristics, depending on the types of buildings, as showed in the below figures. First of all, all types of buildings show the higher electricity demand in summer. The main reason is obviously that the demand for cooling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

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

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



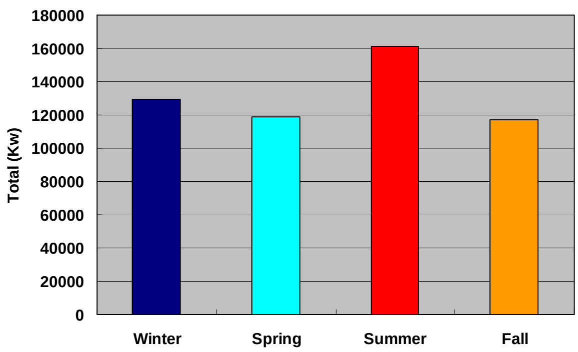
(A) Total per day by season



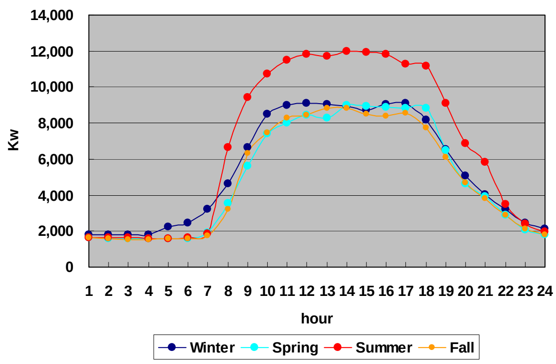
(B) Hourly load curves by season

Figure 16 Electricity Use for Hospitals in Seoul

Data Source: Roh, Dong S., KEEI



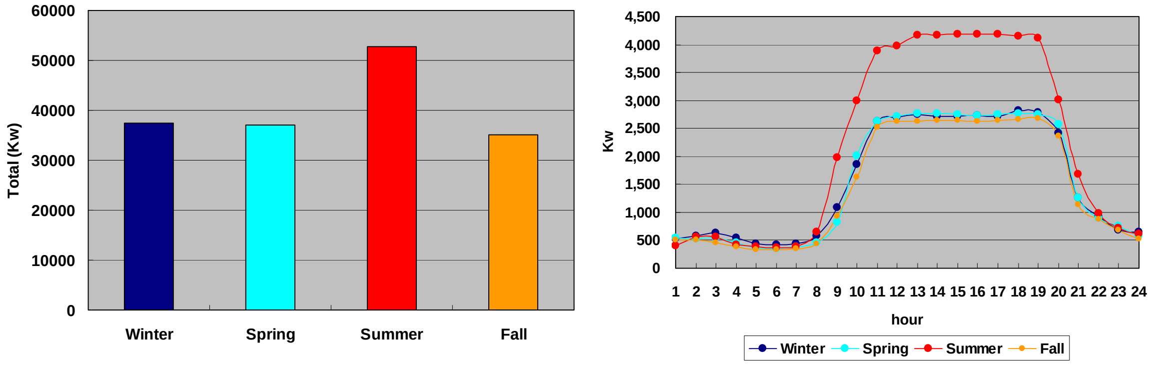
(A) Total per day by season



(B) Hourly load curves by season

Figure 17 Electricity Use for Offices in Seoul

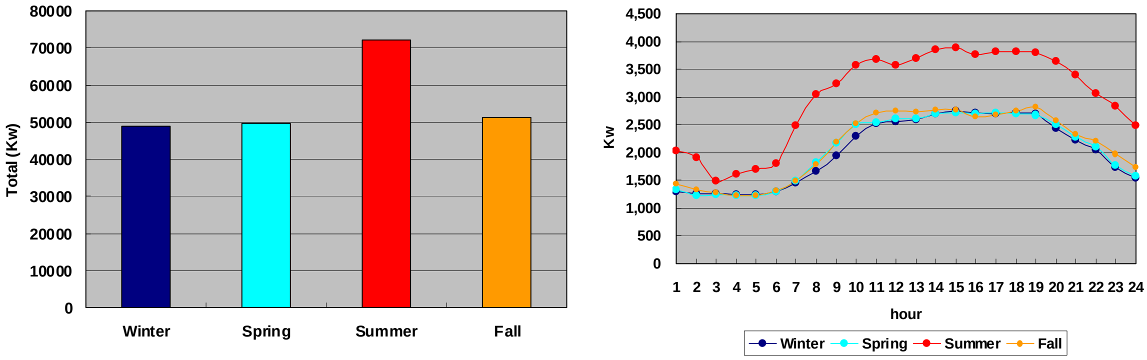
Data Source: Roh, Dong S., KEEI



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

Figure 18 Electricity Use for Departments in Seoul

Data Source: Roh, Dong S., KEEI



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

Figure 19 Electricity Use for Hotels in Seoul

Data Source: Roh, Dong S., KEEI

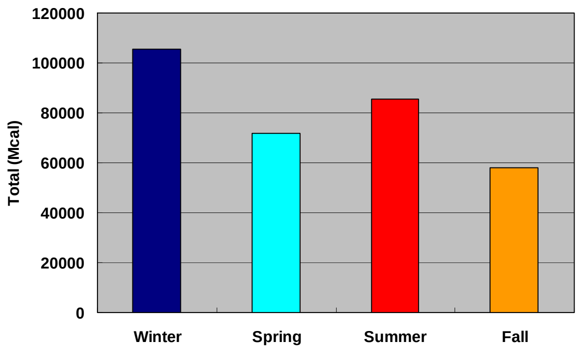
(ii) Heating Energy

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

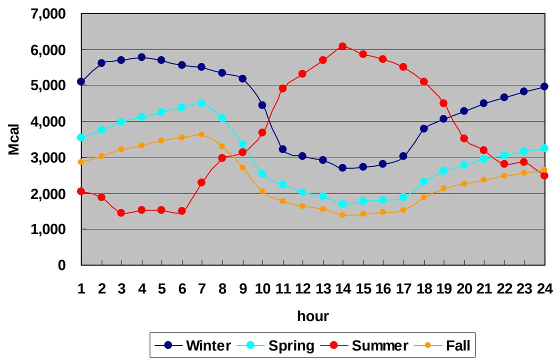
However, the seasonal ratios of peak and off peak are different from types of buildings and this ratio is larger than that of electricity. Another common feature of heat demand in commercial buildings is that in summer during the daytime the peak for heat (cooling) is realized, while in winter this is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

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

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



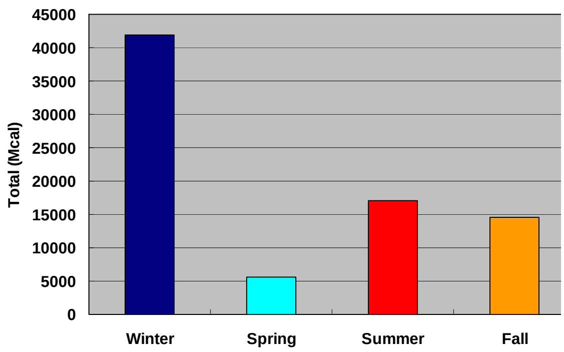
(A) Total per day by season



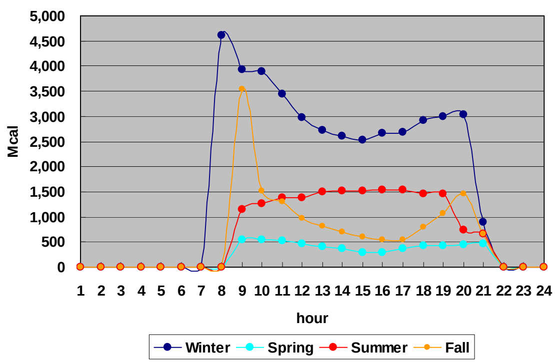
(B) Hourly load curves by season

Figure 20 Heating Energy Use for Hotels in Seoul

Data Source: Roh, Dong S., KEEI



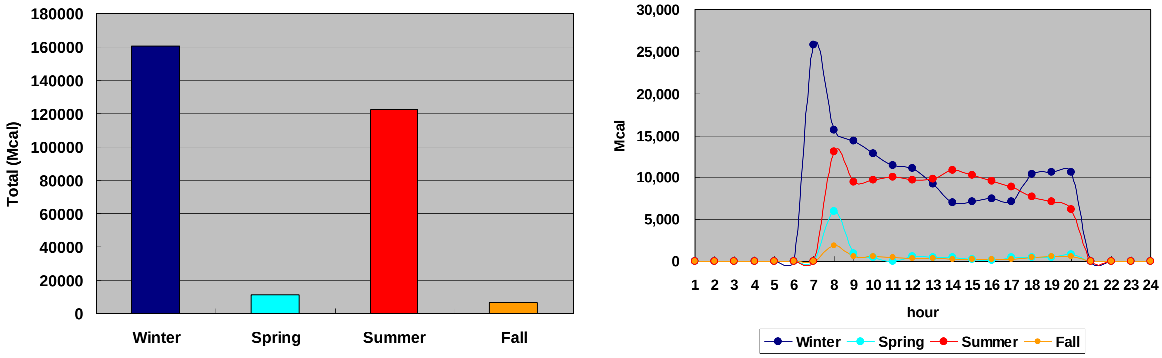
(A) Total per day by season



(B) Hourly load curves by season

Figure 21 Heating Energy Use for Departments in Seoul

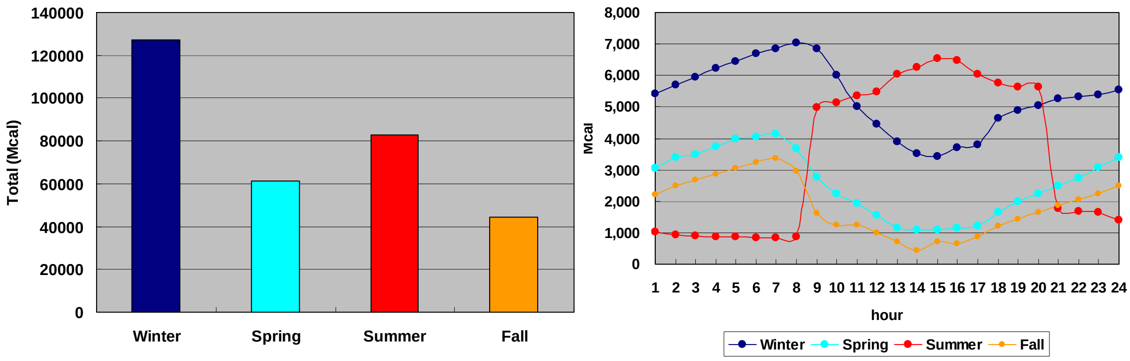
Data Source: Roh, Dong S., KEEI



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

Figure 22 Heating Energy Use for Offices in Seoul

Data Source: Roh, Dong S., KEEI



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

Figure 23 Heating Energy Use for Hospitals in Seoul

Data Source: Roh, Dong S., KEEI

e. Energy Consumption and Factor Analysis of CO_2 Emission

(i) Energy consumption

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

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

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

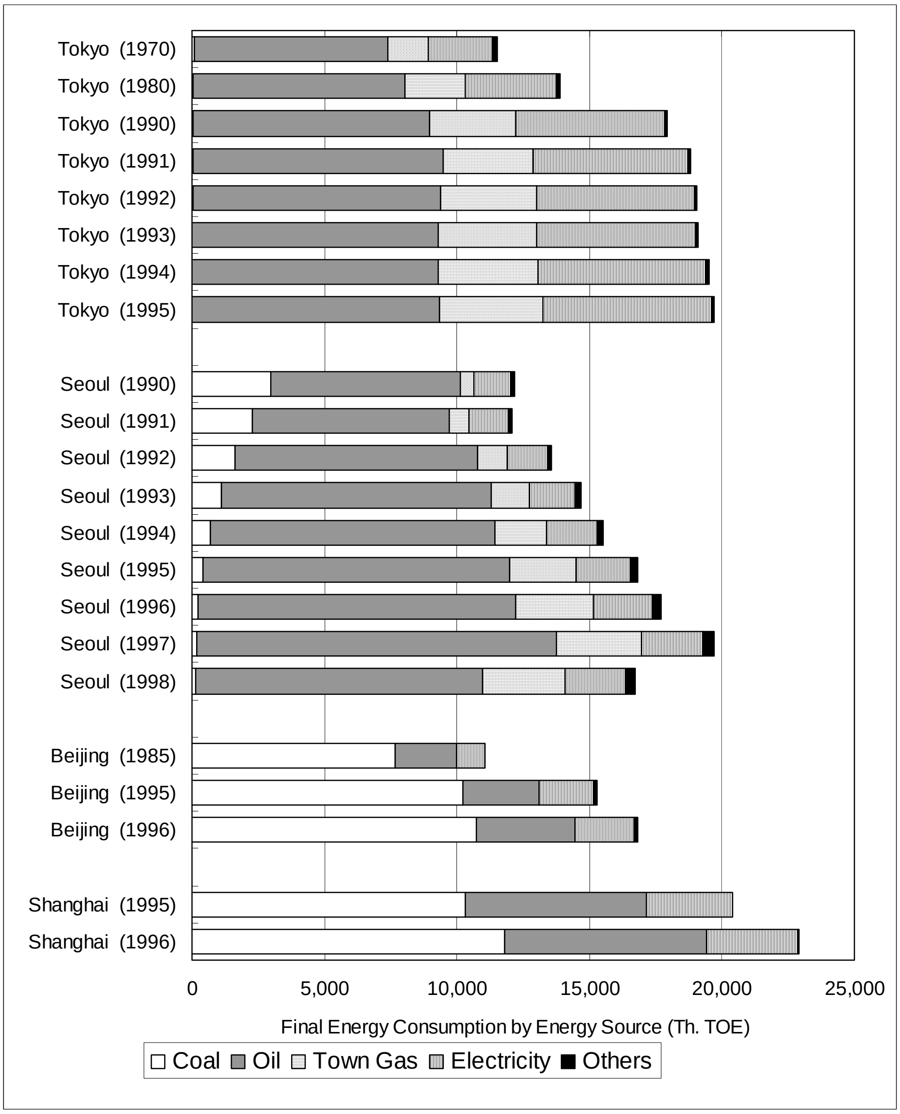


Figure 24 Final Energy Consumption by Energy Type

Data Source: Department of Industrial and Transportation Statistics of China State Statistical Bureau, 1998; Korea Energy Economics Institute, 1998; Korea Energy Economics Institute, 1999; KEEI Database; Bureau of Environmental Protection of Tokyo Metropolitan Government, 1998.

in Tokyo. In 1998, it was sharply dropped, due to the financial crisis occurred in the late 1997.

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

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

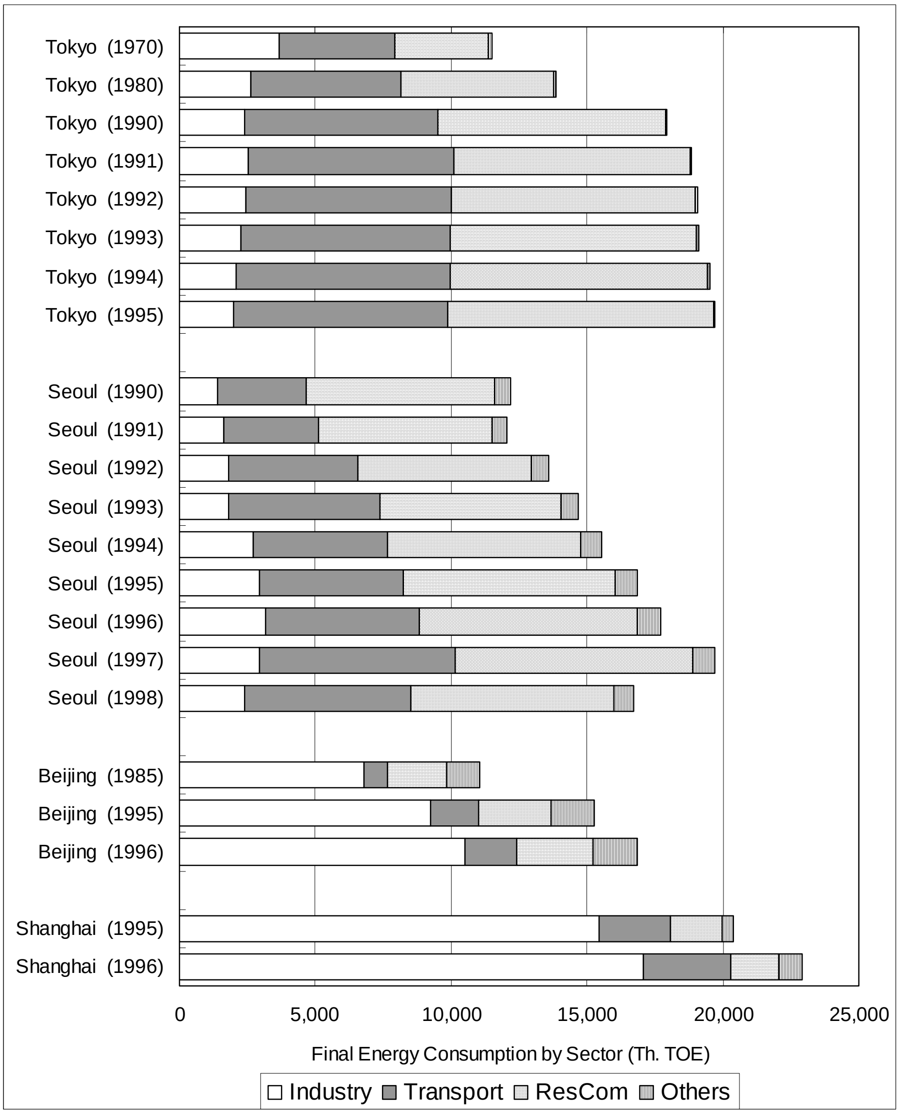


Figure 25 Final Energy Consumption by Sector

Data Source: Department of Industrial and Transportation Statistics of China State Statistical Bureau, 1998; Korea Energy Economics Institute, 1998; Korea Energy Economics Institute, 1999; KEEI Database; Bureau of Environmental Protection of Tokyo Metropolitan Government, 1998.

Figure 25 shows the energy demand trend by sectors. In Tokyo, the absolute amount and shares of energy demand from transport sector has steadily increased. The share of residential and commercial sectors in energy demand has been the largest, as we expect this trend in major mega-cities. For Seoul, we observed the similar trend as in Tokyo. The share of residential and commercial sectors is even larger. On the other hand, the share if industrial sector is larger in Chinese cities.

(ii) Factor Analysis

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

$$CO_2 = (CO2/E)*(E/GRP)*(GRP/Pop)*Pop$$

$$CO_2 = (Carbon\ Intensity) * (Energy\ Intensity) * (Per\ capita\ GRP) * Pop,$$

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

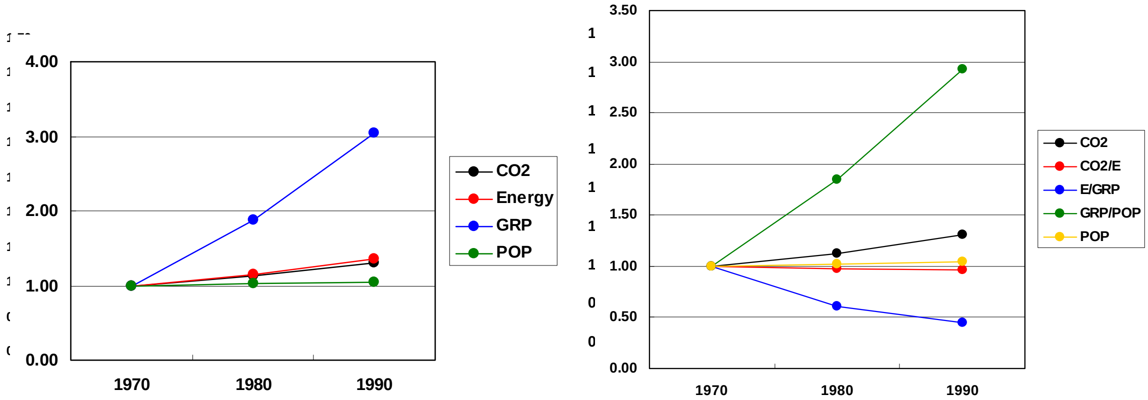
If we differentiate the above equation, the change of CO_2 emissions can be approximately decomposed into the change of those four factors.

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

Hence, we identify the major factors to contribute the change of CO_2 emissions within a specific period.

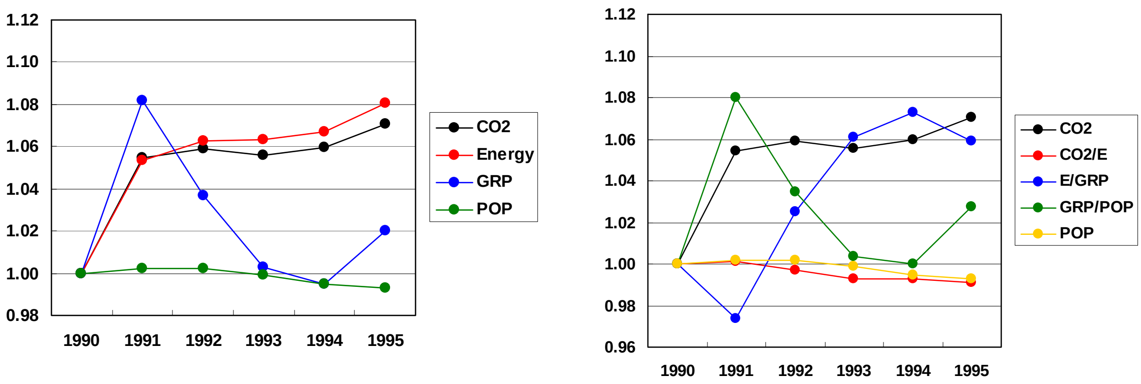
For the empirical study of factor analysis, we applied two cities; For Tokyo, we have data from 1970 – 1990 with 10 year span and 1990 – 1995 with every year span. For Seoul, we have data for 1990 – 1998 for every year.

The first set of figures in the following graphs shows the case of Tokyo for every decade from 1970 (**Figure 26**). As we expect, the economy of Tokyo (GRP) has been increased by three times for two decades. However, the increase of population has been trivial. The energy consumption and CO_2 emissions have been increased with lower growth rates. The right-hand side graph shows the change



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

Figure 26 Major Indicators for Kaya Identity in Tokyo (1970 – 1990)



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

Figure 27 Major Indicators for Kaya Identity in Tokyo (1990 – 1995)

of indicators in Kaya Identity. By this analysis, we identify which factor is the main contributor for the CO_2 emission increase during the period. Obviously, the per capita GRP increase is the main reason for the increase of CO_2 emission in Tokyo, which implies, in other words, that the expansion of economic activities in Tokyo is the main driver for the CO_2 emission increase in this city. Also, it is worthwhile to note that during the same period, the energy intensity has improved more than 50%, which means that during the same period, to produce one unit of output, about half of energy was required. This is an important contribution from energy sector for slowing down the increase of CO_2 emission. However, the contribution of carbon intensity was trivial, which means that the change of CO_2 emission by fuel switching to less carbon intensive one was trivial, while the change of population was also marginal.

However, this situation is changed, if we applied the same method for the period of 1990 – 1995 in Tokyo (see **Figure 27**). During this period, Japanese economy has experienced the severe recessions. The GRP during this period has increased by 2 %, while the population in Tokyo somewhat decreased. On the other hand, energy consumption and CO_2 emissions were increased by about 8%. As a result, during this period, the major contributor to the increase of CO_2 was the increase of energy intensity, while per capita GRP affected in negative way. Still, it is important to note that carbon intensity has consistently improved during this period.

The same analysis was made for the case of Seoul during 1990 – 1998 (see **Figure 28**). Before the financial crisis of 1997, every indicator shows rapid growth except the trend of population. For the case of Seoul, it is worthwhile to note that the trend of energy consumption has exceeded to any other indicator. After the financial crisis, the energy demand dropped most sharply. Since the GRP has steadily increased and population decreased, the change of per capita GRP contributed mostly to the increase of CO_2 emission during this period in Seoul. Then, the change of energy intensity also contributed. However, the change of carbon intensity negatively contributed to the increase of CO_2 emissions. As we explained earlier, the change of carbon intensity has strong relation to the environmental policies on air pollution, which also contributes to reducing CO_2 emissions in Seoul.

3 Further Study

3.1 Goals of the Exercises Conducted by IMURA Group

The objectives of the study that will be carried out by IMURA group are as follows.

1. This study will focus on the mega-cities in Asia including Tokyo, Seoul, Beijing and Shanghai, which are emerging as centers for economic growth and consumption of energy and resources.
2. We will analyze the energy consumption of various urban sectors, in order to provide policy directions for integrating energy related policies and strategies that enhance the effectiveness of local policies.

3.2 Study Items Conducted by IMURA Group

In Seoul meeting held on December 13, 2000, it was agreed on the overall framework of the study. The tasks have been divided into three stages as the followings. For further detail information, the preparation of the working plan is underway, in which the model structure, data issues, assignments, expected outcomes and time schedules are explained.

1. To identify major drivers affecting the energy demand in mega-cities in the process of dynamic structural changes (see **Figure 29**)
2. To forecast the future trend of energy demand in major sectors and to develop policy scenarios to de-couple urban economic development and energy consumption and environmental emissions (see **Figure 30**)
   - ✓ To develop Top-Down Model (Macro Economic Model)
   - ✓ To develop Bottom-Up Model (Engineering Model)
   - ✓ To conduct Material Flow Analysis (MFA)
3. To assess the various environmental impacts caused by intensive energy and material use of both inside and outside of a city (see **Figure 31**)

3.3 Implementation

The studies on the cities in Japan, China and Korea will be conducted in close cooperation with the participation of the following members and under the leadership of Prof. Imura and two IGES researchers (IMURA group).

Japan:

Prof. Hidefumi IMURA (Nagoya Univ./IGES)
Dr. Shinji KANEKO (IGES)*
Dr. Shobhakar DHAKAL (IGES)*
Dr. Tae Yong JUNG (IGES)
Mr. Hiromitsu KAWAHARA (Fujitsu FIP Corporation)

Dr. Toru MATSUMOTO (Kyushu Univ.)

*Two researchers in IGES will be engaged in this project almost on full time basis.

Korea:

Prof. Don-kun LEE (Sangmyung Univ.)

Prof. Euiyong YOON (Hyupsung Univ.)

Prof. Choon-Geol MOON (Hanyang Univ.)

China:

Prof. Kebin HE (Tsinghua Univ.)

Dr. Deliang TONG (Beijing Municipal Institute of City Planning and Design)

Prof. Zhihong WEI (Tsinghua Univ.)

Changhong CHEN, (Shanghai Academy of Environmental Science)

In addition to this, the web site of this project has been developed in IGES server to serve as communication interface among the participants. Set out below is the address of the site.

http://www.iges.or.jp/ue/kaneko/APN

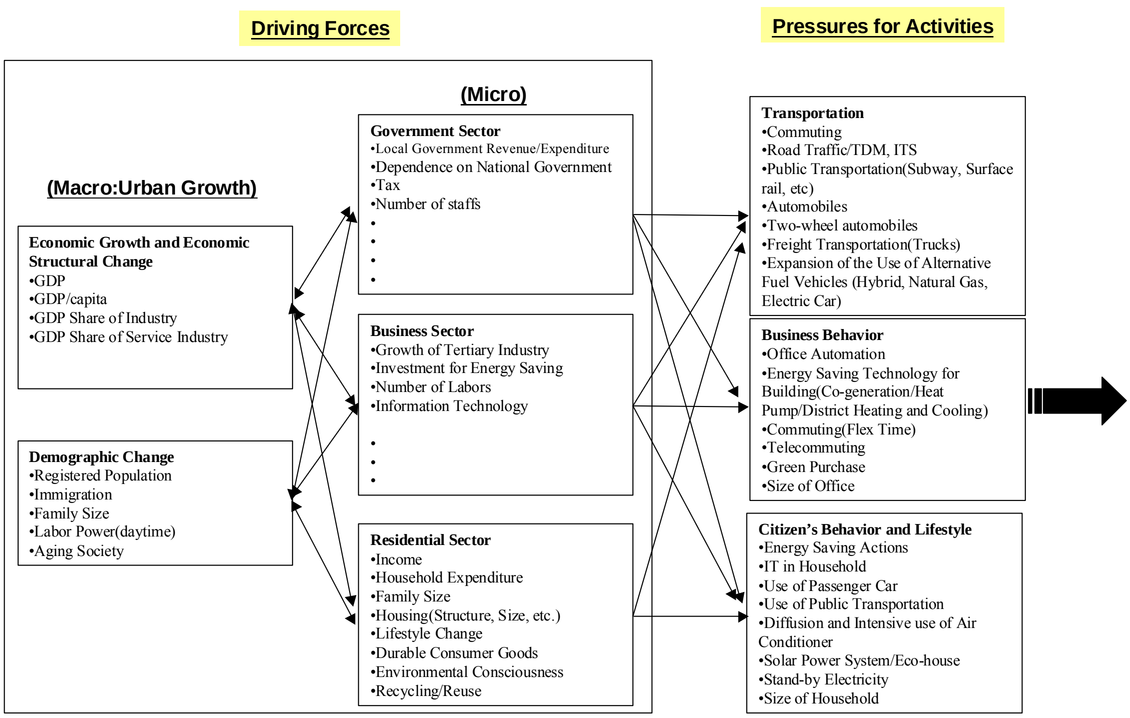


Figure 29 Outline of the Study (Stage I) –Identification of Drivers and Pressures

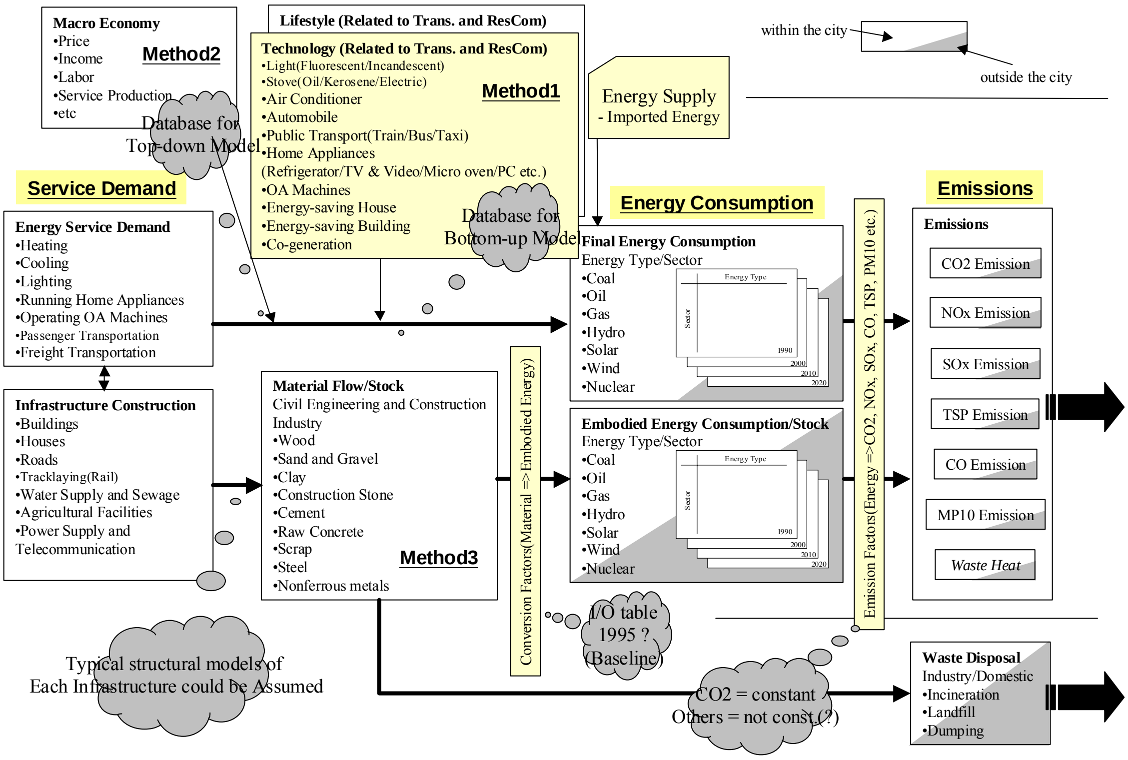


Figure 30 Outline of the Study (Stage II) –Modeling

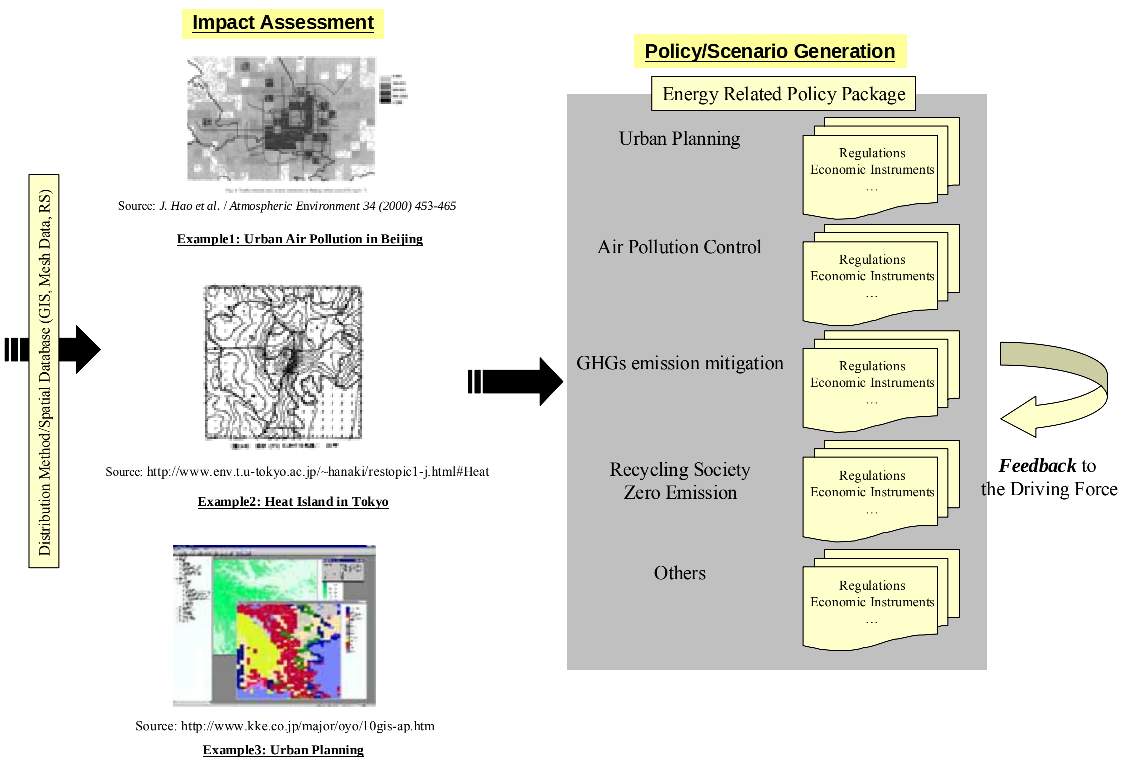


Figure 31 Outline of the Study (Stage III) –Scenario Generation and Policy Assessment

PART II

MITRA Group
(Manila, Delhi and Calcutta)

Project Title: Policy Design of Asia Cities and Mega-cities Data Collection, Indian Component (Project Leader: Dr A.P. Mitra)

APN Funding
US$ 5000

Participants were funded from the following countries
Not Applicable

1 Introduction/Background

There are 15 mega-cities in Asian region with population exceeding five millions. Most of these cities are playing important economic roles as industrial and commercial centers of the respective countries and receiving larger investments by government and private sectors. These mega-cities also have significant share in the overall national emissions of greenhouse gases like CO_2 and CH_4 besides other trace gases like CO, NO_x, & SO_x, and particulate matter.

The mega-cities in developing countries in Asia are in the process of rapid industrialization and are confronted with multiple tasks for economic development and environmental protection. However, they tend to give their policy priorities to immediate, local issues and regard the Global Warming as a long term, distant issue. These cities are, in fact, in a better position to be able to adopt more advanced policy/technological interventions to protect the global environment than the rest of the country and can serve as a role model for other cities.

The prerequisite for systematic actions for this is the scientific analysis of GHG emission budgets of cities. Therefore, in the first place, seven typical Asian mega-cities have been selected for collection of appropriate activity data to prepare inventories of GHGs and other trace gases. The selected cities are Tokyo, Seoul, Beijing, Shanghai, Manila, Bangkok, Delhi, and Calcutta along with their surrounding urban areas. These have been selected based on the following considerations:

- Tokyo: The most developed mega-city in Asia, which have modern urban infrastructures, well-organized mass transport systems, and a number of new energy saving technologies for buildings and products, and where people's awareness about the global warming seems high.

- Seoul: A modern city similar to Tokyo, with stricter land use regulation and planning but with less developed mass-transport system, and larger energy demand for heating in wintertime.

- Beijing: The capital city of China undergoing rapid transformation, with increasing population, new buildings, and automobile traffics. Preliminary analysis has shown that both Beijing and Seoul are following Tokyo in sectors like transport but off course, with phase-lag.

- Shanghai: The richest mega-city in China undergoing rapid transformation, with a growing number of new business facilities, increasing automobile traffics and diffusion of affluent lifestyles.

- Manila: A typical mega-city in Southeast Asia, with serious traffic pollution problems and slums dwelled by poor people with limited access to electricity and gas.

- Delhi: The national capital city of India with largest numbers of automobile population and highest traffic density among Indian cities facing serious air pollution problems.

- Calcutta: The most populated city in India with very different living conditions than Delhi

The Indian component has been the collection of activity data from Delhi, Calcutta and Manila. However, not much data about Manila could be found and therefore, efforts have been concentrated on Delhi and Calcutta.

2 Outline of activities conducted

The activity data about geographical, demographical, aggregate energy data, households, commercial and industrial establishment, transportation, agriculture, infrastructure, waste etc. of Delhi and Calcutta have been collected and compiled in digital forms. Additionally, data about surrounding urban satellite towns of Delhi & Calcutta have also been collected and compiled.

3 Outcomes/Products

The data collected until July 2000 had already been put in the IGES web-site http://www.iges.or.jp/ue/kaneko/APN/Toppage.htm.

In addition, the entire data sets of Delhi & Calcutta would be made available on South Asian START Regional Research Centre's web site (http://www.npl-cgc.ernet.in) by the end of February 2001.

4 Future directions/follow-up work

This data collection and compilation in digital form would continue. Attempts would be made to develop inventories of GHGs and other urban pollutants for Delhi and Calcutta using the IPCC reference approach as well as bottom up approach.

The project proposal entitled `The Budgets of GHGs, Urban Air Pollutants and their Future Emission Scenarios In Selected Mega-Cities in Asia' which is under consideration of APN for funding for 2001-2002 will provide further opportunities to estimate the `embodied emissions' in these mega cities and development of refined inventories.

Project Leader (Indian Component)

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Background Report for a Proposal to
the Asia-Pacific Network for Global Change Research

GHG Implications of Urban Transport Growth Strategies In Liberalizing Asian Economies

Prepared by

Peter Newman, Charles Johnson, Kiyoyuki Kanemitsu and Roland Fuchs[1]
Transportation Working Group

July 14, 2000

Introduction

Asia Pacific currently accounts for 13 of the world's 19 megacities, and Asia is projected to have 20 megacities in 2025 and 40 megacities by 2050. Some of these megacities will be larger than any city in recorded history, and pose a complex array of problems, including environmental impacts locally and globally. This proposal is for a three-stage process based on APN funding of the first stage (the Pilot Project). The second stage project will be based largely on external funding made possible through the successful completion of the Pilot Project, and a possible third stage project would ensure ongoing exchanges of information and capacity building among Asia Pacific governments.

The impacts of Asia's cities on the health of its people and to global climate change is fundamentally related to its transport priorities. If megacities in the Asia Pacific are to be properly understood and their environmental impacts mitigated, then a knowledge of the transport and land use of these cities, and responses to different transport policies is critical.

This project will have considerable synergism with the Urban Greenhouse Gas (UGHG) project in the following areas:

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[1] Dr. Peter Newman, Professor of City Policy, Institute for Sustainable Technology Policy, Murdock University, Perth; Dr. Charles Johnson, Coordinator, Environmental Studies, East-West Center, Hawaii; Mr. Kiyoyuki Kanemitsu, Executive Director, Asian Urban Information Center of Kobe; and Dr. Roland Fuchs, Director. International START Secretariat, Washington DC.

• agreeing to focus on some of the same megacities, but recognizing that this project will be extended to include medium size and small cities that in Asia represent 85 percent of the urban population, and contain future megacities;

• assisting the UGHG project with the data collection on the GHG contributions from transport in *all* of their cities, representing up to half of the GHGs of their study cities; and

• extending the approach taken by the UGHG project by seeing how transport and land use strategies can be better focussed to achieve global change objectives in the planning and strategies used in both existing and emerging Asia Pacific megacities.

The context of the study is that the impacts on global change of megacities is already important and is growing; therefore reduced greenhouse gases should become a clear policy objective of urban planners and managers along with existing health issues of air quality, road accidents, the loss of biodiversity and rural production from urban sprawl, and other negative impacts resulting from traffic and congestion on the quality of urban life.

Despite the negative impacts of megacities, they also play a dynamic role in economic growth in Asian economies, providing a wide array of opportunities that are expected to continue to attract increasing numbers of urban population into these cities. Continued urban sprawl is almost inevitable. Government intervention to prevent or delay the rural to urban trends has had limited long-term success in most countries; and may be less successful in the future due to the combined forces of globalization and liberalization that are accelerating changes across Asia. Therefore, this proposal intends to set out a policy scenario that can improve people's choices in the urban transportation area, while also making an important contribution to address global change.

The Pilot Project is expected to provide significant policy insights and hypotheses of importance to transport planning and global climate change that will be further scientifically validated in the second stage project. Nine cities have been chosen for the Pilot Project three countries. These three countries, Japan, China and India, account for 40 percent of the world's population and 65 percent of Asia's population. The nine cities in these three countries are listed below with their 1995 populations to show the variation from megacities to medium sized cities to smaller cities. Kobe will be used due to the richness of its data availability and expected willingness of the Kobe government to actively participate in future capacity building activities that can benefit the entire APN region. Kobe will be examined in the context of its broader region of Osaka.

Country	**City**	**1995 Population (million)**
Japan	Tokyo	26.8
	Kobe-Osaka	10.6 (1.5 Kobe)
	Sapporo	1.7
China	Beijing	12.4

	Shenyang	5.3
	Kunming	1.9
India	Delhi	9.9
	Cenai	5.9
	Chandigarh	1.2

There has been extensive research and funding on urban problems in Asia, with a strong bias toward Asia's megacities where much of the political power resides. The environmental focus is increasingly on local health damaging pollutants from the transportation sector in urban areas. All major cities across Asia have introduced a range of policies to try to limit the number of automobiles, require cleaner fuels, and in some cases emission control equipment in order to reduce health-damaging pollution in urban areas. Concern is also growing over the loss of biodiversity and rural agriculture production resulting from the loss of land to the almost insatiable need to acquire more land for housing, industry and associated transport infrastructure.

Sustained successes at managing the growth of such megacities are difficult to identify, and the outlook is continued growth in the transport sector for most Asian cities, and more severe pollution and congestion. Only recently have governments given significant attention to GHG emissions from the transport sector in urban cities of Asia. In most cases, little or no action has been taken to directly control carbon emissions for the primary purpose of reducing GHG emissions.

Historically, Asian governments have actively intervened to control the growth in automobiles in the urban sector through taxes and other measures to discourage personal car ownership. However, the double-digit growth in automobile ownership in most Asian economies is direct evidence that many programs are having limited long-term success. In addition, increasingly, governments are liberalizing their economies, resulting in less government intervention in consumer choices. The liberalization in government policies, combined with increasing incomes in most Asia economies has the potential to accelerate the rate of growth in private car ownership in Asia. The transport sector is expected to lead the growth in energy consumption in many Asian developing economies, and in associated GHG emissions over the next two decades.

Although efforts to increase efficiencies of car engines are important, the largest reductions in energy consumption and emissions per passenger kilometer are achieved when passengers choose mass transit systems over private cars. Mass transit systems, particularly fixed rail systems, have the highest front-end costs among transport options, and exceed the ability of most city governments to fully fund these projects through private commercial banks. The needed supplemental lending assistance from major multilateral development lending banks, such as the World Bank and the Asian Development Bank, is limited because of their reluctance to fund large fixed rail mass transit systems. However, recent joint public-private joint ventures are demonstrating that rails can meet acceptable profit criteria, particularly where investors are able to capture some of the increased land value adjacent to rail lines. Incorporating, the global change benefits into rail lines has yet to be undertaken in such evaluations, and is expected to further demonstrate the net benefits of rail systems.

Pilot Project Objectives

(1) Collection of data on selected cities, ranging in population sizes from 1-2 million to megacities of 10+ million in three Asia Pacific countries, with a specific focus on transportation and GHGs. This will include the associated parameters associated with transportation infrastructure and land use and their environmental and economic impacts.

(2) Analyses of how city policy makers and planners in the case-study cities set priorities for their transportation infrastructure.

(3) Research on the different mechanisms used in these cities to allocate funding for their transportation infrastructure, including the priorities and processes of the multilateral funding bodies. This will include an assessment of the degree to which they incorporate both global change issues and public participation in establishing transportation priorities.

(4) Determining how to increase the public choices in urban transportation in the Asia Pacific, particularly through the increased availability of quality, fixed-track transit opportunities, as well as the flexible modes. To the degree possible, the research will build on other relevant research in the Asia Pacific and the United States.

(5) In the pilot stage an attempt will be made to broadly outline the costs and benefits of affordable, high quality fixed rail transport systems versus automobile intensive options using scenario analysis. Detailed analyses will not be possible in the pilot project.

Work Plan and Timeline

Stage 1 - Pilot Project

During the six-month Pilot project, the data will be completed on these nine cities. It will use the database being developed by Newman and Ken worthy for the UITP, which is on 100 Global Cities with 65 parameters. This builds on the 44 cities they have published data on previously (Newman and Kenworthy, 1999 and Kenworthy et al, 1999). For this study data can be used from the UITP study for six of the cities (Tokyo, Osaka, Sapporo, Beijing, Delhi, Cenai). The Pilot project will thus need to add new data on Shenyang, Kunming and Chandigarh, as well as completing the data on Kobe within Osaka.

As well as collecting the quantitative data the Pilot Project will provide a qualitative understanding of how the planning of these megacities is linked to their transportation infrastructure, and in particular it will describe the transportation funding procedure that is applicable to those nine cities.

The Pilot Project will sketch out the basis of a scenario approach to understanding the impact of megacities on global change (both GHG and land loss) and how different strategies can alter these trends.

Finally, a seminar could be developed using the data on Hyogo Prefecture as part of the Kobe-Osaka case study, to be presented at next year's seminar in conjunction with presentations on Hyogo Prefecture from the other APN working groups.

Stage 2 – Major Project

The next phase of the work will allow in-depth analyses and capacity building for the nine cities from the stage 1 pilot project, plus will extend the data and analysis to a larger selection of cities. This phase lasting some about two years will set out the full economic analysis of transportation financing in the megacities, including the parameters of global change. This will include scenario analyses on how the impacts are expected to evolve if present trends (base case) continue to 2025 and 2050, versus outcomes with accelerated introduction of affordable, quality, fixed rail transport systems. The results can be used in economic models on the region and provide inputs into climate change models.

To avoid being boxed into scenarios bounded by existing trends and infrastructure constraints, a longer-term time horizon has been selected to allow for the full social, economic and environmental impacts of different transport development scenarios. The environmental situation will be compared with the situation in 2025 and 2050 under two basic scenarios, one with auto intensive systems and limited affordable, high-quality fixed-track transit systems. A second scenario will assume a fully developed fixed track system in conjunction with a highly functional and flexible local non-car transport systems. Specifically, the potential dimensions of urban transport-related GHG emissions will be assessed for the next 25-50 years assuming continued liberalization and economic growth in Asia, with and without the accelerated introduction of efficient mass transit/ non-car mode systems in the major urban cities of Asia Pacific.

A strategy of accelerated introduction of mass transit systems cannot be based primarily on the GHG (carbon) reduction whose benefits appear to be decades away, and difficult to quantify. However, the same transport fuels that generate GHG emissions of global importance, also release pollutants that have high health risks to the urban populations, and these vehicles contribute to high accident impacts. Previous analyses of Newman and Kenworthy also show numerous other benefits that appear to be related to the greater land use efficiency in transit-oriented development (e.g. each rail line carries between 3 and 50 lanes of traffic equivalent). The total economic benefits of affordable, high quality mass transit systems will need to be more clearly demonstrated, in addition to GHG emission benefits, in order to convince governments to commit to accelerated introduction of mass transit systems in urban Asia.

The sizes of megacities that are expected to emerge in the next quarter century surpass anything ever experienced in human history. No one can accurately map out the social, economic and environmental implications of these super-megacities. But it is possible to broadly suggest the GHG implications under different transport mix scenarios, and the proposed Major Proposal will develop such scenarios along with their economic implications.

Stage 3 – Possible Asia-wide Project

The ultimate aim will be to enable all the cities of Asia Pacific to become involved in data collection and analyses, which can enable them to better plan for futures that have less harmful local and global environmental impacts. This multi-year project would involve training of urban professionals and the establishment of a coordinated central urban data processing unit for APN. This might include an APN publication on the State of Asia Pacific Cities and Global Change.

(1) Relationship to Priority Topics in the APN Research Framework

This proposal enhances APN's ***Climate Change and Variability*** theme area. The proposal is based on solid scientific data and analyses developed over two decades of research and publications (Newman and Kenworthy, 1999; Kenworthy et al, 1999), and more than two decades of experience of each of the principal investigators in working with Asia Pacific government policy people and planners. The research will discuss the relationship between scientific research and analyses, economics and human behavior, and how this can be used in formulating urban transport planning strategies. In particular, the policy and climate change implications of the "liberalizing" trend in Asia will be discussed in the context of plausible impacts on transport choices under scenarios with and without fully developed, affordable and efficient rail transport systems together with competitive, local, non-car modes. The policy implications will be primarily related to how the cities prioritize funding their transport infrastructure. The interests of natural sciences in biodiversity and rural production will be incorporated through the relative differences in land loss due to the different urban forms involved.

Giving attention to the GHG implications of urban transport growth in liberalizing Asian economies is an important area with limited research, but growing interest among APN member economies. This project has the potential to produce solid results in a relatively short period, and will help in establishing APN as a respected regional institution that produces timely, original research of importance in addressing global climate change issues.

(2) Regional Collaboration

This project is designed to promote strong interest and collaboration among Asia Pacific urban policy makers, the scientific community involved in climate change issues, and to the degree possible, multilateral lending agencies. Key people/institutions involved in urban planning, urban transport and climate change issues in the case study countries will be contacted during the pilot project stage to: (i) ensure the identification of similar and overlapping work in the area, (ii) exchange views on the best way to implement the project, (iii) to explore how best to include interested people/institutions in the research and data collection and validation, and (iv) to encourage their participation in the dissemination of project results, and subsequent planning for follow-up activities, including training.

(3) Capacity Building

An essential goal is the transfer of data, analyses and policy implications to policy planners dealing with urban transport planning and policies and/or global climate change issues. During this pilot phase of the project, research results will be preliminary and incomplete, and funding levels cannot justify major capacity building activities. Half-day seminars will be held in all nine case-study cities (subject to finding suitable host institutions) to explain the project plans and research methodologies, and expected results of policy significance. During these seminars and subsequent data collection and discussions in each city, the principal investigators will identify those people and institutions to be included in more extensive capacity building activities planned for Stage 2 of the project when the complete results of the project area available. It is the explicit intention to include the collaboration of relevant bodies within Kobe in this activity.

(4) Links to Policy

The policy rationale for the project is that it seeks to provide strategies for megacity policy and planning people (plus the range of smaller cities) to cope with the global change agenda, and also to incorporate transport policy implications of liberalization of Asian economies. The key to linking successfully with policy makers is to establish both a sound scientific basis in support of the analyses and recommendations, and second to include policy makers as early as possible in undertaking the project to ensure that their inputs are accommodated in the project. Finally, early involvement of policy makers in the project can help to establish relationships for longer-term cooperative activities among participants and policy makers.

(5) Preferred Options

Data collected by Newman and Kenworthy (1999) in their Global Cities Study shows that there is almost no correlation between the wealth of a city and its per capita use (vehicle kilometers per person) of cars. Some cities have invested in good quality, fixed-rail public transport and this provides the best option for how they move the majority of people down their main corridors. The data show that where a transit system provides a faster service than the alternative route through the traffic, then people will prefer to use it. This then is the first part of the rationale – how can megacities provide a transit service that competes with the traffic system. If this can be done then not only will the citizenry have a preferred option, but it will enable that city to reduce their global change impacts. This will occur due to reduced growth in traffic, even absolute reductions in traffic. The mechanism is not just due to modal shifts but also in preferred land use options, which reduce travel distances. The value of a quality transit option is that the city's growth can be channeled into more compact centers (less dispersion) while still having a market-based mechanism driving it.

As well as providing for the fixed transit system there is also a need for the flexible modes to link into this system and provide preferred options in local areas. A key reason why cars are so popular is that they are able to provide flexible, local options as well as fast options down fixed corridors. To provide better local options means that a city needs to provide for its local flexible, non-car modes. Thus cities which enable each station area in a sub center to be the base for easy access by walking, bike, bechuk, tuk tuks, jitneys etc, can have the best of both fixed and flexible systems. The new train in Bangkok has been associated with rapid growth in demand for small, flexible vehicles around each of the stations.

The growth in car ownership can potentially continue even though this process of reduced "*use"* of cars is occurring. There are cities, which have demonstrated this.

(6) Localized Transport Funding System

The second fundamental of how the global change agenda can be met in a liberalizing economy, is through a more localized transport funding system. The process of allowing more localized approaches, incorporating all stakeholders and with greater public participation in decisions impacting on cities, regions and localities, is also part of the liberalization approach. However it has not been applied to transportation infrastructure until more recently. The funding systems that have been heavily top down and closed to the public have sometimes provided good transit/ bike/walk options (e.g. Hong Kong) but in general the traffic engineering approach has led to a major emphasis on high capacity roads. The Newman-Kenworthy study shows that this has not had the economic outcomes that had been hoped for; indeed the cities, which have preferred transit to high capacity roads, have much reduced transport costs as a proportion of the city's wealth. Wherever there is more public input it is possible to see greater emphasis on transit, and non-car flexible modes. This is particularly obvious in the new TEA-21 approach to funding in the US and also in Europe. The localized approach appears to be of benefit to fixed transit systems and also to local solutions for flexible, non-car modes. It appears to be essential for achieving global change objectives as well as liberalizing urban economies.

This project will seek to find the application of these policy directions to the Mega-Cities and future Mega-Cities of the Asia Pacific.

(6) Relationship to Global Change Research Program

This project relates to all four of the areas defined in the research framework as follows:

- *Changes in Atmospheric Composition*

  Transport in cities is a major source of pollutants that alter the composition of the urban atmosphere, and also contribute significantly to the global atmospheric composition. The study will present data on some of the pollutants that contribute to the atmospheric composition.

- *Changes in Coastal Zones and Inland Waters*

  A substantial share of Asia's urban population live in cities located in coastal zones and inland waterways. Unrestrained growth in these coastal cities has already had severe impacts on the fragile ecology and sustainability of costal zones and inland waters. Planning of mass transit systems and zoning restrictions can help to mitigate the most detrimental impacts of urban sprawl.

- *Climate Change & Variability*

  The urban transport sector is a significant and growing source of GHGs that contributes to global change. The largest positive impact on the trajectory of growing GHGs emissions from the urban transport sector is likely to be from the mass-transit options to be examined in this study. The transport-related GHG emissions from a billion+ middle-income urban people in Asia by 2050 is very large under car intensive scenarios, and will be contrasted with the major GHG savings from the mass-transit systems suggested in this study.

- *Changes in Terrestrial Ecosystems & Biodiversity*

  The land losses from sprawling cities in Asia is already stressing the terrestrial ecosystems and threatening the biodiversity in the vicinity of these cities. This study will show how the shapes and sizes of cities and urban sprawl can be modified to reduce the detrimental impacts to terrestrial ecosystems & biodiversity.

APPENDIX 1
Major Collaborators

APPENDIX 2
Curriculum Vitae

NAME	**Peter WG Newman**
DATE OF BIRTH	20 August, 1945
NATIONALITY	Australian
QUALIFICATIONS	BSc (Hons) (University of Western Australia), 1967. PhD (University of Western Australia), 1972. Dip Env Sci & Tech (Delft), 1973.
CONTACT DETAILS	Institute for Sustainability and Technology Policy Murdoch University, Perth, Western Australia. Telephone: +61 8 9360 2902 Facsimile: +61 8 9360 6421 E-mail: newman@central.murdoch.edu.ua

PROFESSIONAL EXPERIENCE
Professor Newman's specialist fields of expertise include: development and integration of urban environmental policy, particularly as it applies to urban transport/land use interactions, appropriate technology (particularly in the areas of sanitation systems and renewables), environmental impact assessment and public participation, sustainable cities development, , ecological housing and strategic planning.

Current
Director and Professor of City Policy - Institute for Sustainability and Technology Policy Murdoch University, Perth, Western Australia

The ISTP was founded in 1988 through a West Australian State Government grant. It is now independent based on its teaching and research. There are 9 academic staff, 6 research staff, 50 PhD students and 100 MA students which makes it the biggest research institute of its kind in Australia. The ISTP does research on the overlapping areas of sustainability, innovation and human values. It manages several on-going international research projects including the global cities study (supported by the World Bank and UITP), an environmental ethics project (involving an international fund to bring an ecofeminist scholar to ISTP every second year), a project to develop a community-based waste treatment system in an Indonesian squatter town, and a project on renewable energy in Bangladesh (involving major Australian sources and the UN). In the past 5 years ISTP has attracted some $3 million in outside research funds. The ISTP teaches an undergraduate degree in Sustainable Development and an MA degree with specialities in City Policy, Ecologically Sustainable Development, Ecological Public Health, Development Studies, Public Policy and Science and Technology Policy. Its latest degree is an on-line Masters in Asian Sustainable Development developed through AusAID.

Other Appointments Previously Held at Murdoch University

Foundation Lecturer in Environmental Science 1974-1980
Senior Lecturer in Environmental Science 1980-1986
Associate Professor in Environmental Science 1986-1990

Other Relevant Professional Experience

I have worked for over twenty years on how cities can integrate environmental concerns into their urban fabric. This has been through political involvement as well as research on cities around the world gathering data on the extent of automobile dependence. My recent work emphasises case studies on cities that have begun to overcome the problems of excessive car use. I also work on sustainable urban water systems, particularly in third world cities, and on renewable energy policy issues.

I was an elected City Councillor for the City of Fremantle from 1976 to 1980 during the time it began to reverse its economic decline through emphasising its heritage and urban qualities as an alternative to Perth's glass towers and car-based suburbia. Fremantle is now seen as a model of urban revitalisation and low energy use.

I have also worked on secondment to the West Australian State Government in transport planning and environmental planning roles in the 80's and am best known for my work in helping to rebuild Perth's rail system. I have worked for the Australian Government on the Ecologically Sustainable Development process, energy research priorities (NERDDC), the State of the Environment reporting process and the Better Cities program.

I have been a consultant to OECD and the World Bank on urban policy issues, and am the author of many academic and popular publications as well as several books including "Cities and Automobile Dependence", "Winning Back the Cities" and "Case Studies in Environmental Hope". My latest book is “Sustainability and Cities: Overcoming Automobile Dependence” which was launched in the White House in early 1999.

I am a Visiting Professor at the University of Pennsylvania where I teach a Masters course on Sustainable Cities and in 1996 I was a Visiting Professor at the Royal Danish Academy of Fine Arts. I have worked at the University Pertanian Malaysia and am a Visiting Professor at Merdeka University Malang, Indonesia.

A list of the relevant Government positions that I have held are outlined below:

- **1989 - 1990**
  Director Environmental Planning and Development (Secondment)
  Office of the Cabinet
  WA Government
- **1986 - 1987**
  Adviser to the State Minister for Transport and Regional Development (Secondment)
  WA Government
- **1987 - 1989**
  Member of the Environmental Protection Authority
- **1986 - 1989**

Member of Metropolitan Planning Council

- **1987 - 1993**
  Member of the Board of Transperth

CONSULTANCY PROJECTS WITH GOVERNMENT AND INDUSTRY

- "A Review of Northern Suburbs Rapid Transit Options" for WA Government, 1988.
- "A Review of Mitchell Freeway Widening" for WA Government, 1990.
- "Urban Infrastructure" for DITAC, 1991.
- "Moving Melbourne - a Public Transport Strategy for Inner Melbourne". For Inner Metropolitan Regional Association, 1991.
- "Towards Better Cities - reurbanisation and transport energy scenarios", for DASSET and Commission for the Future, 1991.
- "Towards a More Sustainable Canberra", Canberra Business Council, ACT Government, Australian Conservation Foundation, 1991.
- "Housing, Transport and Urban Form" for Federal Department of Health, Housing and Community Welfare, 1992.
- "ASEAN Workshop on ESD" for AusAID, 1992
- "Costs and Benefits of Redeveloping East Perth", for East Perth Redevelopment Authority, 1993.
- "Transport for People with Disabilities", for ACROD, 1994
- "Wickham Urban Village - A Concept and Strategy Study", for Newcastle City Council, 1994
- "State of the Environment Report - Human Settlements", for Federal Department of Environment Sport and Territories, 1995/6.
- "Evaluation of Better Cities (Environmental aspects)" for Federal Department of Housing and Regional Development, 1996.
- "Indicators of Transport Efficiency in 37 Global Cities" for World Bank, 1997.
- "Car Free Copenhagen: Perspectives and Ideas for Reducing Car Dependence in Copenhagen", for City of Copenhagen, with Royal Danish Academy of Fine Arts, Copenhagen, 1997.
- "A Critical Review of the Fremantle Eastern ByPass", City of Fremantle, 1997.
- "An Urban Village in North Coogee", City of Cockburn and City of Fremantle, 1998
- "Can Rail Pay? Light Rail and Urban Development in the Coastal Corridor", for City of Cockburn and Fremantle Waterfront Development, 1999

MAIN PUBLICATIONS SINCE 1994

- Newman PWG and Kenworthy JR (1999) **Sustainability and Cities: Overcoming Automobile Dependence**, Island Press, Washington, DC.
- Kenworthy J., Laube F., Newman P., Barter P., Raad T., Poboon C. and Guia B. (1999), **An International Sourcebook of Automobile Dependence in Cities, 1960~1990**, University Press of Colorado, Boulder, Colorado, ISBN : 0-87081-523-7.
- Newman PWG, Kenworthy JR and Laube, F (1999) 'The Global City and Sustainability' in Brotchie J, Newton, P, Hall P, and Dickey J, **East West Perspectives on 21st Century Urban Development: Sustainable Eastern and Western Cities in the New Millenium**, Ashgate Publishers, Aldershot.

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- Newman PWG et al (1996) 'Human Settlements' chapter in **State of the Australian Environment, 1996**, Department of Environment, Sport and Territories, CSIRO Publishing, Melbourne.
- Newman, P.W.G. (1996) Transportation. Chapter in **United Nations Global Review of Human Settlements** Satterthwaite, D. (Ed.) United Nations Habitat Program Oxford University Press, Oxford.
- Newman, P. and Mouritz, M (1996). Principles and planning opportunities for community scale systems of water and waste management. **Desalination** 10 : 339-354.
- Kenworthy, J.R., Newman, P.W.G., Barter, P. and Poboon, C. (1995) Is Increasing Automobile Dependence Inevitable in Booming Economies?: Asian Cities in an International Context, **IATSS Research** 19(2): 58-67.
- Newman, P.W.G. (1994) Urban design, transportation and greenhouse, Chapter Five (pp. 69-84) in **Global Warming and the Built Environment**. Ballinger, J. (Ed), University of NSW Press, Sydney.
- Newman, P.W.G. (1994) Energy Conservation in Transport and Urban Settlements. Chapter four (pp. 76-110) in **Sustainable Energy Systems: Pathways for Australian Energy Reform** Dovers, S. (Ed.) Cambridge University Press.
- Newman, P.W.G. (1994) The Car, The Community and Quality of Life. **A Chapter in Urban and Regional Quality of Life Indicators** Mercer, C. (Ed.) Institute for Cultural Studies, Griffith University pp. 55-74.
- Ingvarson, D., Marinova, D. and Newman, P.W.G. (1994) Electronic Networking: Social and Policy Aspects of a Rapidly Growing Technology Electronic Networking Policy Aspects for Australia. **Computer Networking and ISDN Systems.** 27(3):411-418.
- Newman, P.W.G. (1994) The Transport Dilemma in Developing Nation Cities in **Social Dimensions of Development**. Jayasuriya, L and Lee, M. (Eds), Paradigm Books, Perth.

Full Vita to be submitted with the formal proposal

Charles J. Johnson

Coordinator, Environmental Studies
Head Urban and Transboundary Pollution Project
East-West Center

He holds a Ph.D. from Pennsylvania State University in minerals economics (specialization energy economics), a MS in geological sciences from the University of California, Riverside, and a BS in geology from San Jose State. His focus of research is on reducing energy-related environmental impacts through policy instruments, the introduction of advanced energy and environmental technologies and fuel switching. He has been an advisor to the US Department of Energy on Asian energy issues for the past decade, and assists in their APEC clean energy activities, including two international seminars each year, the publication and distribution of the proceedings, technical reviewer of all APEC initiated research projects through the APEC clean energy group (most recently alternative transportation fuels and CO_2 reduction strategies). He has published more than 75 papers on energy and environmental issues in Asia, plus about 150 newspaper articles and references.

He has been a consultant to the Asia Foundation, Asian Development Bank, Harvard Institute for International Development, Ford Foundation, United Nations, World Bank, UNDP/Global Environmental Facility and many private energy companies. He was previously employed by the National Science Foundation, US Treasury, Conzinc Riotinto of Australia and the Commonwealth Secretariat (London).

APPENDIX 3

Budget for the eight-month pilot project is expected to be within the $35,000-50,000 range.

APN Workshop on Urbanization, Industrial Transformation and Environmental Change

Rapporteurs' Report on Group session on GHG emissions and mega-cities

C. Sharma

The group session began with opening remarks of Prof. Imura who apprised about the various components of this project, which is being formulated to account for the first time the embodied emissions also besides direct GHG emissions. He also proposed the tentative approach and time lines for discussions by the participants. Dr Mitra emphasized the need to take into account other urban pollutants like CO, NOx & SOx besides particulate matter as those have great impacts on health as well as climate and are associated with the sources responsible for greenhouse gas emissions. He pointed out that during the forthcoming discussions, there will be need to address questions like the definition and geographical boundaries of the mega-cities which are increasingly becoming epicenter of urbanization of surrounding erstwhile non-urban areas. It will also be needed to identify suitable time periods to enable development of future scenarios based on past history of growth rate besides incorporation of various socio-economic (consumption pattern) factors.

After lunch, Prof. Imura apprised about the ICLEI's project reports and pointed out that there is not so much information available for the developing world. He also informed that about 20 cities have joined ICLEI's to reduce their CO2 emissions by 20% by 2010.

Following this, Korean, Japanese, Chinese and Indian groups made presentations and apprised about the kind of data available for Seoul, Tokyo, Beijing, Delhi and Calcutta. These groups also presented studies carried out so far, which have relevance with the present effort and have already generated quite useful database and information.

While it has been realized that lot of data already exists which can be used in this project but substantial efforts would be needed to put all the data in usable format and for their quality control & quality assurance analysis. Another significant information emerged about the importance of different sectors in different mega-cities e.g. in Seoul, it is the building sector which is important, in cities like Tokyo and Delhi, transport sector is important. It was also decided to accelerate efforts about the database generation for Shanghai and Manila.

Later on Dr Jung made presentations on the `approach of possible analysis framework' and `data-base construction' for primarily Seoul, Tokyo & Beijing. But it was agreed upon that for Delhi, Calcutta and Manila, efforts would be made to use such approach with or without modifications. Dr Yoon made a brief presentation about his research efforts in waste sector in Seoul.

After that, participants discussed about the future strategies for the development of the pilot pre-proposal to be submitted to APN before the September 2000 deadline. Various issues about the feasibility & viability of such proposal, components, selection of mega-cities, time frame, approach to be undertaken, embodied emissions, deliverables etc were discusses in great length and finally a consensus has emerged. It has been decided to concentrate efforts in seven mega-cities in Asian region namely Tokyo, Beijing, Seoul, Shanghai, Manila, Delhi and Calcutta. However, participants are welcome to incorporate other cities too.

The group had advantage of interacting with the members of transportation group and noted the apparent overlapping in the two group's efforts. However, it was made clear that this group's objectives are different than that of transport group's objectives and, therefore, approaches of the two groups will be very different. This group will be doing the more microscopic studies which would be very different from the transport group's efforts. But a close interaction will be established with transport group to get maximum benefit from their efforts.

It was decided to prepare following:

1. Draft version of -1**st** ORDER DOCUMENT by the afternoon of 14th July 2000 comprising of data and analysis presented during the meeting.
2. -1**st** ORDER DOCUMENT by December 2000. The contents and format of this proposed documents have been agreed upon and annexed here. It has been realized that at the moment, all data for all the sectors may not be available but this exercise will lead to identification of gap areas and form basis of inter-comparison and prioritization of issues.
3. Preparation of PROPOSAL for pilot study for submission to APN before September 15, 2000 seeking about US$ 80,000 per year for two years in two phases. This will include elements like inter-comparison of different mega-cities, projections for future using four different scenarios built upon past history and policy implications. It has been realized that this proposal has significant policy implications and provide information to adopt proper mitigation approaches in mega-cities which would have long term as well as short term advantages of reducing GHG emissions but also reducing air pollutants. Therefore, both climate change as well as well health related aspects would be addressed.

4. This exercise will facilitate the eventual formulation of a mega-project for submission to other international funding agencies like GEF etc by the year 2002-2003.

All the data presented during the deliberations were distributed among the group members. All of the participants resolved to continue and enhance mutual collaboration.

Workshop Agenda for GHG Budgets for Selected Megacities in Asia

Wednesday, 12 July – Friday, 14 July, 2000

1. Opening statement--- Prof. Imura and Dr. Mitra
2. Introduction of the participants
3. Draft Research Plan --- Prof. Imura
4. Review of the Relevant Works --- H. Imura
   (1) Existing Studies on Municipal GHG Budgets for Japanese Cities
   (2) ICLEI's Project on Municipal GHG Budgets
   (3) Others
   Review of the Relevant Works --- A.P. Mitra
5. Preliminary Study Information
   - Seoul--- Dr. Tae Young JUNG, Dr. Euiyoung YOON and Dr. Sunghan JO
   - Tokyo --- Dr. Shinji KANEKO
   - Beijing (1) (Commercial and Residential Sector)
     --- Prof. Zhihong WEI and Dr. Deliang TONG
   - Beijing (2) (Urban Transport Sector) --- Prof. Kebin HE
   - India and Southeast Asian Cities
     --- Dr. Sharma (Delhi) and Mr. Dasgupta (Calcutta)
6. Analysis Framework and Data Collection
   - A proposal of a possible analysis framework --- Dr. Tae Young JUNG
   - Proposals and suggestions on data collection
   - Comments and free discussion
   - Wrap-up and summary
7. Revised Research Plan and Future Schedule
   - Discussion and approval
8. Closing

Report on the Feasibility Study for Climate Change and Water Resources for Asia Pacific Cities.

Richard Berk
Chris Cocklin

March, 2001

Introduction

Of the potential effects of climate change, the implications for water resources are among the most important to society. An adequate supply of potable water is essential for human habitation. In many parts of the Asia Pacific, the demand for consumptive (e.g., water supply) and non-consumptive (e.g., navigation, hydroelectric power generation, industrial cooling, instream flow) uses of fresh water is barely balanced by sustainable surface and groundwater. Climate change will almost certainly further complicate matters.

In October 1999, the APN convened a workshop in Kobe on the prospects for climate and other environmental change research with a focus on policy and human-dimensions relevant to the Asia Pacific region. As an outcome of that workshop, a pre-proposal was submitted to the APN that provided a rationale and research design for a study of the impact of global and regional climate change on the water resources of Asia Pacific cities. In July 2000, a second APN-sponsored workshop was held in Kobe to refine that pre-proposal, and the APN has since provided seed money to explore the feasibility of the proposed research. This is brief report on that feasibility study.

Goals of the Feasibility Study

If one is going to study the links between climate change, the hydrological cycle, and water resources in Asia Pacific Cities, data availability and quality are critical. While the extant scientific knowledge is considerable, the theory is insufficiently precise or complete to allow modeling of the all of the relevant physical, biological and social processes. Consequently, most of the key relationships need to be examined empirically.

At the meeting held in Kobe in July 2000, members of the water resources working group agreed that a feasibility study was needed in a number of Asia Pacific cities to determine data quality and availability. These initial explorations were to be undertaken in the following cities: Kobe, Tianjin, Bangkok, Bandung, Suva, Singapore, Karachi, Phnom Pen, Kuala Lumpur, chosen to represent a range of climate regimes, water delivery systems, and local institutions. In each city, a member of the group or a local colleague would try to determine the availability and quality of data on the follow data types.

1. Climate data (e.g., precipitation, temperature, wind speed and direction, etc)
2. Water transport data – how the water is moved from place to place (e.g., pipes, aqueducts, etc)
3. Water use for different user types – residential, commercial, industrial, agricultural, and so on (e.g., total household water use by month)

4. Water losses (e.g., from leaks, evaporation, water theft)
5. Water quality data (e.g., salinity, suspended solids, heavy metals, haloforms, natural organic matter, bacteria)
6. Runoff volume and quality (e.g., measures of flow from storm drains)
7. Wastewater volume and quality (e.g., at sewage treatment plants)
8. Land use and land cover (e.g., digitized maps showing green space)
9. Water sources in addition to precipitation (e.g., use of ground water, water imported from rivers or reservoirs)
10. Institutional setting and regulations (e.g., who is responsible for providing water to city residents and how is it priced)
11. Functioning of ecosystems
12. Public health

For each data types the following data attributes would be explored.

1. Units (e.g., total cubic meters per month, total millimeters per hour)
2. Spatial span – the geographical areas are represented (e.g., the entire city)
3. Temporal span – the time periods are represented (e.g., 1970-2000)
4. Spatial scale – the spatial units (e.g., by city district)
5. Temporal scale – the temporal units (e.g., by month)
6. Holes in the data – for what data types, locations, and time periods might the data be incomplete or missing?
7. Errors in the data (e.g., amounts of ground water used are only rough estimates)
8. Media on which the data could be provided (e.g., diskettes, GIS electronic files, web-based downloading)

With the resources provided by APN, it would not have been practical to try to actually collect samples of data from each site, let alone collect all the data one might use to do the research. Aspirations were far more modest: to determine in principle what data were available and what its likely quality would be. By and large, we were able to collect useful information on these issues and overall the news is encouraging

- Kobe --- With the generous assistance of the Asian Urban Information Center of Kobe (AUICK), we were able to determine that data of excellent quality appear to be available for at least two decades on data types 1-10. Data type 11 (ecosystems functioning) is also available, but on a case by case basis. Data type 12 (public health) still needs to be explored in part because data on water borne diseases is generally not available except for very serious illnesses, which are rare Kobe. AUICK was also able to actually provide substantial amounts of data of just the sort one would use for the research. Preliminary study of the data indicates that it is of wonderful quality.

- Singapore --- We have some data samples and extensive information, all to the effect that the data are likely to be excellent. Coverage and quality is much like in Kobe. Data access seems not to be a serious problem.

- Bangkok --- While we do not have meaningful samples of the data, it appears that the coverage in Bangkok has data much like Kobe's. That is, there look to be useful information on data types 1-10 routinely available and reasonably complete. Without actually collecting the some of the data, however, it is difficult to know for sure and there is reason to be a bit concerned about data comparability over time. Still, the prospects are good.

- Klang Valley/Kuala Lumpur --- We have no data samples, but the data appear to be much the same as available from Bangkok. So, here too the prospects are good.

- Karachi --- The final evaluation is not yet complete. It is clear that there are good climate data and that with some effort, helpful data on water resources will be available. This is one site where public health data would be especially important, but what exists may be not be very good. We are still checking.

- Bandung --- We have made initial contacts, but have yet to get the information needed. We remain very hopeful.

- Phom Phen ---- We have made initial contacts, but have not yet been able to determine data availability and quality. We remain hopeful, but the local politics are complicated

- Tianjin --- There seems to have been some miscommunication with our local contact, and we have at this point no concrete information. In principle, excellent data should be available, and we have been assured informally that such is the case.

- Suva --- The data inventory was delayed by political instability in Fiji during 2000. However, a member of staff the University of the South Pacific has recently been involved in the study and is in the process of assessing data availability and quality.

In summary, there is good evidence that the research we propose could be usefully undertaken in Kobe, Singapore, Bangkok, Kuala Lumpur, and Karachi. At those cites, data items 1-10 are likely to be of good quality and available. We remain optimistic about the other sites, where in two cases (Bandung and Phem Phen) we have been delayed by the need to establish better local contacts (but not for lack of trying), and in two cases we simply have not been able yet to get much useful feedback, though Fiji now looks promising. We suspect that in all four instances, instructive data exist. The problem has been access.

However, data on ecosystem impacts are likely to be problematic, or if available, will be so on a case by case basis. Public health data will also be problematic. Data on water borne disease is not likely to be routinely available because such diseases are either not a serious problem, or because the existing records are inadequate.

It is important to stress that with the exception of Kobe and (partly) Singapore, we have not actually collected any data. That was not part of our mandate nor were there time and resources to do the work required. It will almost certainly be the case, therefore, that some complications will surface should we proceed with data collection. For example, for some data in some locales and time periods, data that should be available will be lost or misplaced. Or, the ways in which the data were collected will change over time so that longitudinal comparisons will be more difficult (e.g., changes in spatial or temporal units). Or, on close inspection, we will find errors or other unexplained anomalies. While our work to date suggests that such problems will not pose insurmountable obstacles, they will certainly complicate the data analysis.

<u>Other Activities</u>

There seems to be great interest in our proposed research. Examples include the following.

1. A proposal to follow-up on the feasibility study was submitted to APN in time for their fall deadline.
2. Berk gave a talk on the project at Yale University in October 2000.
3. Berk and Cocklin were invited to write a short article on the project for the IHDP Newsletter. The article appeared in the January, 2001 edition with several other articles on water resources.
4. Cocklin gave a plenary talk on the project at a conference in Thailand on Global Environmental Change and Sustainable Development in February 2001.
5. Berk and Cocklin submitted an abstract on the project for the Open Sciences Meetings being held by the IGBP in Amsterdam in July of 2001. Since the abstract was invited, it seems likely that a paper on the work will be presented at a session on water resources and climate change.
6. Based on the work completed to date, Berk has been invited to participate in workshop at the Fred J. Hansen Institute for World Peace, at San Diego State University, on "Assessment of the Impact of Vulnerability to Global Change of Regional Water Resources: a Cooperative Program with India, Pakistan, Bangladesh, and Nepal," to be help the end of April, 2001.

Outline for the Workshop on Climate Change and Water use in Asian-Pacific Cities

Richard Berk
Meg Keen
Chris Cocklin

June, 2000

Attached is a draft of the concept paper written by Richard Berk and Meg Keen to conduct research on climate change and water resources in Asian-Pacific Cities. The premises of this concept paper are important. All follow from the "mission-oriented" nature of the proposed work. In particular, there are important empirical questions to be answered about climate change and water use that will require a wide range of expertise, technical skills, and backgrounds. It follows, therefore, that the interests and concerns of natural scientists, social scientists and policy makers will be linked in manner that will be highly interdisciplinary. In the same spirit, there will be the need for some collaborators who have in-depth knowledge about particular research sites and for some collaborators who are generalists. Likewise, both "hard" and "soft" data will be required. Finally, the proposed research is organized into phases because there will be the need for refinements as the enterprise proceeds. This workshop is the initial refinement exercise.

While the agenda for the workshop is subject to revision, especially during the workshop itself, listed immediately below is a set of topics that will need to be addressed, organized in approximate chronological order. The order is similar to the order of topics in the proposal. The "deliverables" at the end of the workshop will be 1) a series of concrete suggestions for revising of the concept paper and 2) a set of specific activities for implementing the pilot study, 3) suggestions for possible organizational structures in which to house the proposed research.

I. Overview of the Concept Paper (Wednesday --- 11:00 – 12:30)
   A. Theme – integrating human activities into the natural water cycle in the context of climate change
   B. Policy Concerns – water sustainability
   C. Staging
      1. Development
      2. Pilot Research
      3. Full Scale Research,
      4. Dissemination
   D. Research Design

II. Nature of the Research and Policy Problem (13:30-15:30)
   A. Current Issues in Water Resources in Asian-Pacific Cities
   B. Possible Impacts of Climate Change

III. Integrated Assessment as an Organizing Framework (15:45–16:15)
   A. Integration of causal processes involving physical, biological and human processes

B. Integration over temporal and spatial scales
C. Integration across traditional academic disciplines
D. Integration of research and policy concerns
E. Immediate application: linking climate, hydrology, water supply infrastructure, water demand, water use, and water disposal
    1. where both the quantity and quality of water are important
    2. where there are quality of life implications (e.g., public health, regional economic health)
    3. where there are implications for wildlife and ecosystems

IV. Climate Models and Future Climate Scenarios (16:15-1700)
A. Modeling outputs: temperature and precipitation on a regional scale
B. Ideally, by season.
C. Ideally, estimates not just of average tendencies, but variability and extreme events.
D. What is likely to be available in practice?
E. Links to temporal and spatial scales of other processes (hydrology)

V. Research Design (Thursday, all day: 9:30-10:45 11:00-12:00, 13:00-15:00, 15:20-1700)
A. Data Requirements
    1. What needs to be measured, in principle?
    2. Temporal and spatial scales, in principle
    3. Practical and cost constraints
B. Potential Data Analyses
C. Site Selection
D. Time and Costs

VI. Pilot Study over the next 18 Months (Friday --- 9:30-10:45, 11:00-12:00)

VII. Staffing the Pilot Study (13:00-15:00)

APN Workshop
Urbanization, Industrial transformation and Environmental Change
(12-14 July, 2000, Kobe, Japan)

Water Group Discussion
(July.12, 11:00-15:30)

Participants: R.Berk, C.Cocklin, J. Connell, A. Gupta, M.S. Kaosa-Ard,
K.S.Low, A.Rahman, K.Sukasum, R.S. Wang, D.Yates
R.Rockwell

I. Key issues

1. Boundaries & Watersheds
2. Scale – Time & Space
3. Supply and Demands
4. Modeling and Data
5. Quantitative and Qualitative infor.
6. Which cities?
7. First hand data!
8. Policy
9. Change in cities
10. Unintended consequences
11. Sustainability
12. Human activities
13. Comparative advantage
14. Sectorial division
15. Ecosystem service
16. Exogenous

II. Research questions

1. Water supply (quantity)
a. natural
b. transport
c. allocation (structural and non-structural)
d. imports
e. reuse
f. water loses
g. desalinization

2. Water quality
a. application
b. treatment
c. waste water
d. storm water
e. re-use (downstream issues)

3. Water Use
a. Human use (agriculture, domestic, industrial,recreation)
b. Ecosystem service
c. Instream vs. offstream (withdrawal/non-withdrawal)
d. Non-water related activities (impacts on quality)
e. Technological innovation (water efficiency)
f. Institutional reform (policy, pricing, education)
g. Life style change
h. Defensive use (eg. salt water intrusion, substance)

4. **Justice/equity**
   a. accessibility (quality, quantity)
   b. pricing & subsidies
   c. spatial characteristics of disadvantage
   d. water as a human right
   e. across border issues (upstream/downstream)

5. **Public Health**
   a. chronic vs. acute
   b. infection vs. contamination
   c. influence of climate change

6. **Environmental consequences**
   a. aesthetics
   b. ecosystem health
   c. geographical / geotechnical consequences

7. **Governance**
   a. private vs. public ownership
   b. access/use rights
   c. pricing
   d. across-boundary
   e. institutional structures
   f. infrastructure provision
   g. policy, legal structure, administration
   h. data/information

III. Data Availability of candidate cities

	Ka--rach	Bang-kok	Kuala Lun-mpur	Singa-pore	Tian-jin	Port More-sby	Tara-wa	kobe	Jakata
Climate									
Transportation data									
Gross water use									
Gross water quality									
Institutional setting									
Stormwater / runoff									
Output quality									
Public health(infectous disesece									
Land use /land cover									
Water source									

IV. Case Study Selection criteria

a. Economic development/ water availability
b. Information availability and quality

c. Coastal vs. inland
d. Size/scale of settlements
e. Political/institutional dimentions
f. Partnering
g. Economic structure
h. Geographical distribution

V. Personal preference

a. Bangkok
b. Jakarta
c. Kobe
d. Tianjin
e. Yangzhou
f. Pt. Moresby
g. Tarawa
h. Suva
i. Uientiance
j. Phnom Penh
k. Samutprakian
l. Karachi
m. Singapore
n. Bandung

July 13, 2000 (9:30 –15:30)

VI. Academic questions

1. Natural Science:

How does Climate change affect water supply and water process (impact and footprint)

a. How would climate change & affect the water balance of the city, the region, the conceqwent effects on water supply (quantity and quality) and water related process?
b. How do the changes and process vary according to location and other aspects of physical and geographical context (what cities are especially valuable)?
c. How do these changes and process vary according to landuse and other aspects of anthropogenic activities?

2. Social Science:

a. What are the vulnerability of urban populations and societies at large to climate change included variation in water availability and processes?
b. What are the social and institutional capacities to adapt to or mitigate the effects of the change?
c. What recommendation can be made in terms of policy and management to realise the opportunities to adapt to or mitigate the changes? (incl. Especially opportunities for cross-national collaboration and cooperation)

VII. Selection Criteria

a. Data availability
b. Coastal vs. inland
c. Size/scale of settlements
d. Political/institutional dimentions
i. Partnering
j. Economic structure

k. Geographical distribution
l. Climate regimes

VIII. Sites

a. Kobe
b. Tianjin/Yangzhou
c. Bangkok/Chiangmai
d. Jakata/Bandung
e. Suva
f. Singapore
g. Karachi
h. Phnom Penh

Elements	Attributes
Climate	Units Time span Spatial scale Holes Errors Media
Transport	
Gross water use	
Gross water quality	
Storm water / runoff	
Output quality	
Public health	
Land use/cover	
Water source	
Water loses	
Institutional setting	

30 year minimum data

	Karachi	Bangkok	K.L.	Singapore	Tianjin	Port Morsby	Tarawa	Kobe	Jakarta
Climate data (temporal, spatial scales; accuracy and precision)	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
Transport (infrastructure) data (output for treatment plant)	**X**	**X**	**X**	**X**	**X**			**X**	**X**
Water source and data (gw, surface), gross water use	**X (s)**	**X (p)**	**X (p)**	**X (p)**	**X (s)**	**X (p)**	**X (p)**	**X (p)**	**X (s)**
Gross water quality (several constituents)	**X (s)**								
Institutional, pricing mechanisms (billing, rights)	**X**								
Storm water and runoff	**X**	**X**							
Output quality (front end of reuse) waste water quality									
Public health	**P**								
Land use/land cover data	**X**								
Water source	**X**								
Water losses	**X**								

Case study selection criteria

- Economic Development / Water Availability (climate regime)
- Information Availability and quality
- Coastal vs. inland
- Size (small, medium, large)
- Political/institutional dimensions
- Partnering
- Economic structure
- Geographic location (spread)
-

Personal preferences

Bangkok, Jakarta, Kobe, Yang Zhu, Tianjin (medium sized), Vientiane, Port Morsby, Tarawa, Phnom Penh, Samutpranka, Karachi, Singapore.

Agenda for the Workshop on Climate Change and Water use in Asian-Pacific Cities

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Report on
Workshop on Transportation in Asian-Pacific Cities

As cities grow and develop economically, transportation assumes a larger role as a source of air pollution and greenhouse gas emissions. Just as in many cities of North America, automobile transportation is already a serious environmental concern in many cities in the Asia-Pacific region, and there is every reason to expect this concern to rise as these cities grow and develop. That will certainly be true unless these cities find alternatives to the trajectory of development of transportation systems upon which they are now embarked, which is often closely tracking the North American trajectory of automobile-dependent cities.

This workshop was the first meeting sponsored by APN in which industrial transformation, environmental changes, and transportation in cities were considered from the viewpoint of formulating a collaborative, international research project. There have been many meetings about transportation systems, to be sure, but this workshop was able to raise an interesting set of new questions:

a) What is the state of urban transportation in the growing and new cities of the Asia-Pacific region?

b) What are the global, regional, and local environmental consequences of the current transportation systems (or of the lack of systems)?

c) Are these systems acceptable as they stand from an environmental point of view, or if not, are they susceptible to re-engineering or must new systems be invented?

d) What are the economic costs and benefits of the current systems? Why have these systems been chosen or been implemented by default?

e) What planning is being done for urban transportation in the near and medium-term future, and is this planning explicitly taking into account the impacts of urban transportation upon the global environment?

f) What are the sources of funding for urban transportation projects, and what role does global environmental change play in the agendas of those funding agencies?

g) What are the options for future transportation projects (citing environmental and economic costs and benefits of each option)? How do these options differ when taking into full account the differences among cities in the region?

h) To what extent does the liberalization of Asian economies contribute to environmental degradation, and to what extent does it create opportunities for mitigation of the environmental impacts of urban transportation?

This is a set of questions that overlaps the agenda of the urban gases project but extends beyond it. Specifically, it takes policy as a subject for research and examines how policy is made, implemented, and evaluated. The project leader, Professor Rockwell, believes that a viable proposal to APN may be based upon these questions.

Agenda for Transportation Workshop

Wednesday, July 12

0900-1000	Registration
1000-1100	Plenary

Transportation Group Session

1000-1130	Self introductions
1130-1230	Overview of research questions
1200-1300	Lunch
1330-1700	Specification of critical research questions
1830-	Reception

Thursday, July 13

0930-1200	Status and scope of current research on urban transportation and its impacts
1200-1300	Lunch
1300-1500	Identification of questions not being adequately addressed for the region
1500-1700	Preliminary design of an APN research program

Friday, July 14

0930-1200	Concrete proposals for APN research program
1200-1300	Lunch
1300-1500	Report(s) written
1500-1700	Next steps