A Comparative Study on Urban Transport System and Related Environmental Impact in Asian Mega-cities: Beijing, Shanghai and Tokyo

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Workshop of IGES/APN Mega-city Project
Policy Integration Towards Sustainable Urban Energy Use for cities in Asia, 4-5 February, 2003 in Honolulu
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1. Introduction
Introduction

■ Rapid urbanization
  ➢ Urban population grows at a rate of 3.6% in Asia and 5% in China

■ Development of megacities in East Asia region
  ➢ Tokyo: the largest city in the world
  ➢ Beijing and Shanghai: the largest cities in China, and have significance on Chinese economic and social development
  ➢ Seoul: has 10.3 million residents, one-fourth of the national population
# Introduction

## Socioeconomic characteristics of the study cities, 2001

<table>
<thead>
<tr>
<th></th>
<th>Beijing</th>
<th>Shanghai</th>
<th>Tokyo</th>
<th>Seoul</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>GDP/capita (US$)</strong></td>
<td>3060</td>
<td>4500</td>
<td>32700*</td>
<td>8870*</td>
</tr>
<tr>
<td><strong>Population (million)</strong></td>
<td>13.6</td>
<td>16.0</td>
<td>26.4</td>
<td>10.6</td>
</tr>
<tr>
<td><strong>Population Density (pop./km²)</strong></td>
<td>2526</td>
<td>2872</td>
<td>5384</td>
<td>9285</td>
</tr>
<tr>
<td><strong>Vehicle Ownership (per 1000 capita.)</strong></td>
<td>110</td>
<td>48</td>
<td>450</td>
<td>222</td>
</tr>
<tr>
<td><strong>Journey frequency (times/pop. Day)</strong></td>
<td>1.80 (1986)</td>
<td>1.79 (1986)</td>
<td>2.8 (1988)</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>2.20 (2000)</td>
<td>1.95 (1995)</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td><strong>Percentage of Journal for Work (%)</strong></td>
<td>30.2 (1986)</td>
<td>27.7 (1995)</td>
<td>16.0 (1998)</td>
<td>-</td>
</tr>
<tr>
<td>By Private Transport (%)</td>
<td>-</td>
<td>1</td>
<td>29</td>
<td>-</td>
</tr>
<tr>
<td>By Public Transport (%)</td>
<td>-</td>
<td>37</td>
<td>49</td>
<td>-</td>
</tr>
<tr>
<td>By Motorcycle, Bicycle and foot (%)</td>
<td>-</td>
<td>62</td>
<td></td>
<td>-</td>
</tr>
</tbody>
</table>

* National level
Work Targets

- Compare urban and transportation system among these four megacities
- Study the energy and environmental impacts of transport system in the three East Asian megacities
- Provide suggestions for the development of sustainable transport system
2. Urban Transportation System
Vehicle population

A. Vehicle population (1000 units)

- Beijing
- Shanghai
- Tokyo
- Seoul


Vehicle population range: 0.0, 1000.0, 2000.0, 3000.0, 4000.0, 5000.0, 6000.0

Vehicle ownership per 1000 person Vs. GDP per capita

Beijing: $k = 0.0654$

Shanghai: $k = 0.0115$

Tokyo: $k = 0.0011$

Seoul: $k = 0.0305$
Urban transport infrastructure - Road

Road area (km²)/person

- Beijing
- Shanghai
- Tokyo
- seoul

Urban transport infrastructure-Road

Vehicle population/km road length

- Beijing
- Shanghai
- Tokyo
- Seoul

Urban transport infrastructure - Railway

Comparison of Subway

<table>
<thead>
<tr>
<th>City</th>
<th>Total Length (Km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tokyo</td>
<td>248.7</td>
</tr>
<tr>
<td>Seoul</td>
<td>134</td>
</tr>
<tr>
<td>Beijing</td>
<td>55.1</td>
</tr>
<tr>
<td>Shanghai</td>
<td>65.0</td>
</tr>
</tbody>
</table>
Beijing’s Urban railway plan in 2008

the total urban railway length will be 252 km
Growth of Tokyo Railway

Source: Tokyo Urban Transport, Akio Okamoto
Road and Subway system in Seoul

- Intercity freeway
- Urban freeway
- Roads
- Subway
Public transport system

Public transport volume (billion person.times)
3. Energy and Environmental Impacts
Energy and Environmental Impact

- Oil consumption
- $\text{CO}_2$ emission
- Pollutants emissions
  - $\text{NO}_x$, CO, HC, PM$_{10}$, SO$_2$
Fuel economy level of new cars

Japan
Beijing

[Graph showing fuel economy levels for cars of different weights in Japan and Beijing.]
Age distribution of Cars in Beijing

Vehicle population (10^4 units)
Age distribution of Cars in Shanghai
Age distribution of Cars in Tokyo

- VP (10^4 units)
- vehicle age
- year

- 1987
- 1989
- 1991
- 1993
- 1995
- 1997
- 1999
- 2001
- 2003
- 2005
- 2007
- 2009
- 2011
- 2013
- 2015
- 2017
- 2019
- 2020

- 1987
- 1988
- 1989
- 1990
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- 2009
- 2010
- 2011
- 2012
- 2013
- 2014
- 2015
- 2016
- 2017
- 2018
- 2019
- 2020
Fuel consumption

Fuel consumption (Million tons)

- Beijing
- Shanghai
- Tokyo

[Graph showing fuel consumption trends for Beijing, Shanghai, and Tokyo from 1995 to 2020]
In 1995, the oil consumption per vehicle in Beijing and Shanghai is about 10 times that in Tokyo.

In 2020, it will be 2-3 times.
CO$_2$ emission (10$^3$ tons)
Annual CO₂ emission per unit

Annual CO₂ emission per vehicle (ton)

- Beijing
- Shanghai
- Tokyo


Emission levels from 0.0 to 5.0 tons per vehicle.
Comparison of vehicle emission share-NO\textsubscript{x}

NOTES:
The largest contributor is different among the cities:
- Large truck in Beijing
- Small bus in Shanghai
- Small truck in Tokyo
Comparison of vehicle emission share-CO

NOTES:
- Great contribution of cars
- Obvious MC’s emissions
Comparison of vehicle emission share-$PM_{10}$

NOTES:
Absolutely the largest contributor-Large truck
4. Conclusions
For urban transport system

- **Beijing and Shanghai**
  - Rapid increase of traffic volume
  - Greater pressure
  - Gradual decline of urban public transport
  - Laggard urban railway construction

- **Tokyo**
  - Perfect urban railway system
  - The development of road transport seems to be stable

- **Seoul**
  - Develop trend is slowed down
For fuel consumption and CO\textsubscript{2} emission

- With only 1/10 of Tokyo’s fleet, Beijing and Shanghai’s fleet tend to consume equivalent amount of oil and emit amount equivalent CO\textsubscript{2}
  - Improve fuel economy
  - Develop urban transport, especially large-scale public transport
  - Adjust transport structure
For pollutants emission

- Smaller vehicle fleets produce much more emission amount in Beijing and Shanghai
  - Further reduce the VMT of vehicles
  - Strengthen control of in-use vehicles
- Different emission issue in the cities
  - Small bus and motorcycle in Shanghai
  - Small truck in Tokyo
  - Large truck in all the cities, especially for its PM emission
5. Future work

- Improve the data
- Improve the scenario
- Complete the Seoul case in the simulation
- Improve the methodology by integrating urban transport plan in the computation
Thanks!
Growth of total civil motor vehicle population in Shanghai
Methodology

2. Vehicle Growth rates by Type (2000-2020)

4. Average Vehicle Emission Factors by Type (2000)
5. Deterioration level
6. Average Vehicle Mileage by Type (1980-2020)

7. New Vehicle Fuel Economy by Type (1980-2020)
8. Average Vehicle Fuel Economy by Type (2000)
9. Average Vehicle Mileage by Type (1980-2020)

- Vehicle Population of New Vehicle by Type (1980-2020)
- Vehicle Age Distribution (1980-2020)
- Average Vehicle Emission Factors by Type (1980-2020)
- Average Fuel Economy by Vehicle Type (1980-2020)
- Vehicle Emission of Each Pollutant by Vehicle Type (1980-2020)
- Fuel Consumption by Vehicle Type (1980-2020)
- Total Vehicle Emission (1980-2020)
- Total Fuel Consumption (1980-2020)

S and C Content of Fuel
Please Readme First!

**INPUT**

1. Vehicle Population
2. Fuel Specification
3. Fuel Economy
4. Emission Factors

**GRAPHIC**

1. Vehicle Population
2. Fuel Consumption
3. Pollutants Emission

**COMPUTE**
基准年(1999)排放及浓度贡献(6)
基准年(1999)排放及浓度贡献

1999年北京城八区 NO2 浓度分布等值线图（ug/m3）