



East-west Center, Honolulu, HI, USA
Feb. 4-5, 2003

Lifestyles and Energy Consumption in Households

Toru Matsumoto
The University of Kitakyushu

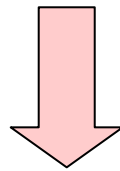
CONTENTS

1. Introduction
2. Lifestyles and energy consumption
3. Modeling for energy demand of res/com sectors
4. Projection of energy consumption and CO₂ emission
5. Future directions

1. Introduction

Introduction

- ✍ Further expansion of Asian mega-cities
- ✍ Urbanization
- ✍ Increase in per capita income



synergistic effect

Energy consumption by residential and commercial sectors will drastically increase.

Not even considering air pollution issues in urban areas, urban activities hold an important key for future global warming issues also.

Comparison of 4 Cities on Population, Area and Population Density

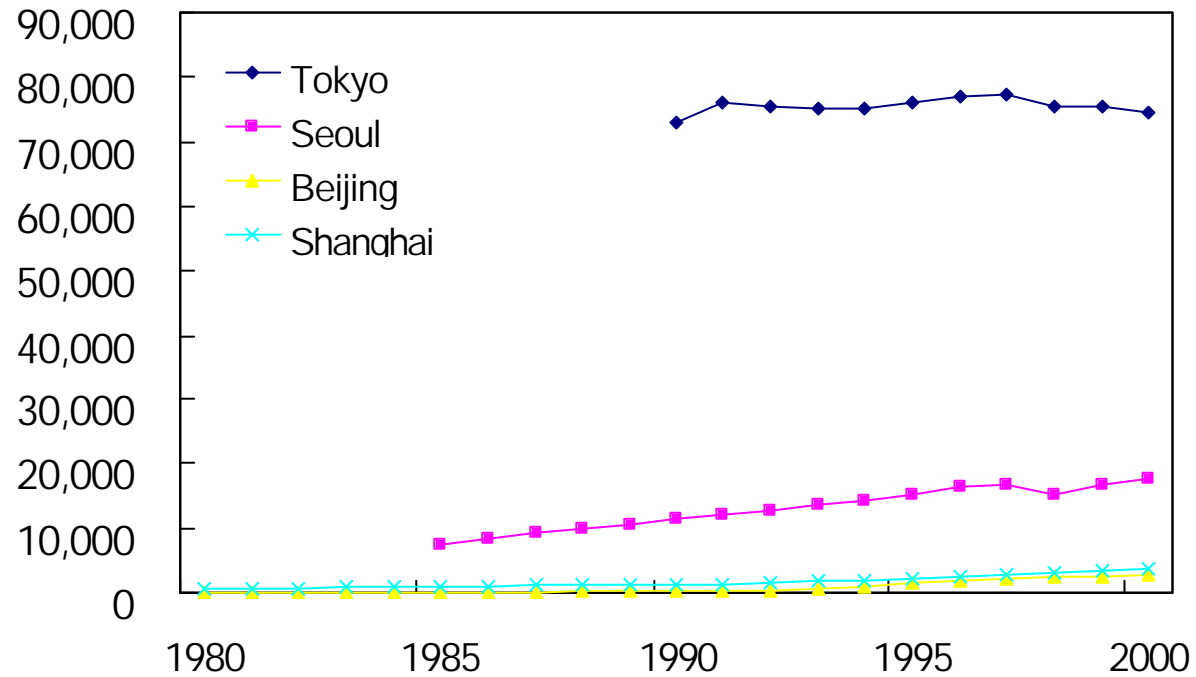
	Tokyo	Seoul	Beijing	Shanghai
Population (10^3)	12,059	10,373	12,780	13,216
Area (sq.km)	2,102	606	16,808	6,341
Population density (persons/sq.km)	5,737	17,132	760	2,084

Data Source: Tokyo Statistical Yearbook 2001, Statistical Yearbook Seoul 2001, Statistical Yearbook of Beijing 2001, Statistical Yearbook of Shanghai 2001.

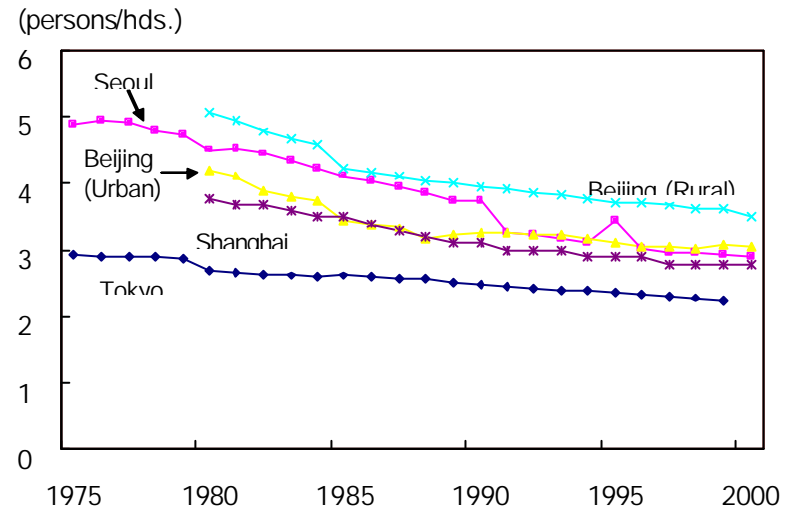
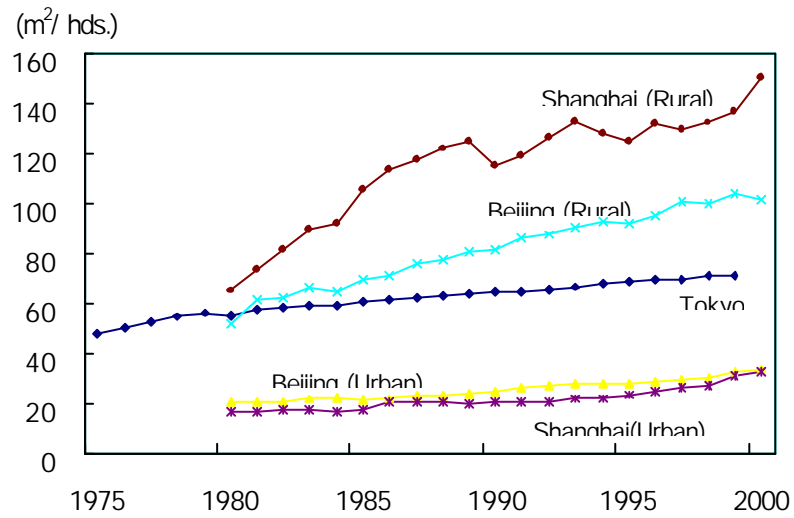
2. Lifestyles and Energy Consumption

Trends in GRP per Capita

(USD at 1995 price)

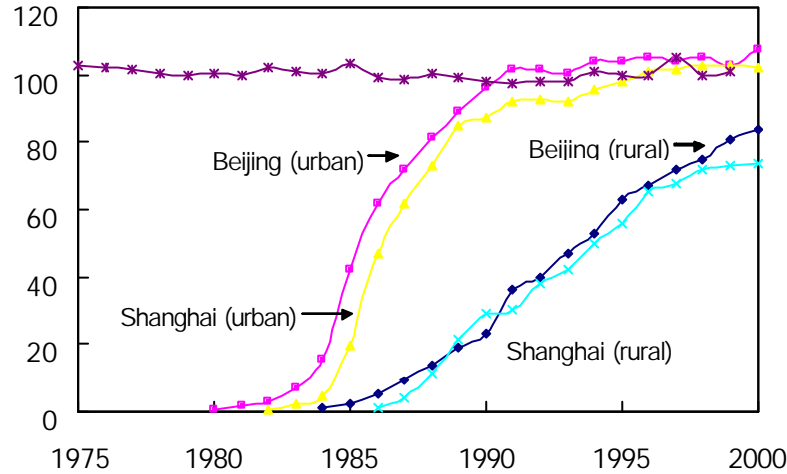


Trends in Flour Space and Size of Household

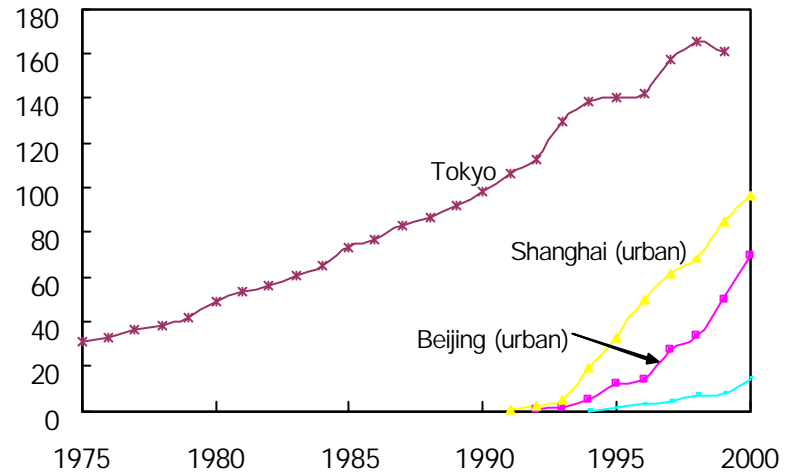


Trends in Ownership Rate of Home Electric Appliances

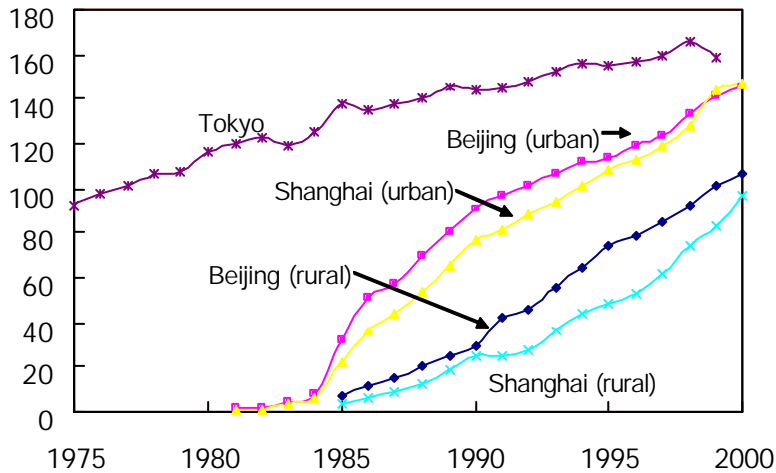
Refrigerator (/ 100 households)



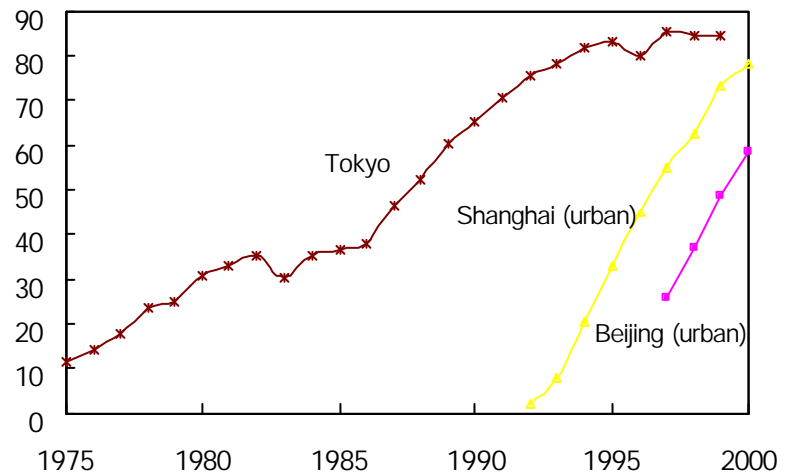
Air condition (/100 households)



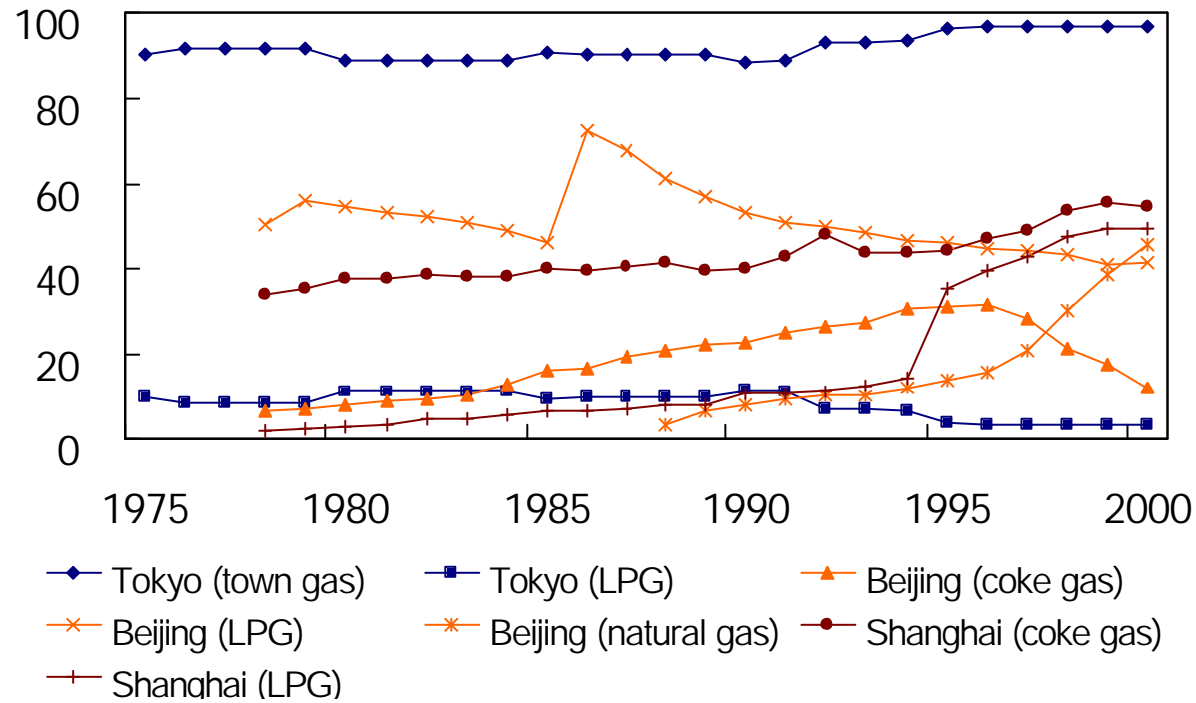
Color TV (/100 households)



Microwave oven (/100 households)

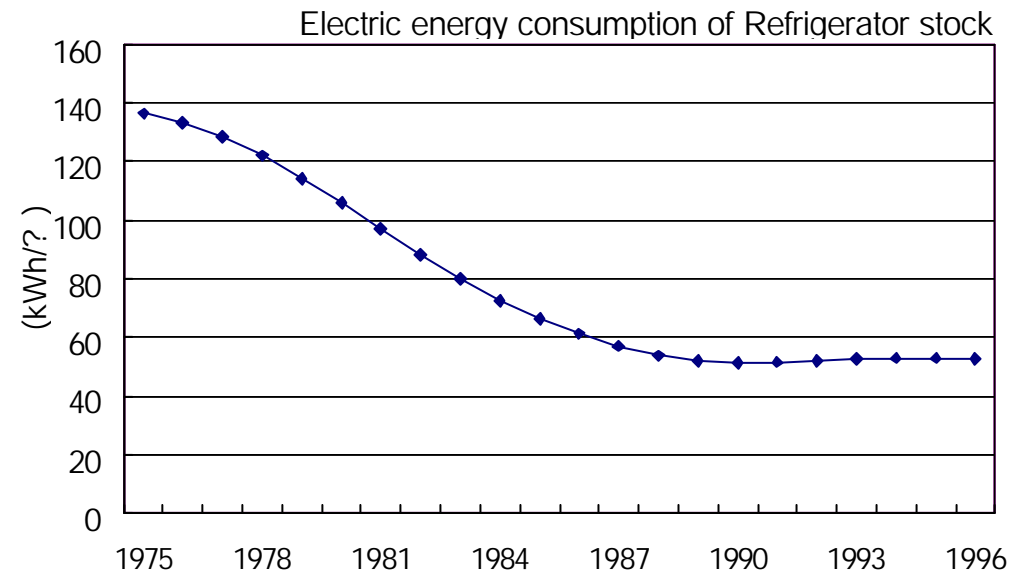
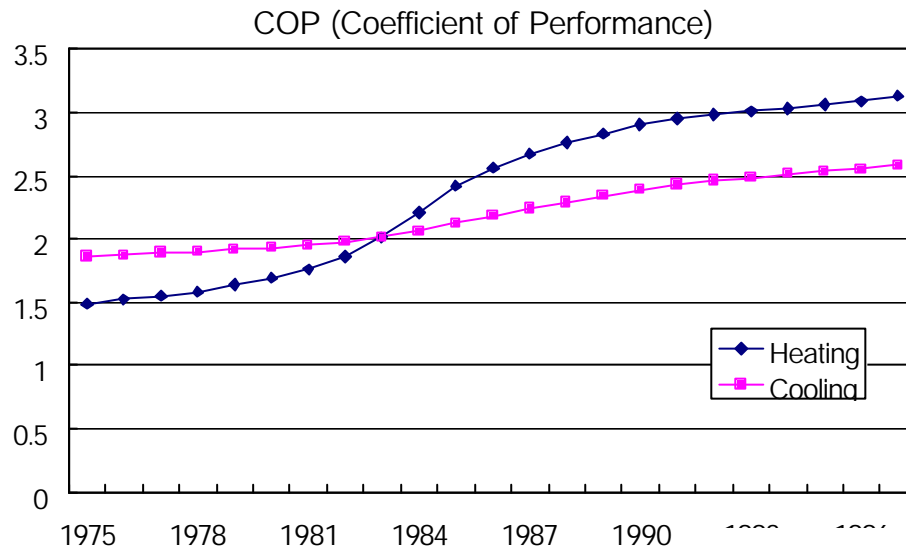


Trends in Share of Household Using Town Gas and LPG



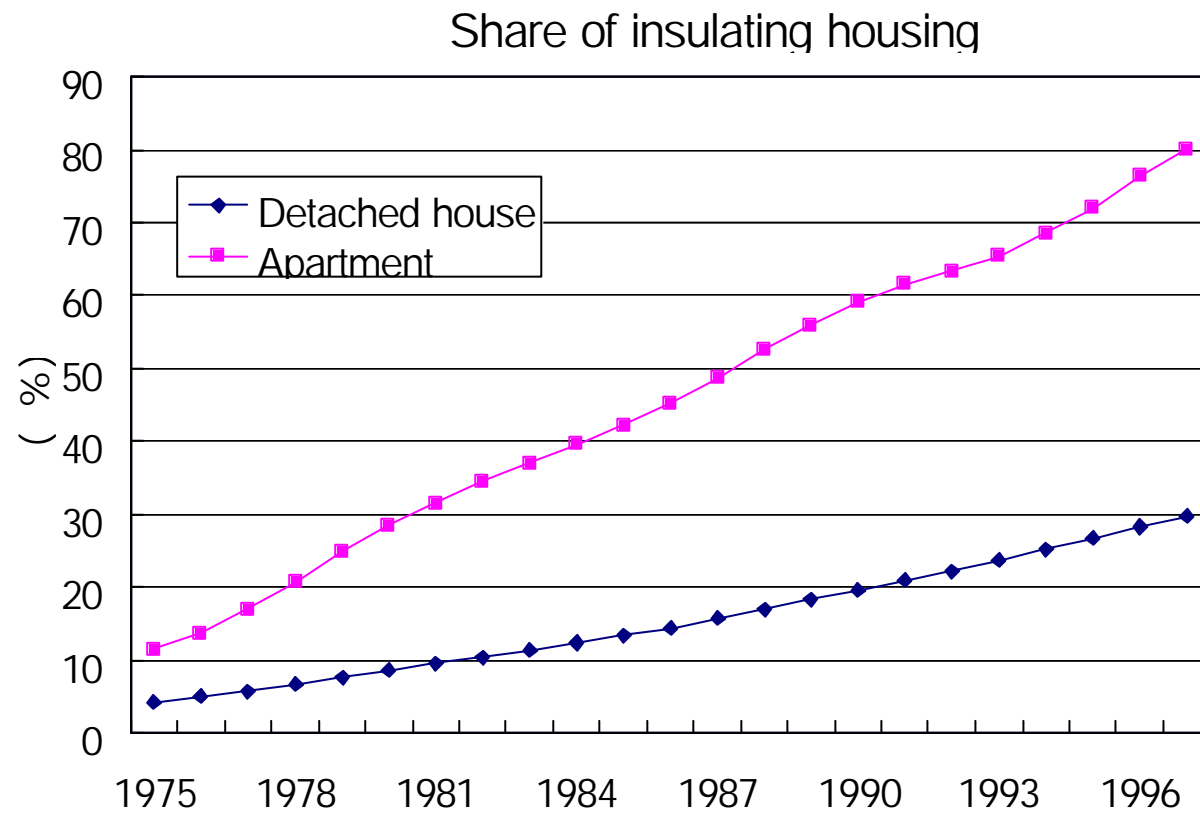
Trends of Energy Efficiency

(case of Tokyo)



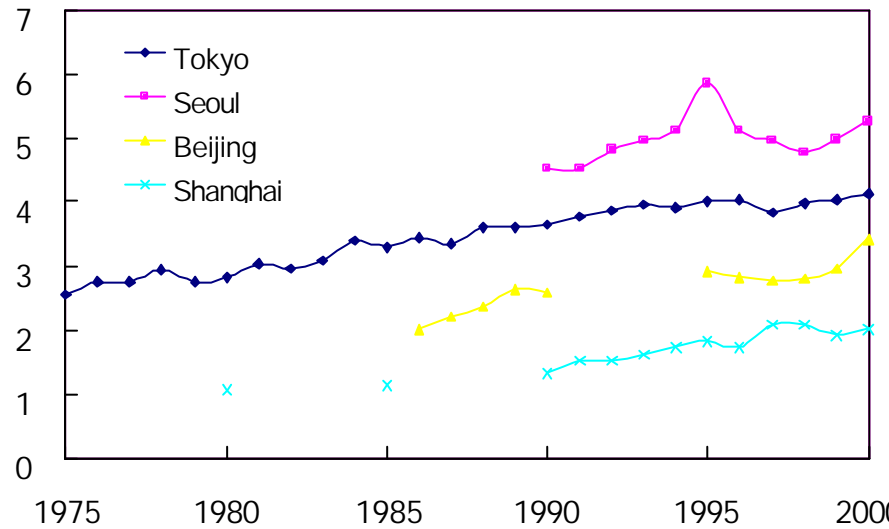
Trends of Housing Property

(case of Tokyo)

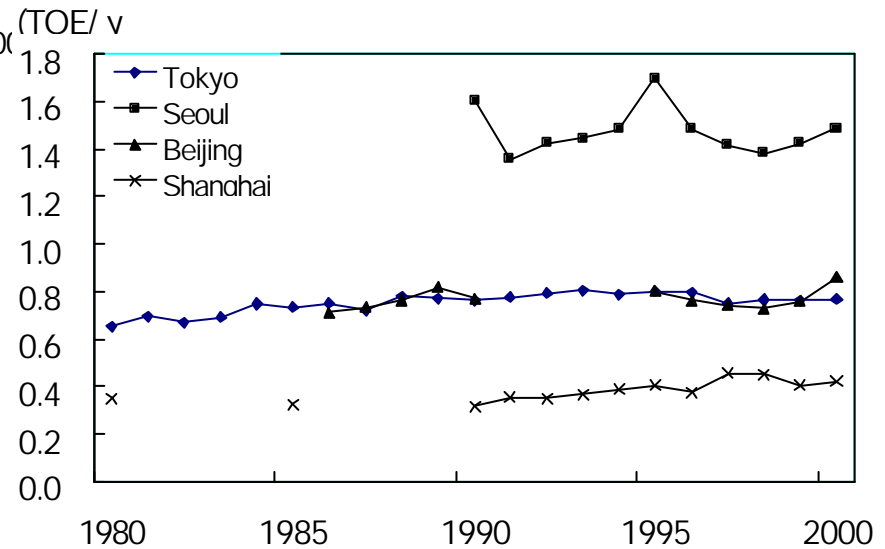


Energy Consumption in Residential Sector

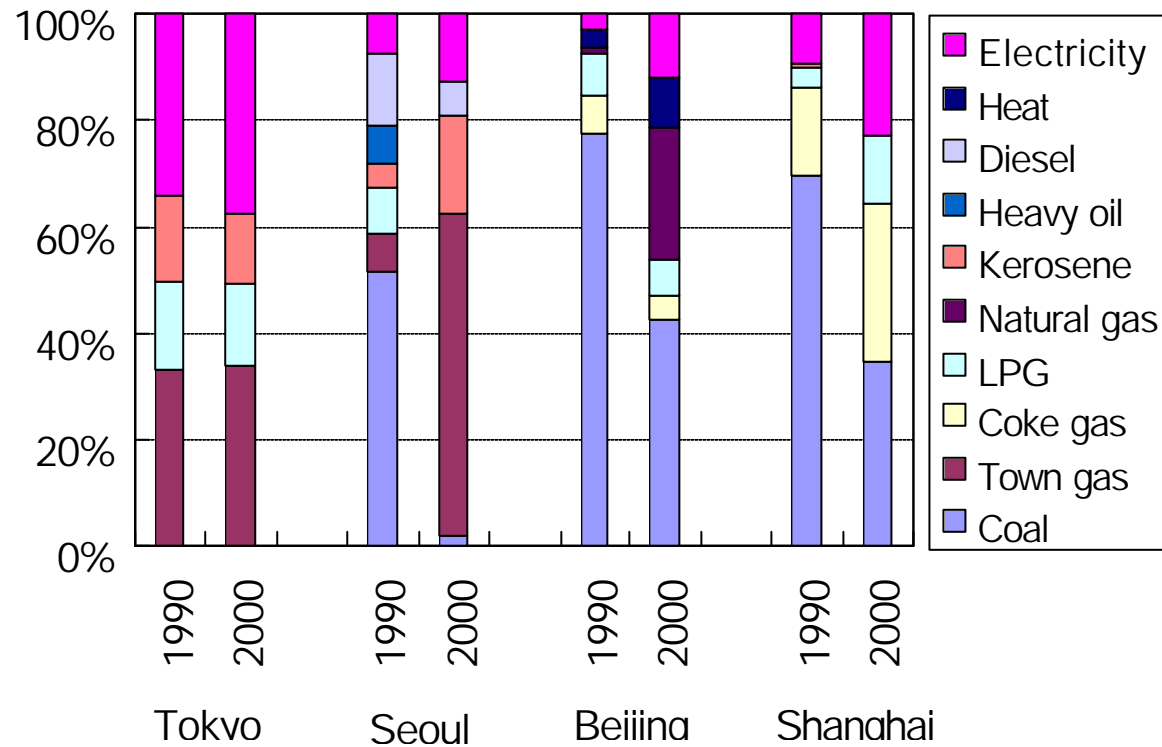
(10^6 TOE)



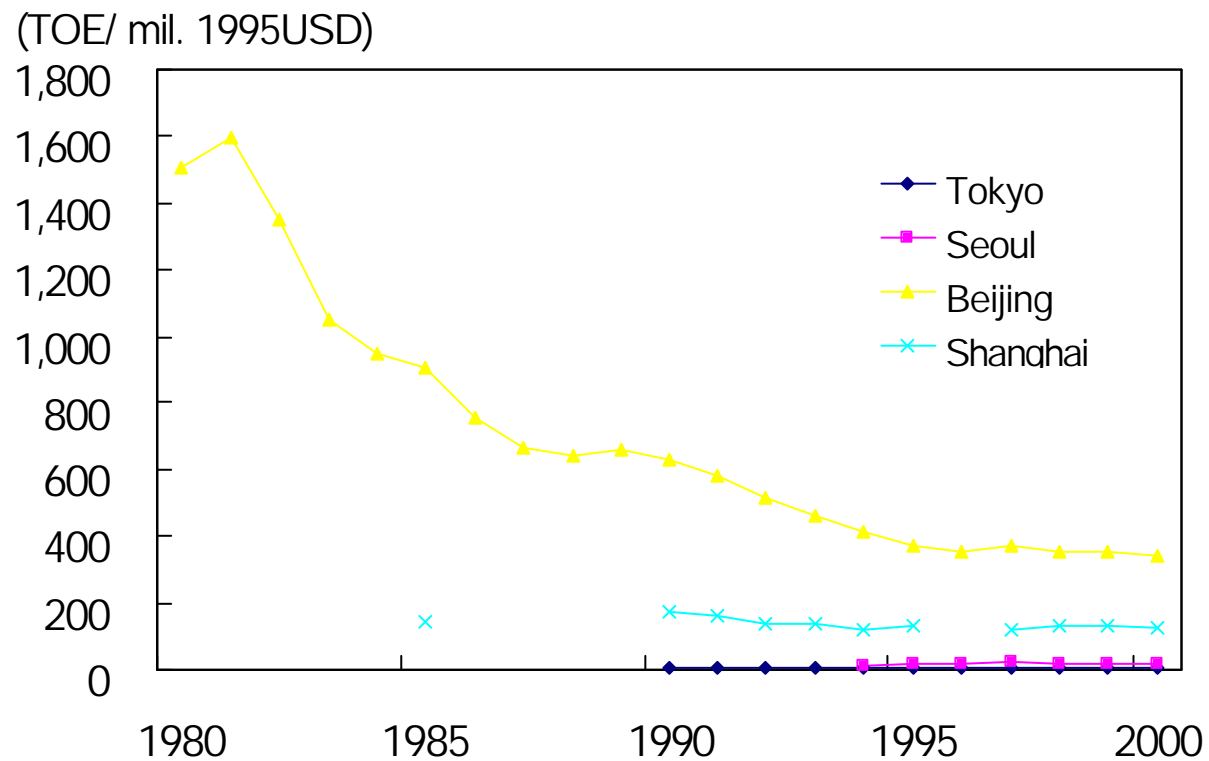
per Household



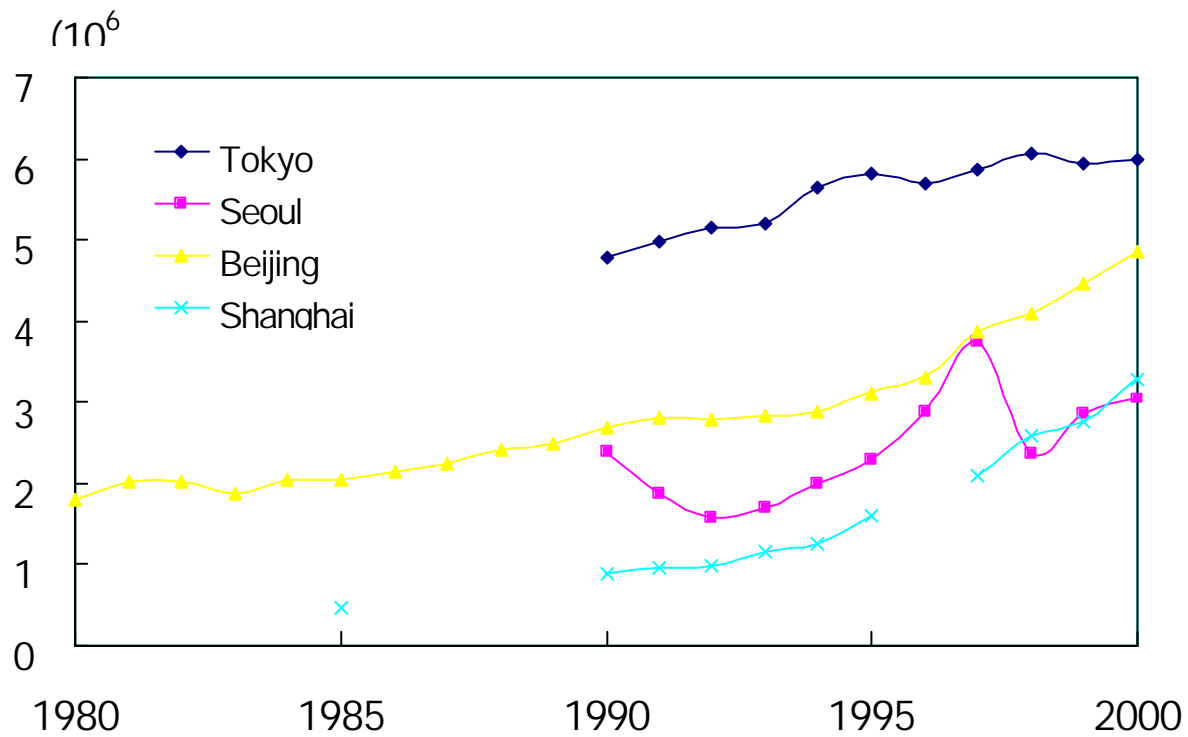
Compositional Changes of Residential Energy Consumption



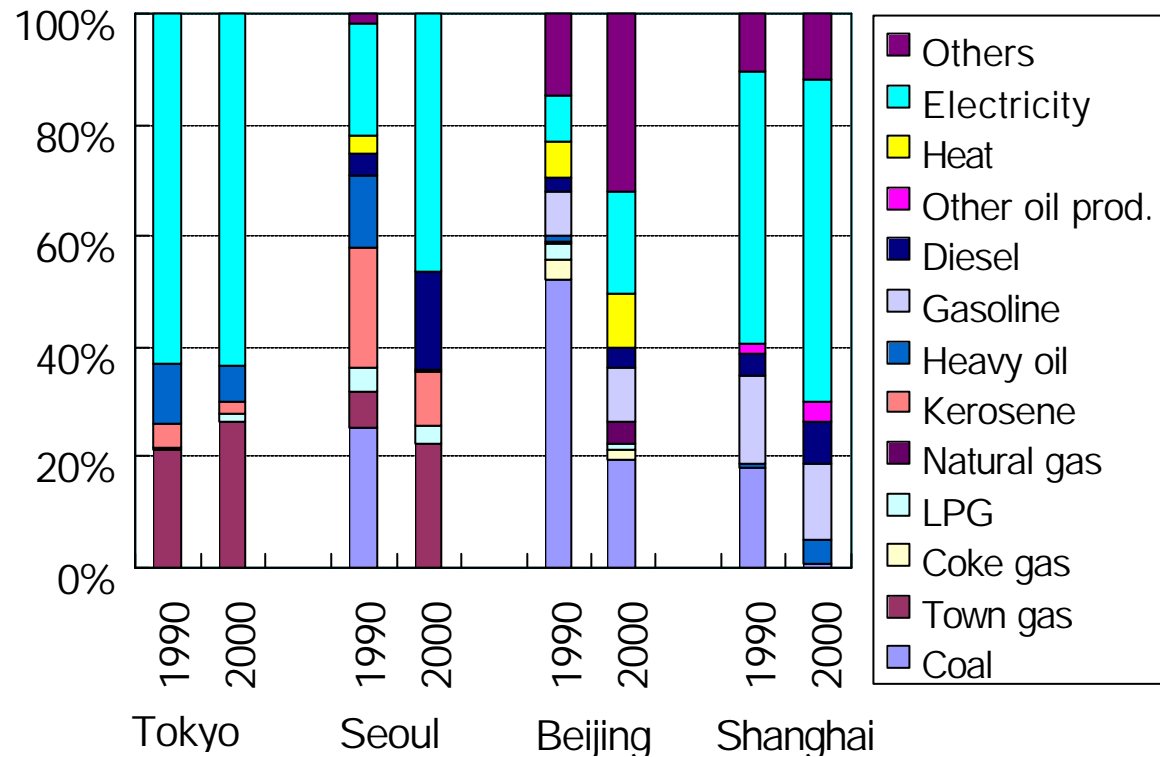
Trends in Commercial Energy Consumption per Unit of Tertiary GRP



Trends in Total Commercial Energy Consumption



Compositional Changes of Commercial Energy Consumption



3. Modeling for Energy Demand of Residential & Commercial Sectors

Data Availability for Residential Sector

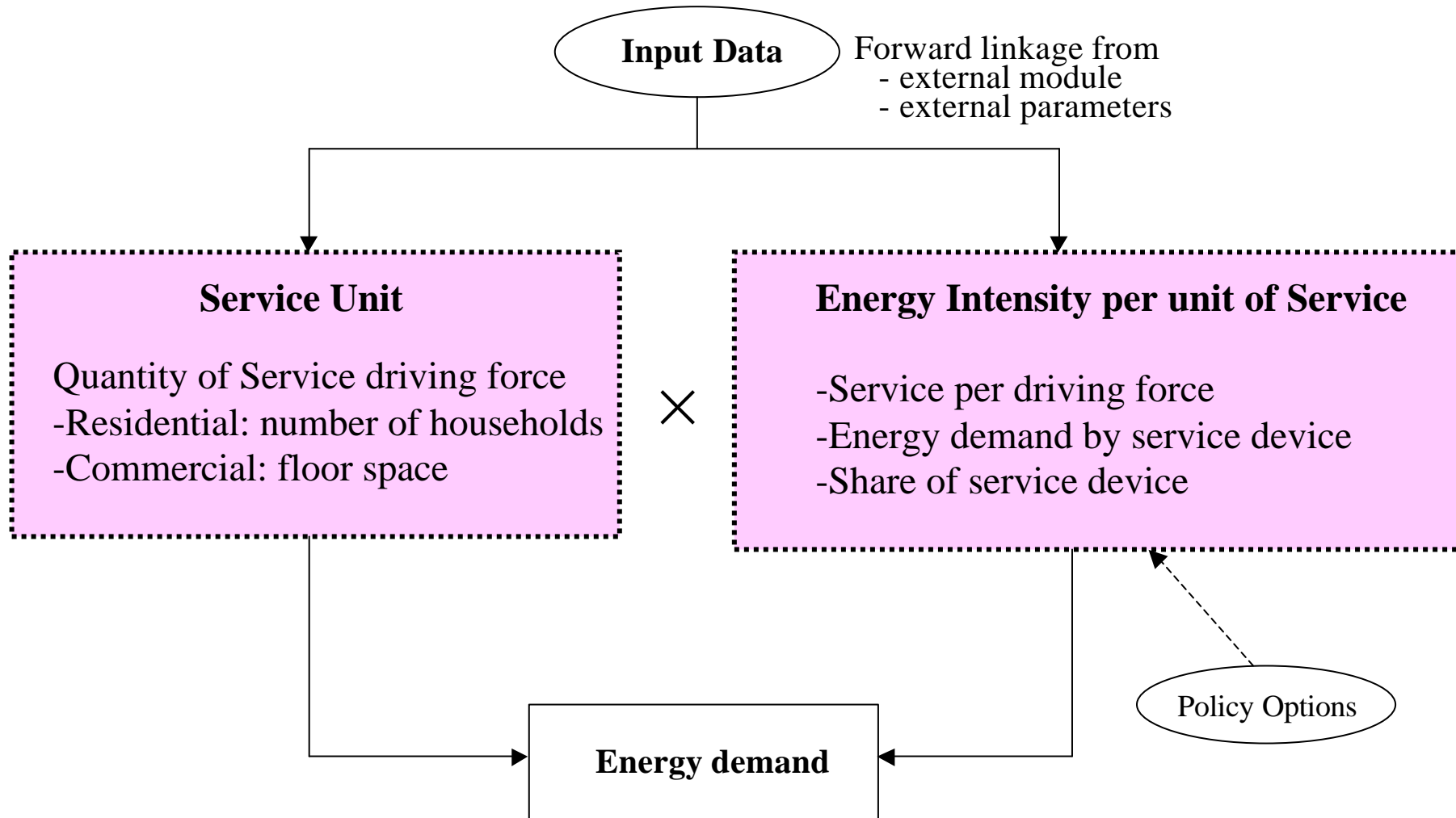
		Tokyo	Seoul	Beijing	Shanghai
Energy consumption	By usage types and energy types	?	×	×	×
	By energy types	?	?	?	?
	By usage types and energy types	?	×	×	×
Residential building property	Floor space	?	?	?	?
	Insulated rate	Detached	? ^{Note}	? ^{Note}	? ^{Note}
		Apartment	? ^{Note}	? ^{Note}	? ^{Note}
Energy consumption appliance	Possession rate	?	×	?	?
	Energy efficiency factor	?	×	×	×
Water consumption for residential use per household		?	?	?	?
Energy price	By energy types	?	?	?	?
	By usages	?	×	×	×
Climate factor	Cooling degree day	?	?	?	?
	Heating degree day	?	?	?	?

Note: intrusive rate of heat

Data Availability for Commercial Sector

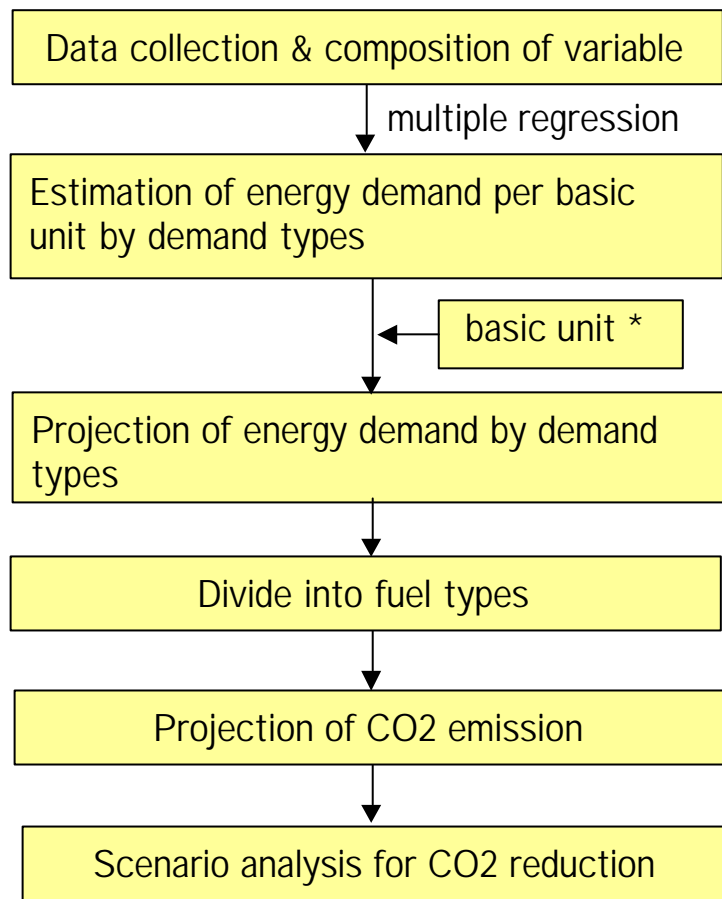
		Tokyo	Seoul	Beijing	Shanghai	
Energy consumption	By building usage types	?	?	×	×	
	By energy types	?	?	?	?	
	By building usage types and energy types	?	?	×	×	
Floor space	Total	?	?	?	?	
	By building usage types	?	?	×	×	
Business activity	Total	GDP of tertiary industry	?	?	?	?
		No. of employee of tertiary sector	?	?	?	?
	Office	No. of computers	?	×	×	×
	Hospital	No. of patients	?	?	?	?
	School	No. of students	?	?	?	?
		No. of computers	?	×	×	×
Energy price	By energy types	?	?	?	?	
Climate factor	Cooling degree day	?	?	?	?	
	Heating degree day	?	?	?	?	

Basic Concept of Analysis



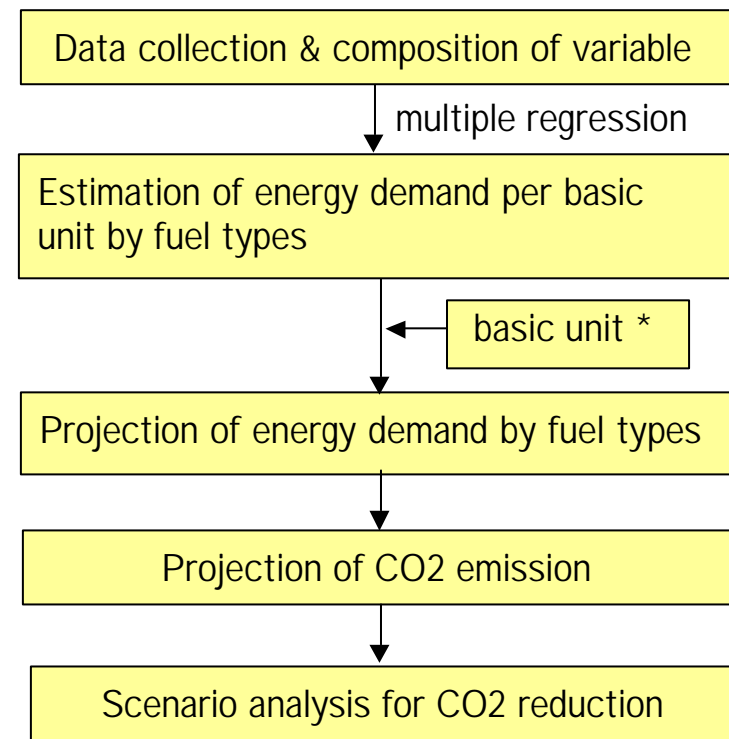
Analytical Flows for Tokyo and Other Cities in Residential Sector

<Tokyo>



* Basic unit = floor space or household

<Others>

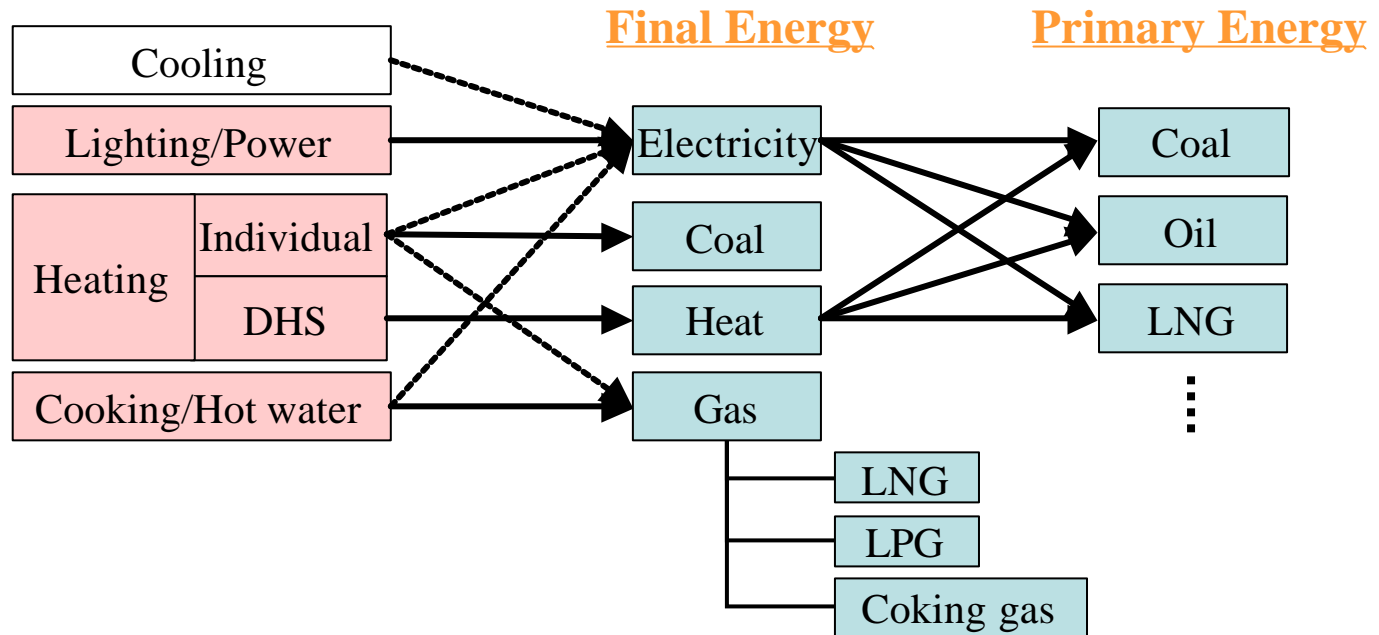


* Basic unit = household

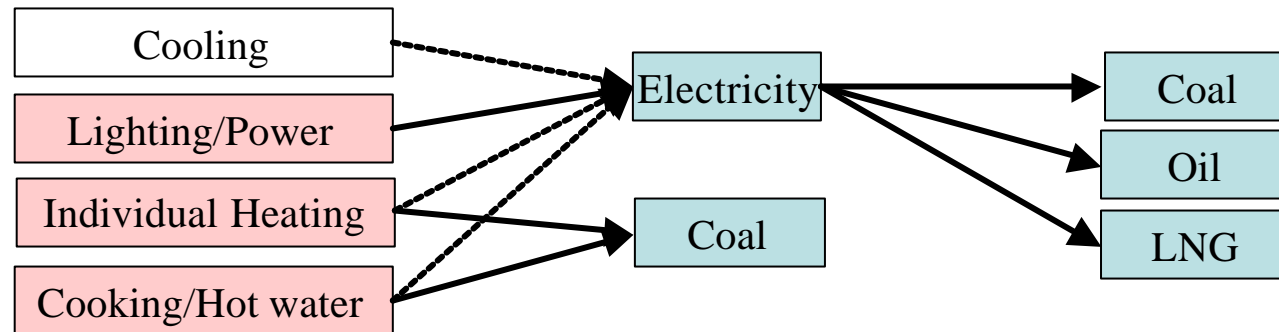
Matching Demand Type to Energy Type (case of Beijing)



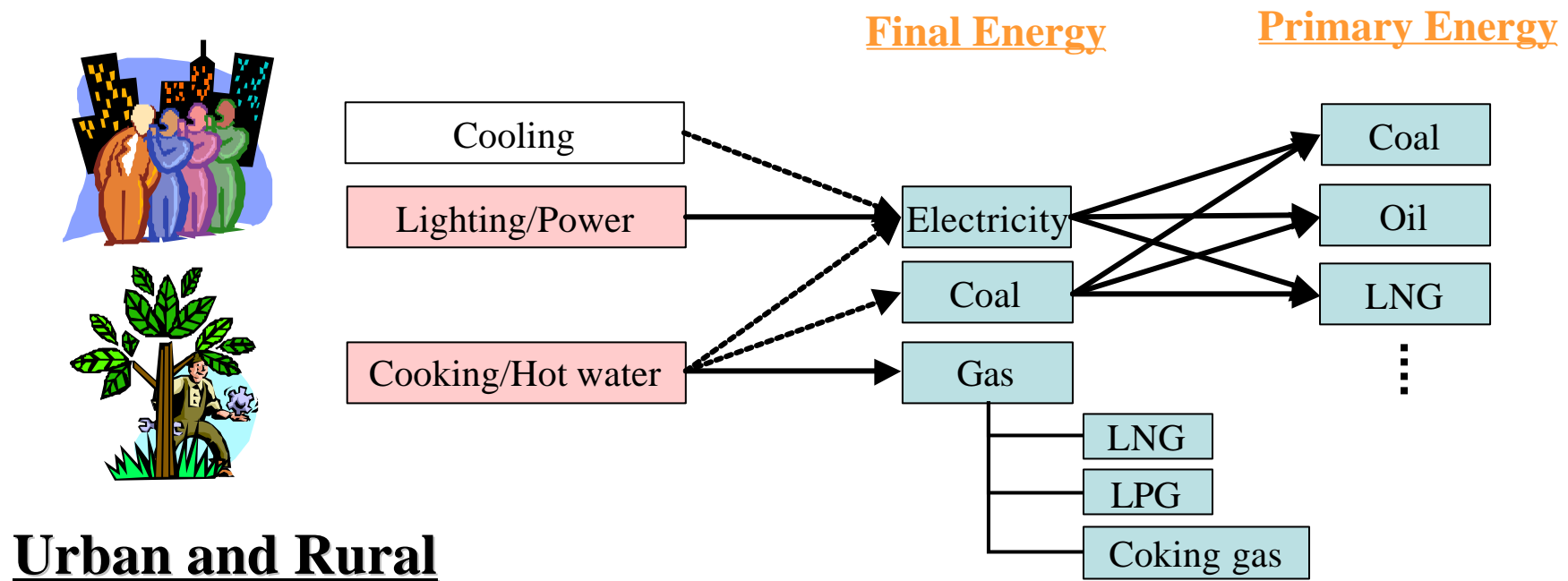
Urban



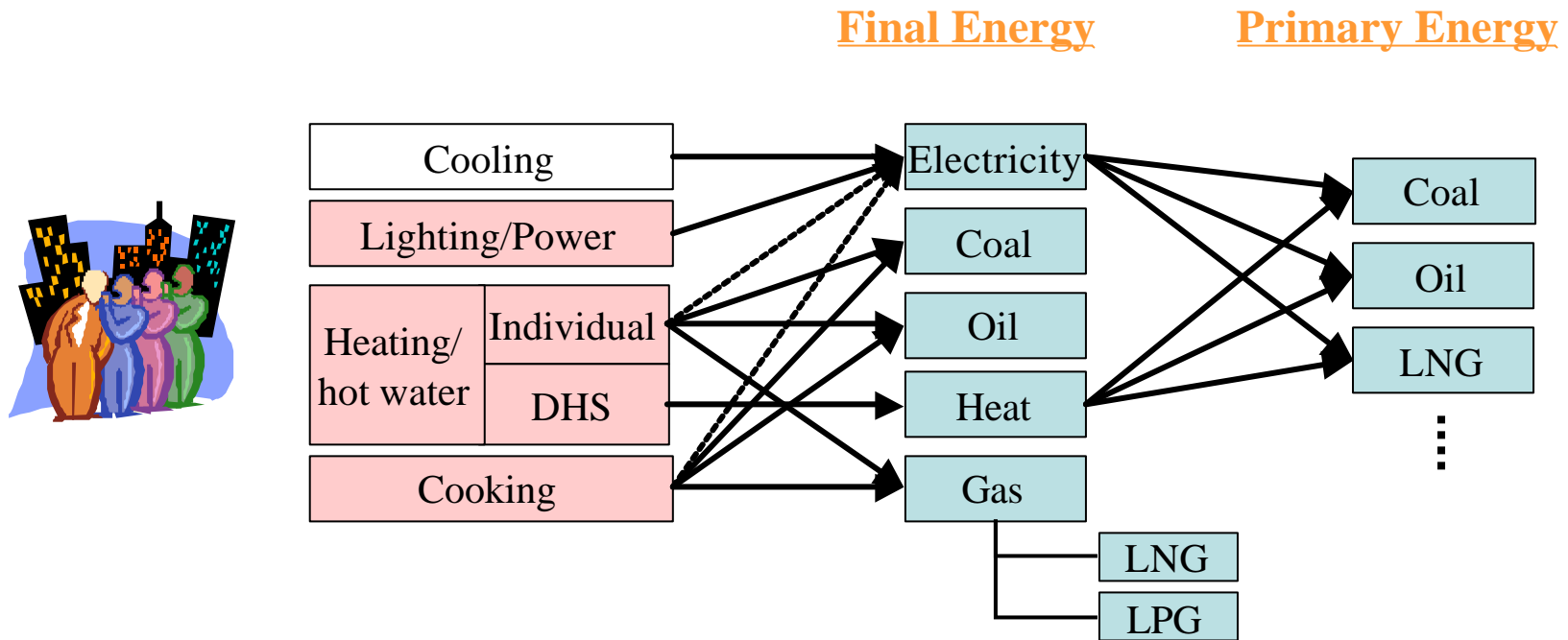
Rural



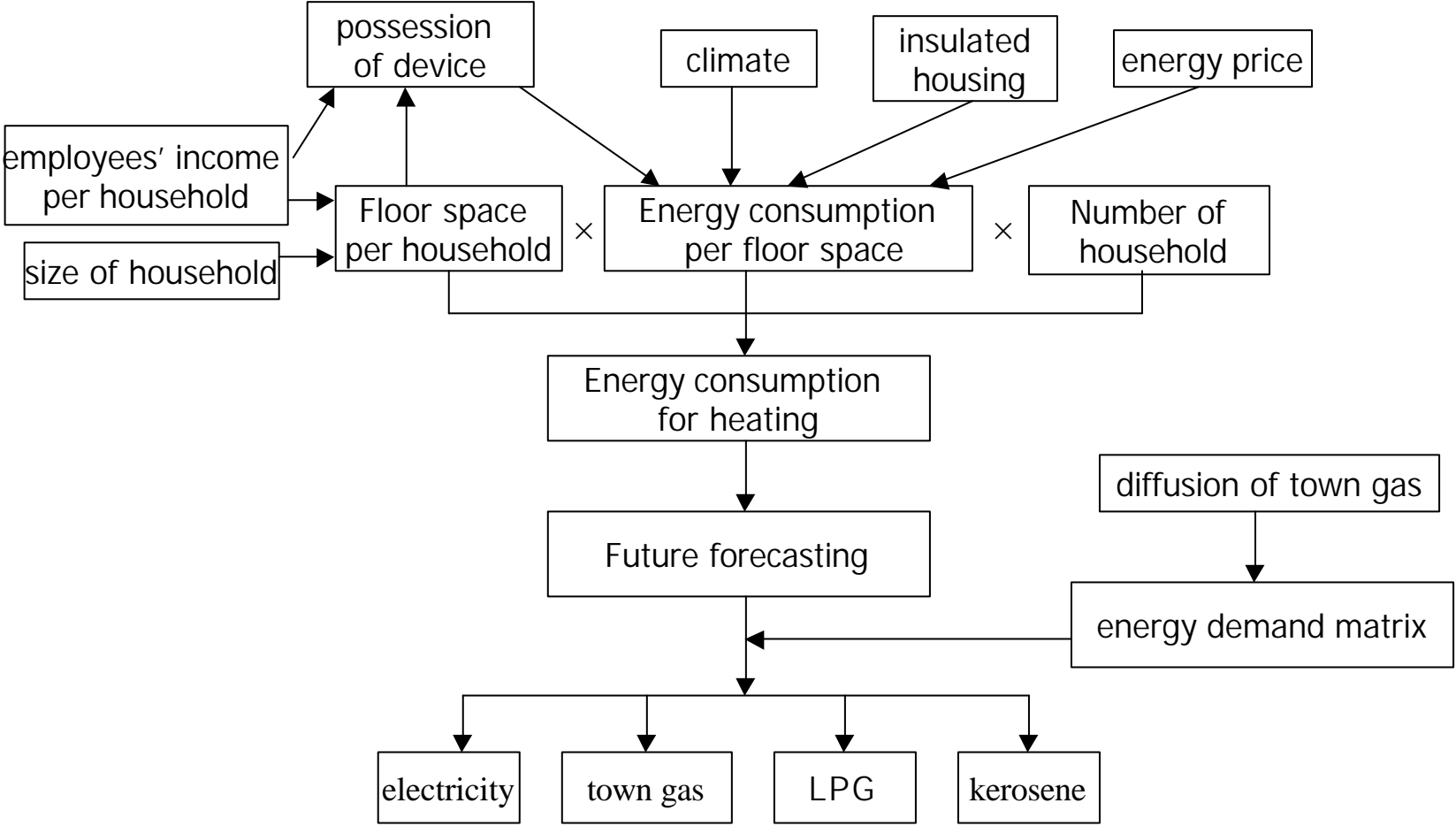
Matching Demand Type to Energy Type (case of Shanghai)



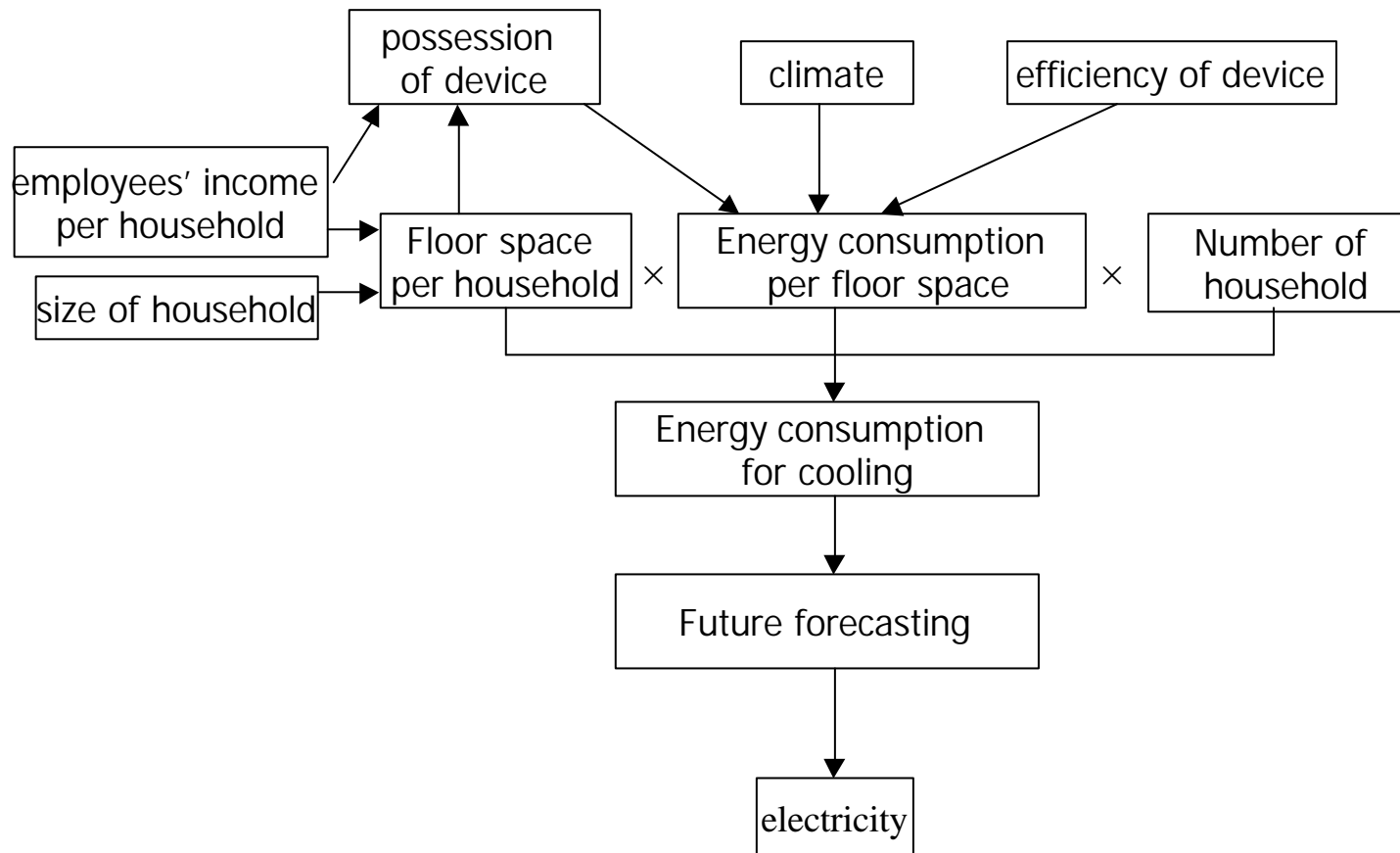
Matching Demand Type to Energy Type (case of Seoul)



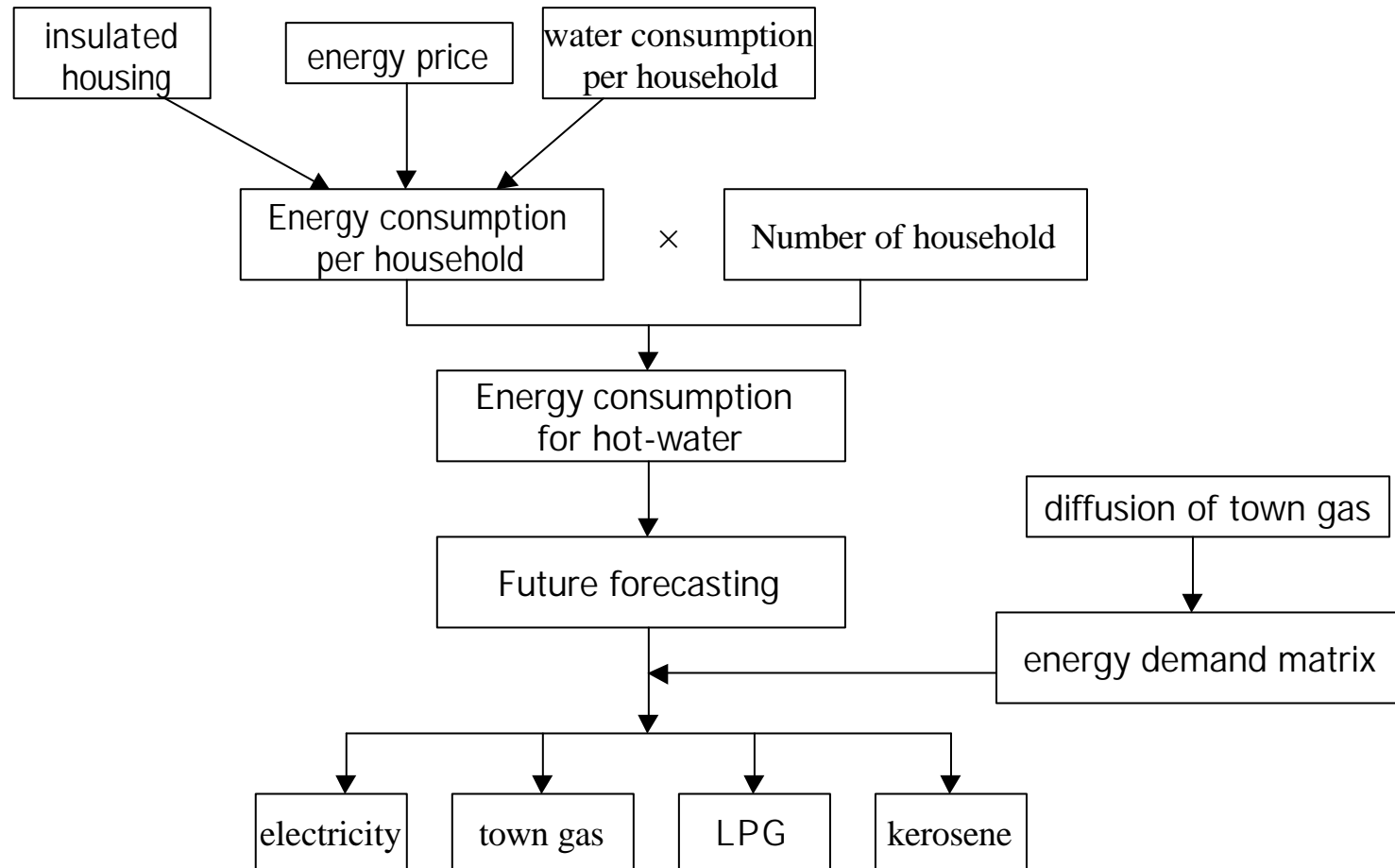
Flow Chart of the Estimation of Energy Consumption for heating



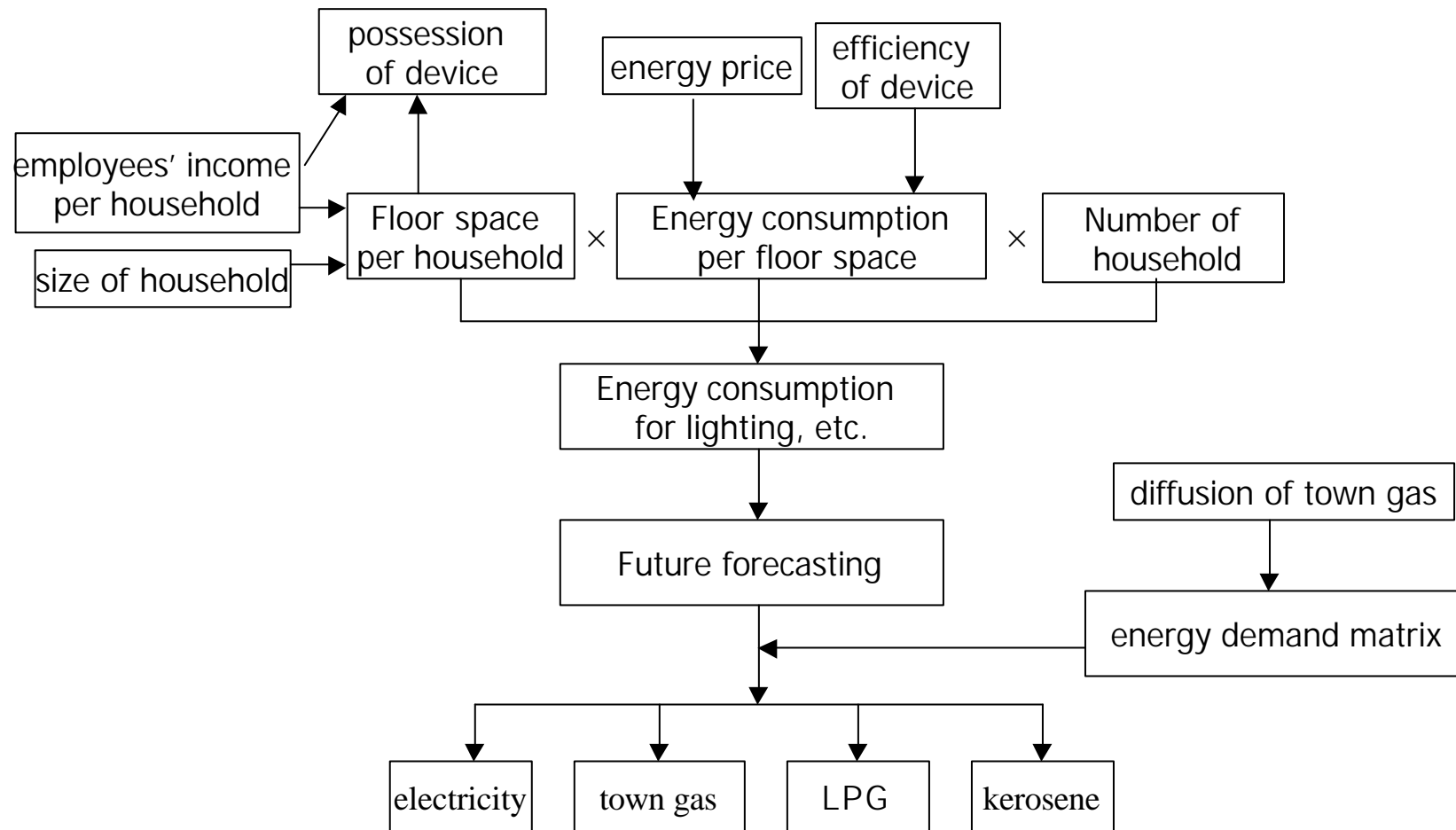
Flow Chart of the Estimation of Energy Consumption for Cooling



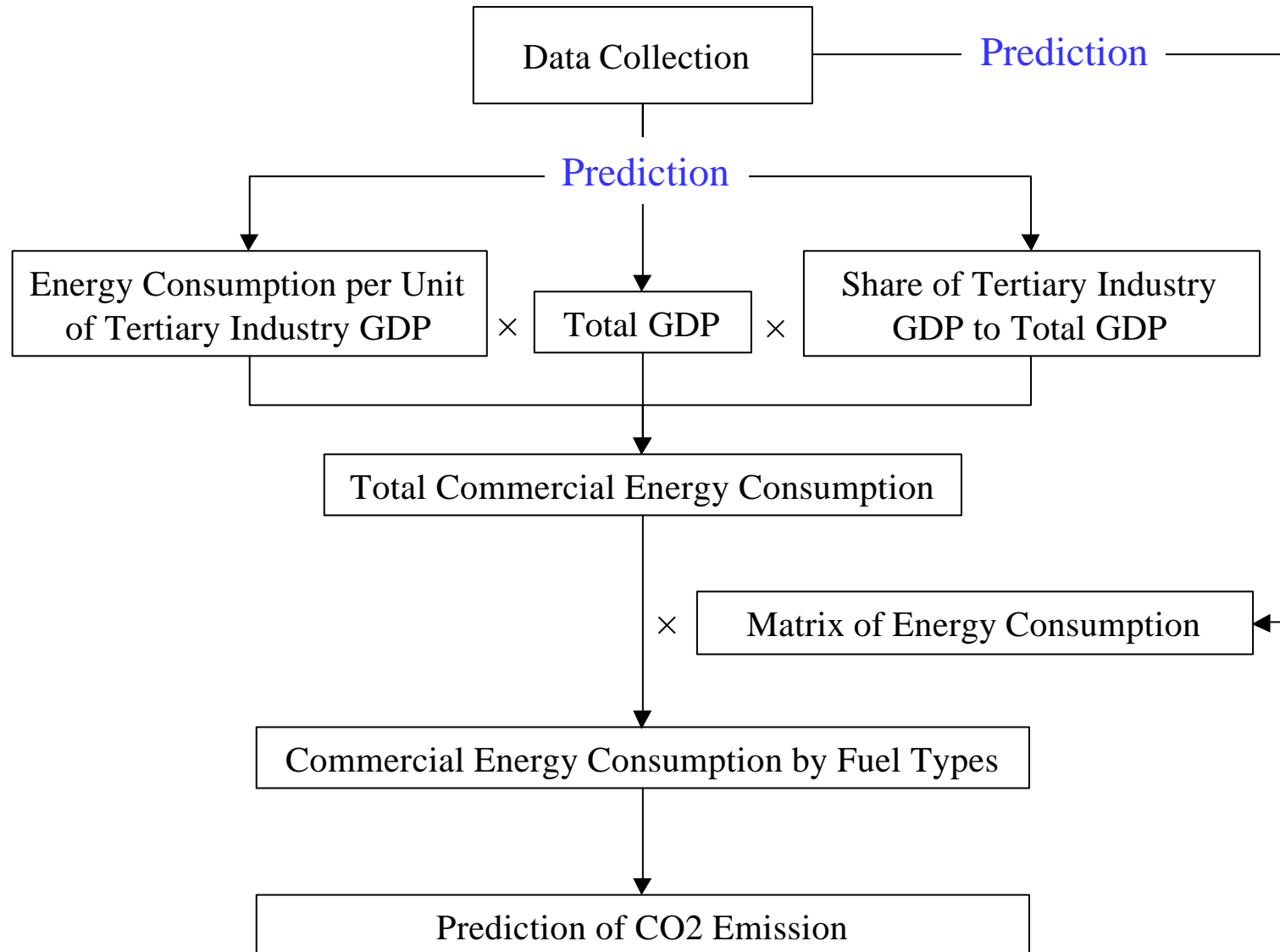
Flow Chart of the Estimation of Energy Consumption by Hot-water Supply



Flow Chart of the Estimation of Energy Consumption for Lighting, driving, etc.



Analytical Flow of Commercial Sector



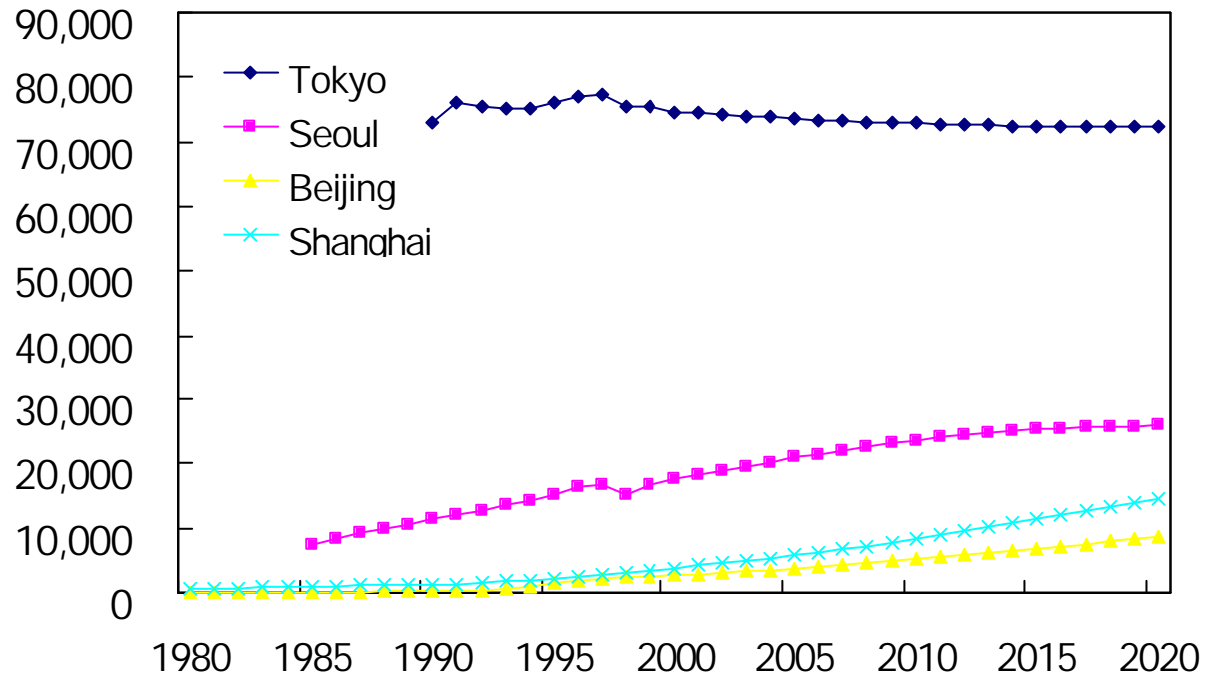
4. Projection of Energy Consumption and CO₂ emissions

Setting up the Exogenous Variable (case of Tokyo)

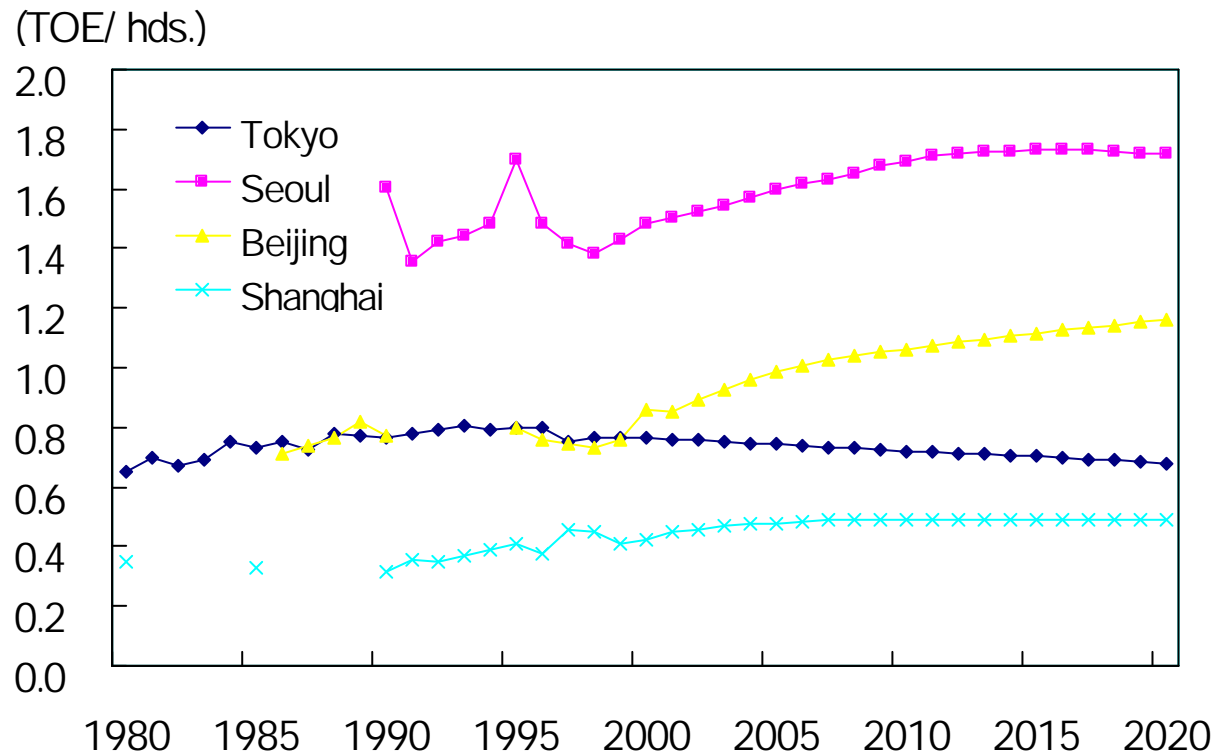
- ✍ Degree: average (1975-99)
- ✍ Energy price: average (1991-99)
- ✍ Water consumption: Straight line approximation of water consumption per capita (1975-99)
- ✍ Number of household: estimated by National Institute of Population, Japan
- ✍ Size of household : estimated by National Institute of Population, Japan
- ✍ Employees' income: average of increasing rate (1989-99)

Projection of GRP per Capita

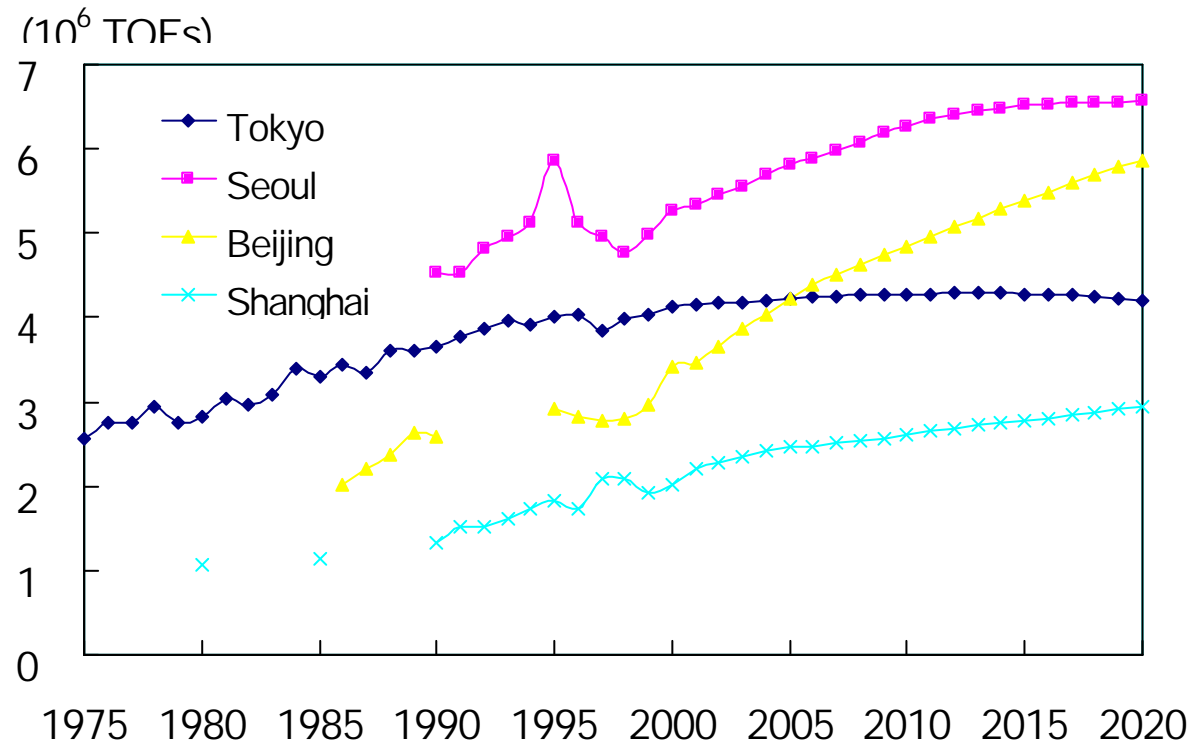
(USD, 1995price)



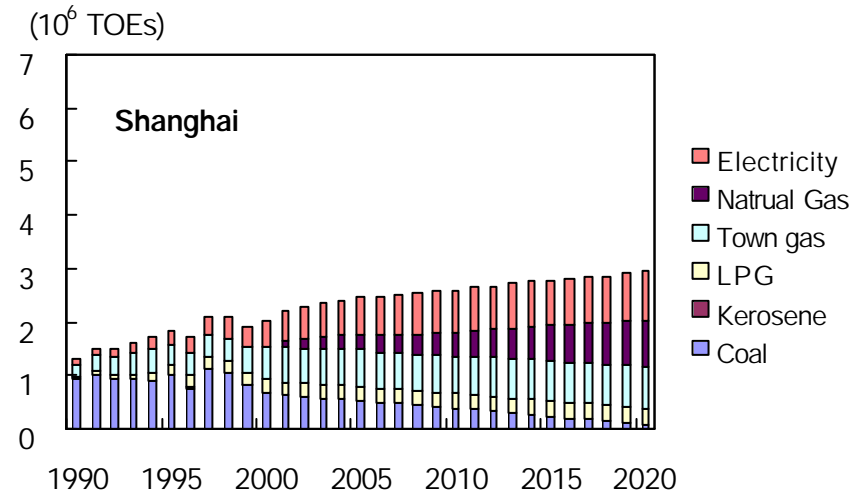
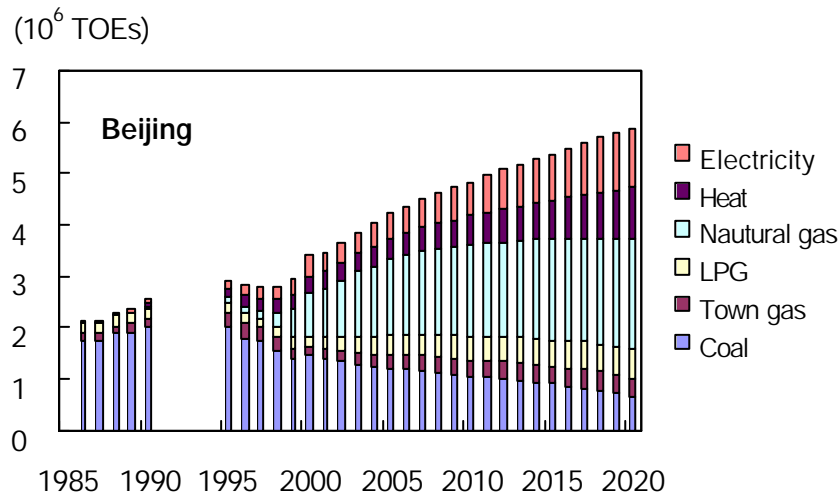
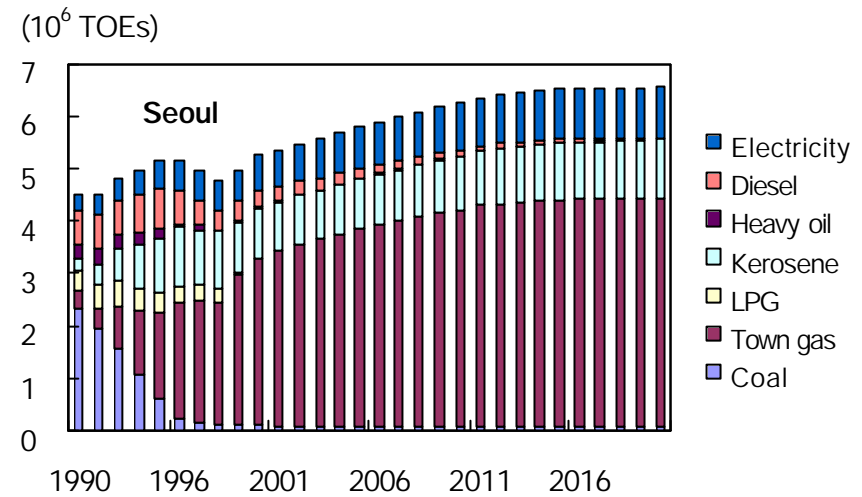
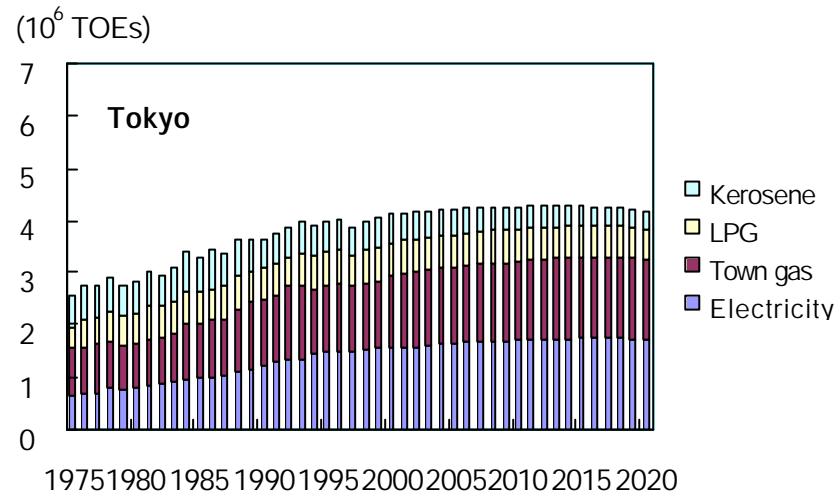
Projection of Residential Energy Consumption per Household



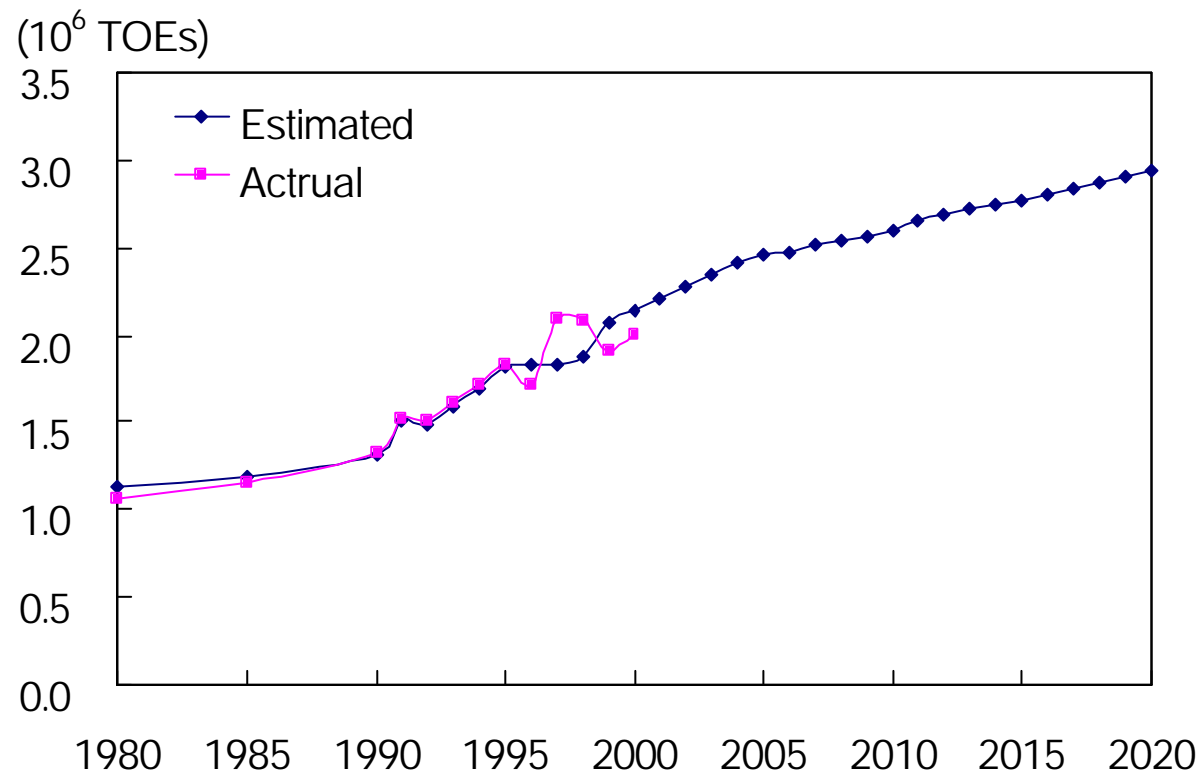
Projection of Total Residential Energy Consumption



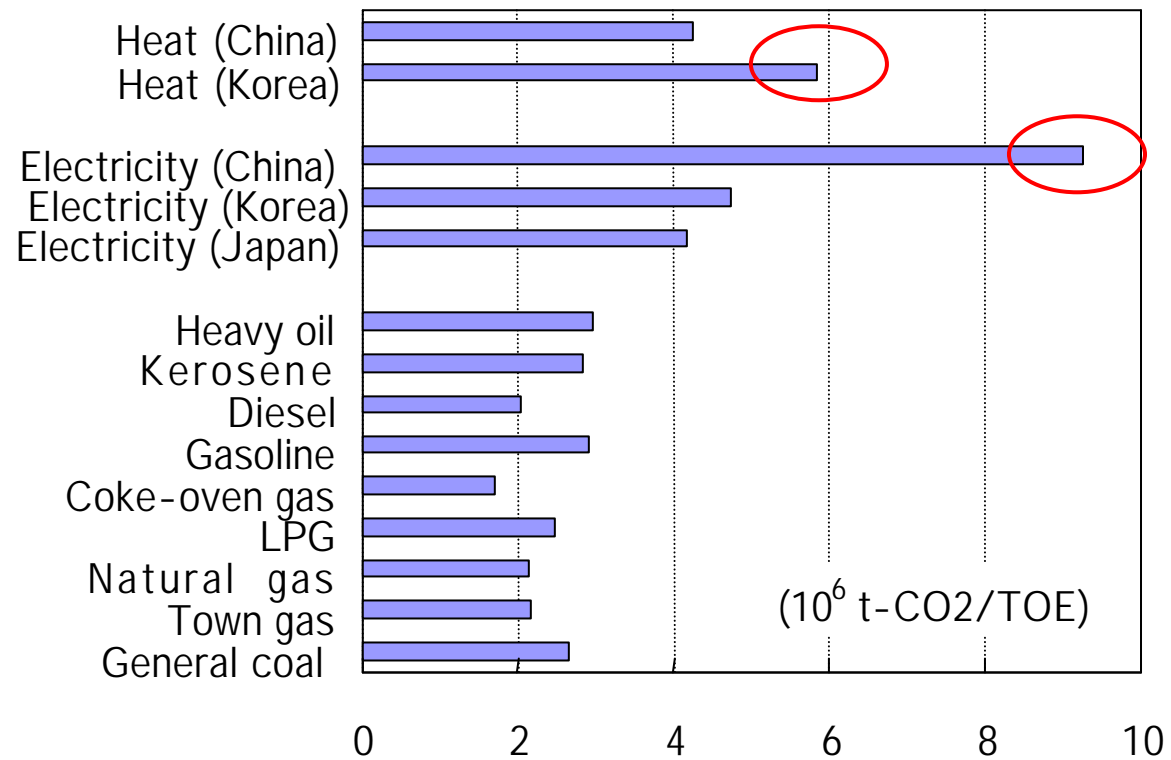
Projection of Residential Energy Consumption



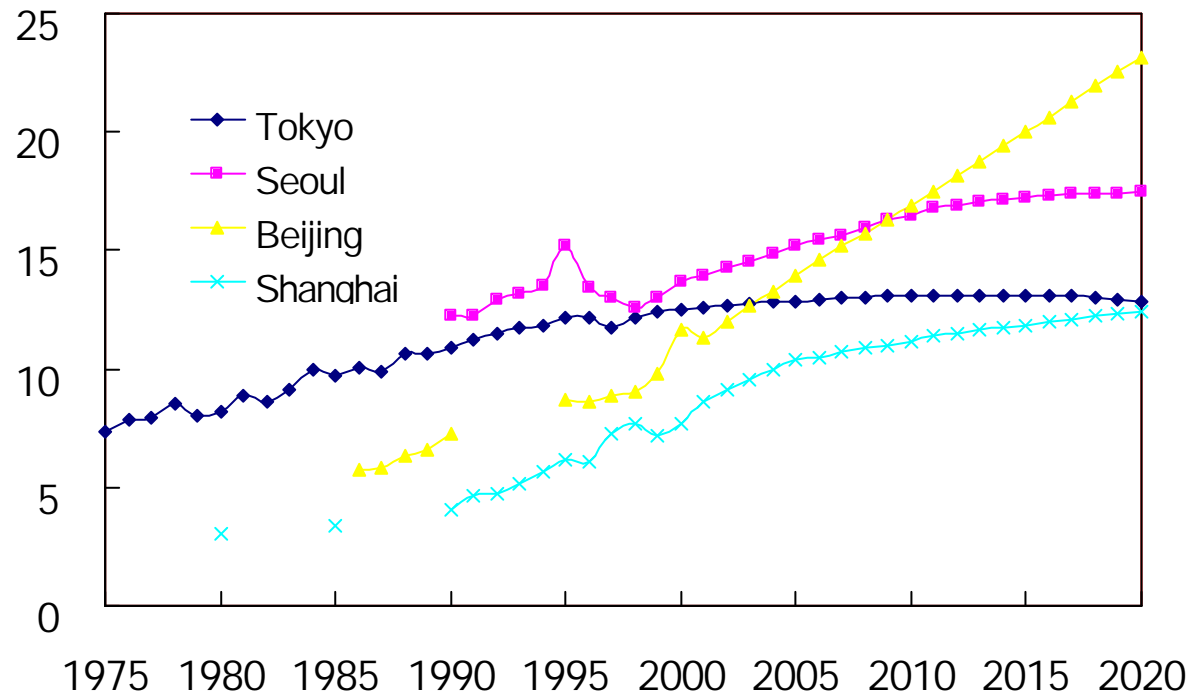
Estimated and Actual Values of Total Residential Energy Consumption (case of Shanghai)



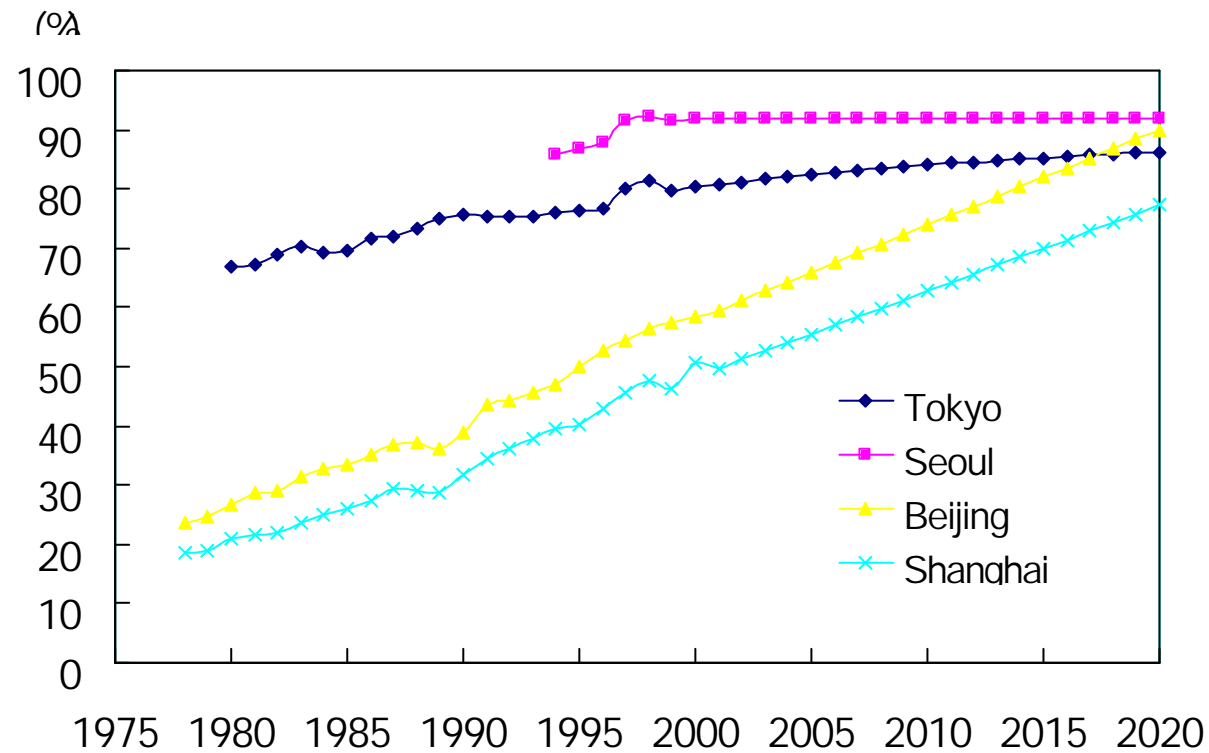
CO₂ Emission Factor by Energy Types



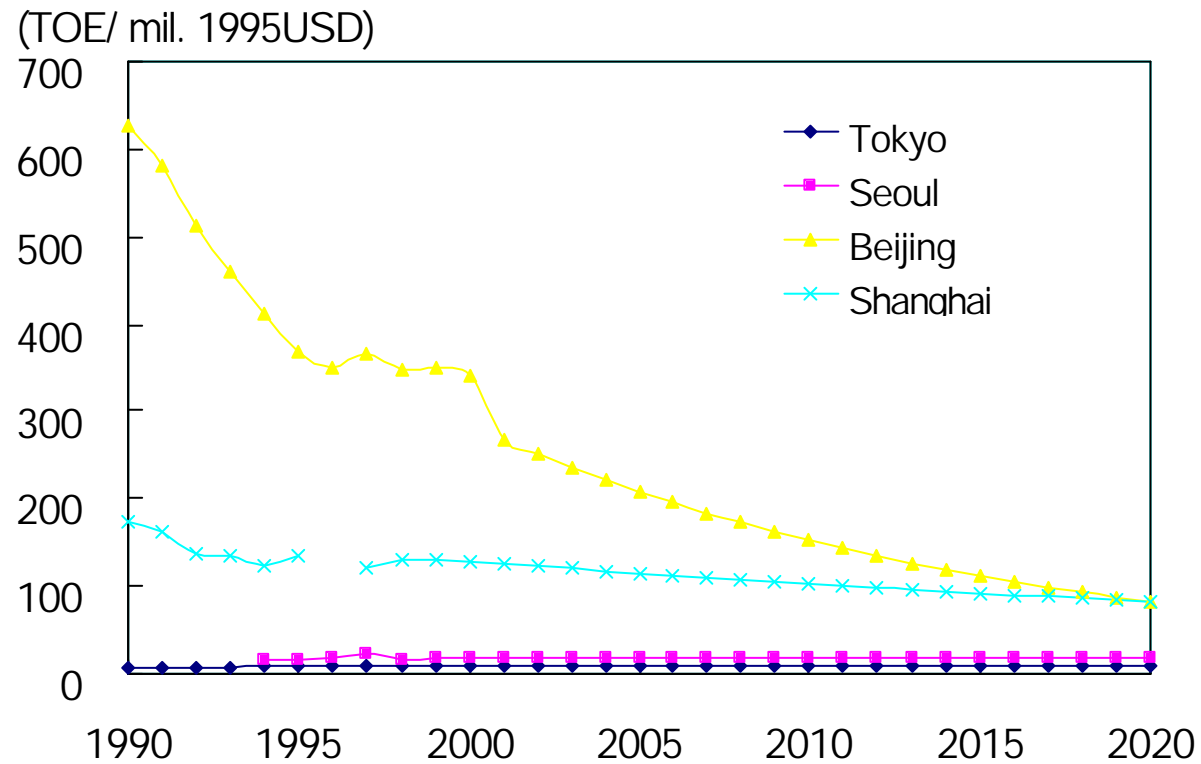
Projection of Total CO₂ Emission of Residential Energy Consumption



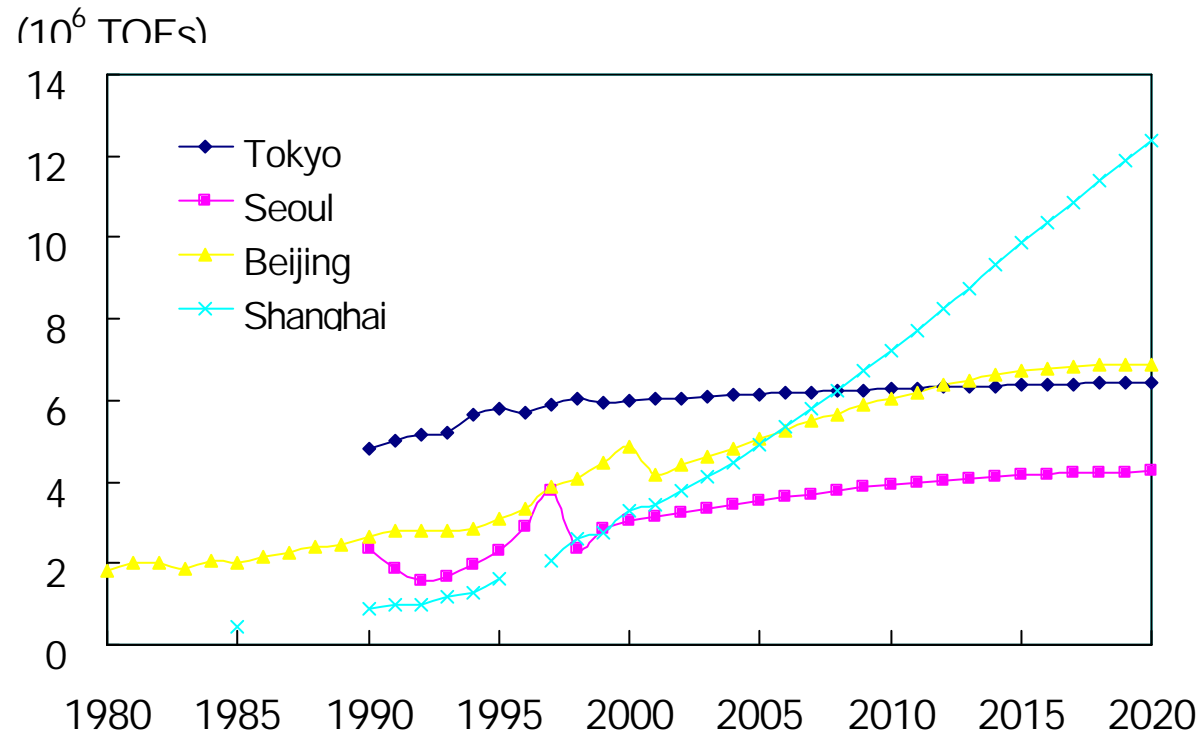
Trends and Projection of Share of Tertiary GRP to Total GRP



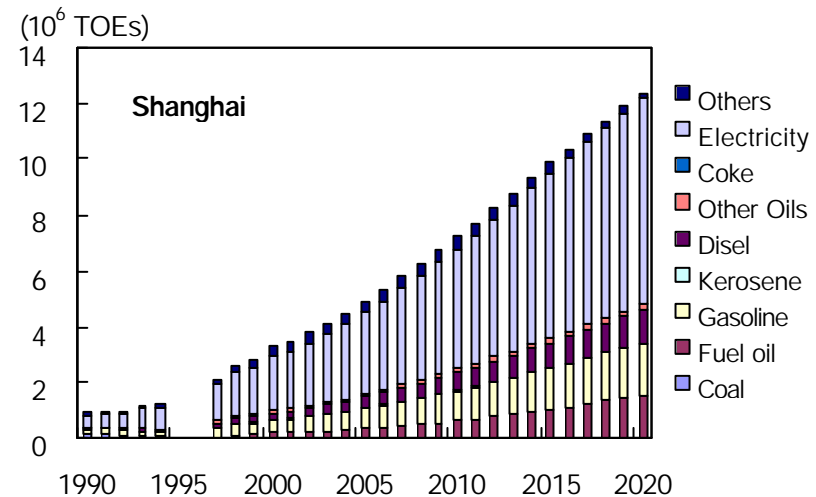
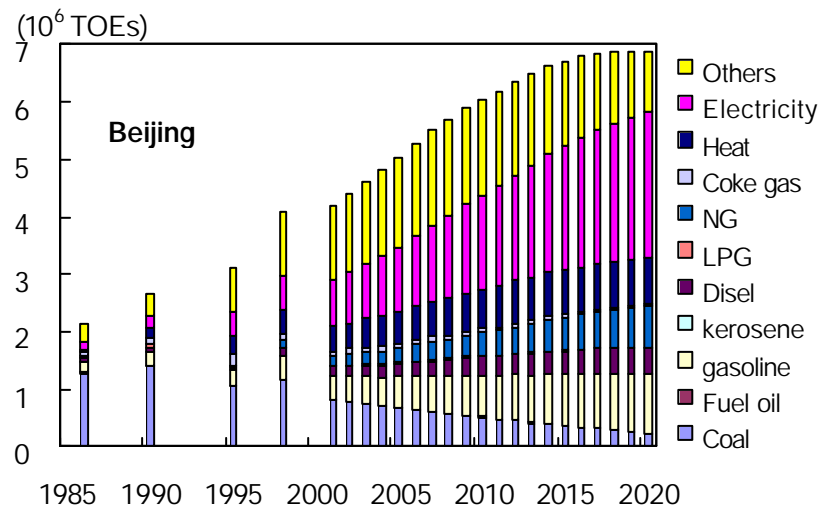
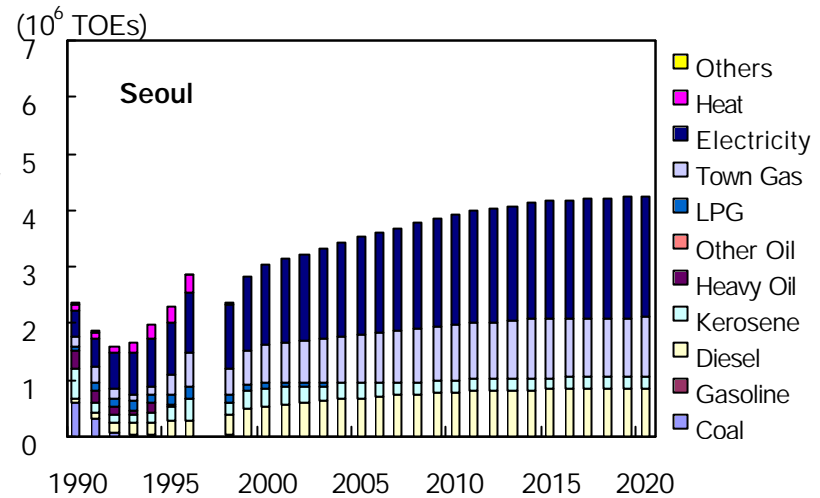
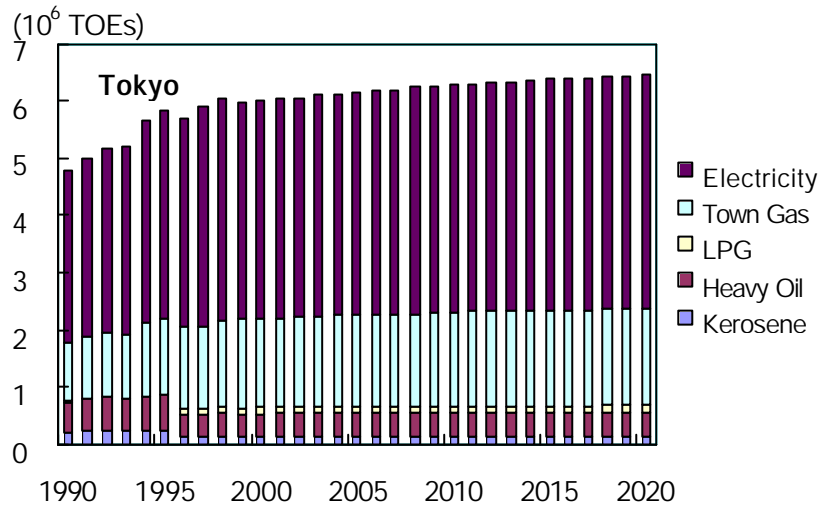
Projection of Energy Consumption per Unit of Tertiary GRP



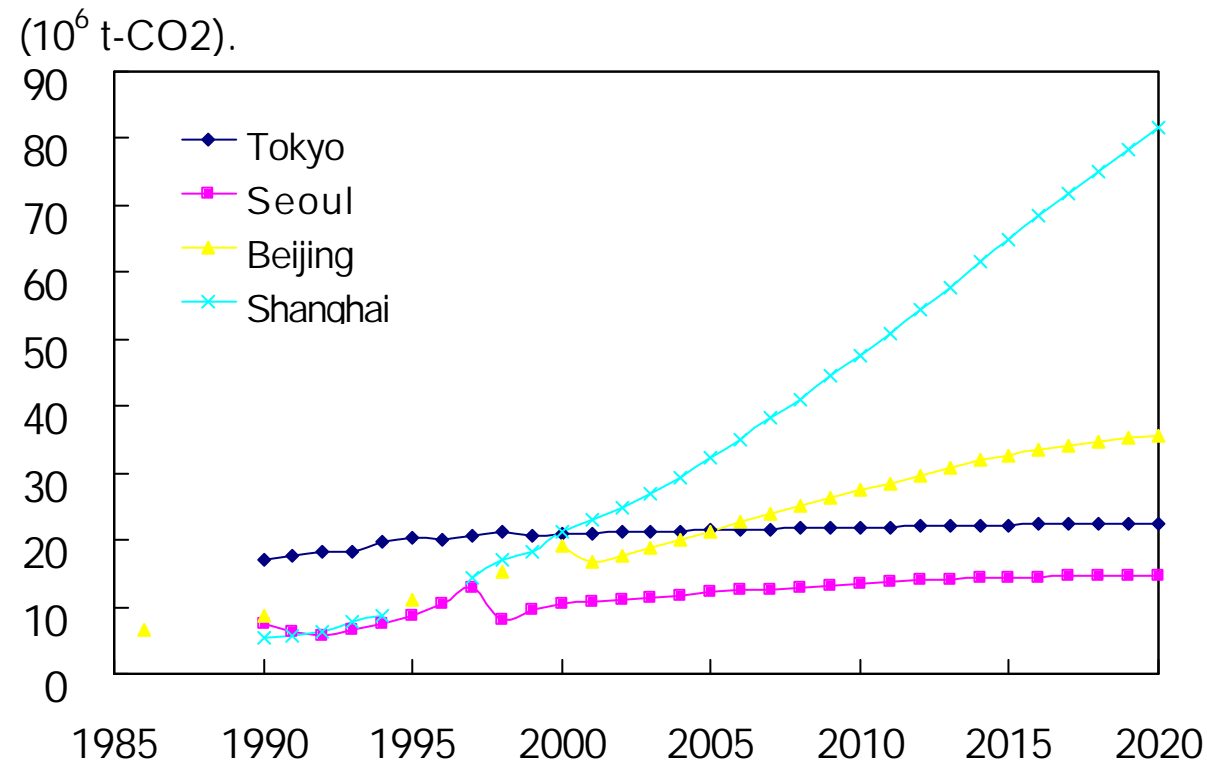
Projection of Total Commercial Energy Consumption



Projection of Commercial Energy Consumption



Projection of Total CO₂ Emission due to Commercial Energy Consumption



5. Future Directions

Future Directions

Improvements in data and model structures

Two directions can be considered

1. to aim at more simplified model to deal with same structure as other mega-cities
2. to aim at a complete, bottom-up model which model variables can be closely based on policy options.

Scenario analysis

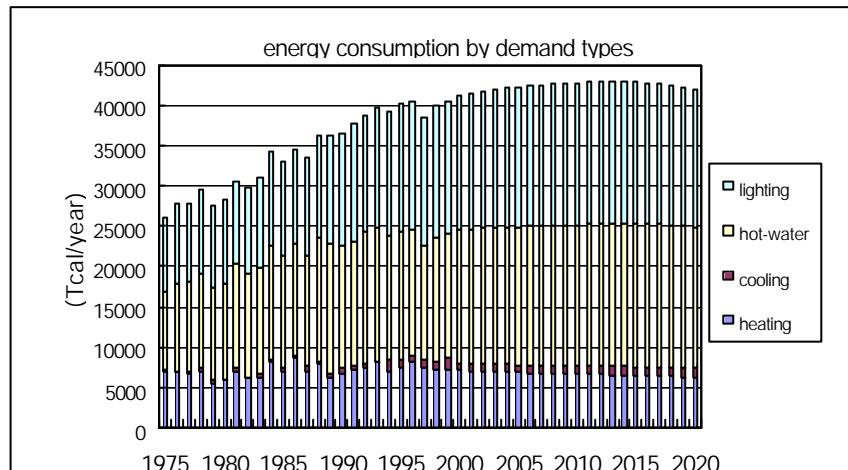
Scenarios can be described in the area of

1. household attributes and lifestyle factors
2. architectural characteristics
3. characteristics of energy devices
4. carbon intensity in energy consumption

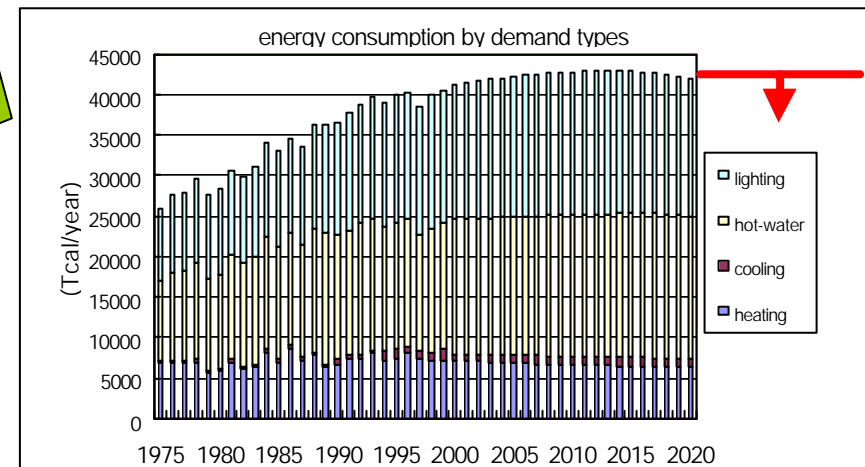
Thank you!

Concept of Scenario Analysis

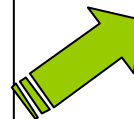
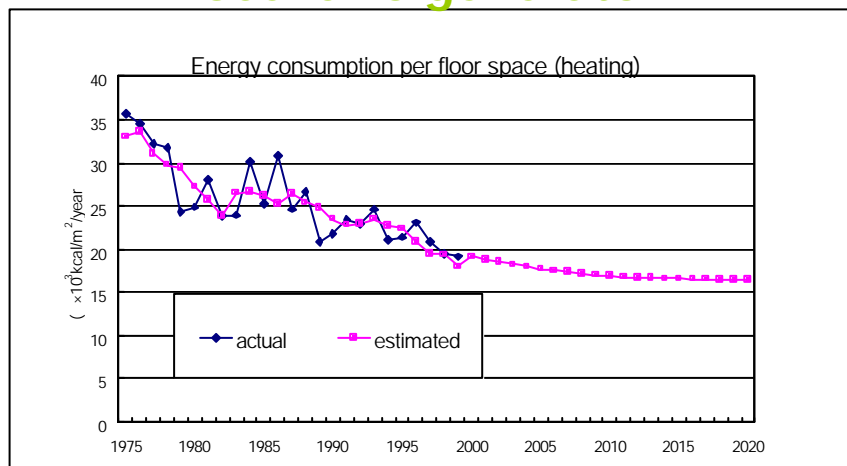
BaU



Reflection of scenario



Scenario generator



Example of scenarios

- ✍ Improvements in energy efficiency of appliances & equipments
- ✍ Improvements in Insulated performance of buildings
- ✍ Improvements in carbon intensity of energy
- ✍ etc.