Strategies and Policy/Technology Instruments for Sustainable Land Use and Transport - *International Comparisons* -

Yoshitsugu Hayashi  
Director, International Research Center for Sustainable Transport and Cities, *Nagoya University*, Japan  
Chair, Scientific Committee of *WCTRS*  
(World Conference on Transport Research Society)
URGENT!

There is an urgent need to involve transport as a major sector in the climate change negotiation. WCTRS could help UNFCCC and the IPCC to promote this process.

WCTRS (World Conference on Transport Research Society)
The WCTRS covers multi-modal, multi-disciplinary, and multi-sectoral fields. The members span almost all aspects of transportation research, planning, policy and management. The World Conferences held every 3 years mirror this breadth of interests. 67 countries are represented in the WCTRS, with more than 1,500 members.

President: Anthony May (University of Leeds, UK)
Chair of Scientific Committee: Yoshitsugu Hayashi (Nagoya University, Japan)

WCTRS SIG 11 (Special Interest Group 11) - Transport and the Environment
The SIG11 aims at seeking ways to establish effective mechanisms for mitigating environmental degradation due to transport in the international domain. The following topics are researched: a) Comparing the emission of greenhouse gas and air pollution between countries and cities, b) Diagnosing transport system and its resulting global and local environmental degradation and prescribing countermeasure policies, and developing an evaluation system of their performance, c) Providing scientific instruments for evaluation of international mechanism for environmentally sustainable transport and the methods to collect the necessary financial resources.

Sponsored by:
Global Environment Research Fund (S-6-5), Ministry of Environment, Japan

Supported by:
Graduate School of Environmental Studies & Global COE Program “From Earth Science to Basic and Clinical Environmental Studies”, Nagoya University, Japan
College of Architecture and Urban Planning, Tongji University, China

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Website: http://www.sustrac.env.nagoya-u.ac.jp/en/

World Conference on Transport Research Society (WCTRS)
http://www.wctrs.org/

December 2011
School boy waiting for a bus at 4:30 am in Suburb of Bangkok (1993)
Slower than walkers in Sukunvit Rd., Bangkok
8hr+ Commuters > 10% (1993)

Photo by Yoshitsugu Hayashi (1993)
Bike Taxi in Bangkok

Photo by Yoshitsugu Hayashi (1993)
Negative Spiral between Motorization and Urban Sprawl

Motorization

Development of Infrastructure

Excessive Traffic demand

Insufficiency of Road

Level of Technology

Improvement of emission factor (IMPROVE)

Restraint of unnecessary demand (AVOID)

Urban Sprawl

Econ. Growth

Sift to low-emission mode (SHIFT)

Bottleneck of Traffic

Obstacle to progress of economy

Problems from local to global

Env.

Econ.
Car Ownership

GDP per Capita US$ (1995)

Cars per 1,000 inhabitants

Moscow
London
Bangkok
Tokyo
Seoul
Hong Kong
Singapore (CA)
Nagoya

Nagoya Univ. study result.

7June2012
Hayashi Laboratory, Nagoya University

* Result of the study of Nagoya Univ.
Road Infrastructure Supply vs. Motorization Level vs. Peak Hour Speed

![Graph showing the relationship between road infrastructure supply, motorization level, and peak hour speed over time in various cities.]
Motorization & Road Supply

(*TOE/km) (*000/12hr)
(litre/km) (km/hr)

<table>
<thead>
<tr>
<th></th>
<th>Energy consumption</th>
<th>Sectional volume</th>
<th>Consumption Rate</th>
<th>Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greater London</td>
<td>18.7</td>
<td>15.8</td>
<td>21.8</td>
<td>0.11</td>
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<tr>
<td>Tokyo</td>
<td>196</td>
<td>0.13</td>
<td>160</td>
<td>0.13</td>
</tr>
<tr>
<td>Nagoya</td>
<td>30</td>
<td>0.1</td>
<td>29</td>
<td>0.1</td>
</tr>
<tr>
<td>Bangkok Met Area</td>
<td>120</td>
<td>10.0</td>
<td>54</td>
<td>0.17</td>
</tr>
<tr>
<td></td>
<td>627</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
Decomposition of Urban Transport Emission

Emission = Total Trip Length × Modal Share × Emission Factor

Urban area
Concentration of urban activity
Transport Frequency

Emission
year

Avoid
Shift
Improve

Reduce need to travel
Shift to low-emission mode
Improve emission intensity

Compact Development
Development of Public Transport
LEV diffuse

Regulation

Regulation of Sprawl

Road Pricing
Fuel Tax

IT/ITS

Total

Rate of Car dependence

Technical Level

Degree of Car dependence

Road Improvement

LEV Ratio

Fuel Economy

CUTE Policy Matrix

7June2012
## Innovating Transport Systems

### CUTE Matrix: (Strategy) x (Instruments)

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Avoid</th>
<th>Shift</th>
<th>Improve</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Instrument</strong></td>
<td><strong>Reduce need to travel</strong></td>
<td><strong>Reduce car use</strong></td>
<td><strong>Improve alternative modes</strong></td>
</tr>
<tr>
<td>Technology</td>
<td>Reduce need to travel</td>
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<td>Improve alternative modes</td>
</tr>
<tr>
<td>TOD</td>
<td>Pedestrian friendly urban design</td>
<td>Rail/bus infrastructure</td>
<td>IMTS</td>
</tr>
<tr>
<td>Regulation</td>
<td>Compact city</td>
<td>Access permits</td>
<td>Bus/tram priorities</td>
</tr>
<tr>
<td>Mix land use</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Information</td>
<td>Teleworking</td>
<td>Car sharing</td>
<td>Bus location system</td>
</tr>
<tr>
<td>Location awareness campaign</td>
<td>IT / ITS</td>
<td>IT / ITS</td>
<td>IT / ITS</td>
</tr>
<tr>
<td>Economy</td>
<td>Locational Subsidy</td>
<td>Fuel tax</td>
<td>Rail/bus fare</td>
</tr>
<tr>
<td>Location</td>
<td>Road pricing</td>
<td>Road pricing</td>
<td>LEV preferential tax</td>
</tr>
<tr>
<td>7 June 2012</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>
## Innovating Transport Systems

### CUTE Matrix: Avoid

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<tr>
<td>Regulation</td>
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<td>Access permits</td>
<td>Bus and tram priorities</td>
</tr>
<tr>
<td>Information</td>
<td>Teleworking</td>
<td>Car sharing</td>
<td>Awareness campaign</td>
</tr>
<tr>
<td>Economy</td>
<td>Location subsidy</td>
<td>Fuel tax</td>
<td>Rail/bus fare</td>
</tr>
</tbody>
</table>

### Key Points:
- **Technology:** Transit Oriented Development (TOD), Railway development
- **Regulation:** Compact city, Mix land use, Access permits, Bus and tram priorities
- **Information:** Telework, Car sharing, Awareness campaign
- **Economy:** Location subsidy, Fuel tax, Rail/bus fare, Road pricing, LEV subsidy, LEV preferential tax

### Cities:
- Tokyo, London, Singapore

### Urban Compaction

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**Note:**
- The table and diagram illustrate strategies and instruments for innovating transport systems with a focus on avoiding the need to travel and reducing car use, improving alternative modes, and enhancing road networks and vehicles and fuels.
Urban Sprawl

Changes in Built-up Areas

Tokyo

Nagoya

London

Bangkok

AVOID

* Result of the study of Nagoya Univ.
Transit Oriented Development

1. Purchased undeveloped land
2. Improved the infrastructure and constructed new railway
   • Supermarket in station, department store in city terminal, leisure site in terminal
3. Sold the land again
   • Restore the development benefits TOD without public investment

New town construction by Tokyu Railway Company
Around Tana Station, Yokohama city

1970

Source:
Left: http://11.pro.tok2.com/~mu3rail/link156.html
http://w3land.mlit.go.jp/WebGIS/index.html
Right: Google maps
## Innovating Transport Systems

### CUTE Matrix: Shift

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<tr>
<td>Information</td>
<td>Teleworking</td>
<td>Car sharing Awareness campaign</td>
<td></td>
</tr>
<tr>
<td>Economy</td>
<td>Locationa l Subsidy</td>
<td>Fuel tax Road pricing</td>
<td></td>
</tr>
</tbody>
</table>

- **Bangkok, Tokyo, Seoul, Shanghai, London**
- Mass Transit System for Urban/Suburban Lines
## Railways Improvement vs Road Congestion

<table>
<thead>
<tr>
<th></th>
<th>Tokyo</th>
<th>Seoul</th>
<th>Shanghai</th>
<th>Singapore</th>
<th>London</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Area (km²)</strong></td>
<td>615 (15,000)</td>
<td>606 (1,900)</td>
<td>600 (2,900)</td>
<td>700</td>
<td>319 (18,000)</td>
</tr>
<tr>
<td><strong>Population (million)</strong></td>
<td>8.8 (35.2)</td>
<td>9.9 (19.9)</td>
<td>10.0 (18.4)</td>
<td>4.5</td>
<td>3.0 (20.0)</td>
</tr>
<tr>
<td><strong>Urban railway (km)</strong></td>
<td>292</td>
<td>338</td>
<td>420</td>
<td>138</td>
<td>652</td>
</tr>
<tr>
<td><strong>Avg car speed (km/h)</strong></td>
<td>26</td>
<td>17</td>
<td>20</td>
<td>32</td>
<td>26</td>
</tr>
</tbody>
</table>

(): 2010 data of urban area in the Metropolitan Region (source: demographia)
Modal share on commuter trip in Tokyo metropolitan area

<table>
<thead>
<tr>
<th>O</th>
<th>D</th>
<th>Inner TOKYO 23Wards</th>
<th>Outer TOKYO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inner</td>
<td>Inner TOKYO 23Wards</td>
<td><img src="chart1.png" alt="Pie chart" /></td>
<td><img src="chart2.png" alt="Pie chart" /></td>
</tr>
<tr>
<td>23</td>
<td>Inner TOKYO 23Wards</td>
<td>Total: 3.07 million trip/day</td>
<td>Total: 0.35 million trip/day</td>
</tr>
<tr>
<td>Wards</td>
<td></td>
<td><img src="chart3.png" alt="Pie chart" /></td>
<td><img src="chart4.png" alt="Pie chart" /></td>
</tr>
<tr>
<td>Outer</td>
<td>Outer TOKYO</td>
<td><img src="chart5.png" alt="Pie chart" /></td>
<td><img src="chart6.png" alt="Pie chart" /></td>
</tr>
<tr>
<td>TOKYO</td>
<td>Total: 3.06 million trip/day</td>
<td>Total: 7.2 million trip/day</td>
<td></td>
</tr>
</tbody>
</table>

- **Car**: 65% (Inner), 46% (Outer)
- **Bus/Tram**: 14% (Inner), 13% (Outer)
- **Rail**: 10% (Inner), 9% (Outer)
- **Walk**: 3% (Inner), 4% (Outer)
- **Cycle**: 8% (Inner), 3% (Outer)
Urban Railway Network

Tokyo

Seoul

<table>
<thead>
<tr>
<th></th>
<th>Tokyo</th>
<th>Seoul</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Line Length</td>
<td>2,313 km</td>
<td>476 km</td>
</tr>
<tr>
<td>City</td>
<td>292 km</td>
<td>338 km</td>
</tr>
<tr>
<td>Hinterland</td>
<td>2,021 km</td>
<td>138 km</td>
</tr>
</tbody>
</table>

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Urban Railway Network

Shanghai

Total Line Length (km) 2,313
City (km) 292
Hinterland (km) 2,021

London

Total Line Length (km) 1,401
City (km) 652
Hinterland (km) 749

<table>
<thead>
<tr>
<th>City (km)</th>
<th>Tokyo</th>
<th>Seoul</th>
<th>Shanghai</th>
<th>London</th>
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</thead>
<tbody>
<tr>
<td>Total Line Length (km)</td>
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<td>2,021</td>
<td>138</td>
<td>309</td>
<td>749</td>
</tr>
</tbody>
</table>

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Situation of Sukhumvit after the opening of Skytrain (2002)
Mass-transit Network of Future Bangkok

2010 84.8km

planning:
2016 236km
2019 391km
2029 509km (12lines)

Master Plan Study to adjust rail mass transit system in Bangkok and its vicinity (2010)
CO2 Emission Reduction from Passenger Car by Railway Development

By 2050, railway will be developed as same level in Tokyo in 2005.

- Without Railway
- Development during mature stage (2030～2050)
- Developed during early stage (2010～2030)

If railway might be developed during early stage, 36% of CO2 can be reduced. If including technological innovation, around 80-86% of CO2 can be reduced.

Without Railway Development during mature stage (2030～2050) Developed during early stage (2010～2030)

SHIFT

Result of the study of Nagoya Univ.
Road vs Rail: which is more effective for mitigation of congestion
# Innovating Transport Systems

## CUTE Matrix: Shift

<table>
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<tr>
<td><strong>Technology</strong></td>
<td>TOD</td>
<td>Pedestrian friendly urban design</td>
<td>MRT development</td>
</tr>
<tr>
<td><strong>Regulation</strong></td>
<td>Compact city</td>
<td>Access permits</td>
<td>Bus priority (BRT)</td>
</tr>
<tr>
<td><strong>Information</strong></td>
<td>Teleworking</td>
<td>Car sharing</td>
<td>IT/ITS operation system</td>
</tr>
<tr>
<td><strong>Economy</strong></td>
<td>Locational Subsidy</td>
<td>Fuel tax</td>
<td>PT fare system</td>
</tr>
</tbody>
</table>

![Diagram](image)

**Singapore & Seoul**

Hierarchically Integrated Transport
Recent Expansion Plan for the City Centre and Railway Network in Singapore

Concept Plan 2001

Marina Bay development (2008)
LRT Integrated with MRT in Singapore

Bukit Panjang LRT
- 8 km, 14 stations
- Opened in 1999

Sengkang LRT
- 11km, 14 stations
- Integrated with Sengkang MRT
- Fully-automated system
- Opened in 2003

Punggol LRT
- 10km, 15 stations
- Integrated with Punggol MRT
- Fully-automated system
- Opened in 2005
Bus Rapid Transit (BRT) in Seoul

**Expansion Plan (13 lines / 192 km)**

Status of Existing Bus Lanes (2005)
- Exclusive median bus lanes: 7 lines/ 84km
- Curbside bus lanes: 293.6km

Source: GyengChul Kim

Before

After

Source: GyengChul Kim
Increase
- Network capacity new bus route +BRT
- Bus ridership
- Bus frequency (Keep Interval)

Decrease
- Total bus operation cost

> Increase    - Bus company revenue
> Decrease    - Subsidy of SMG

Source: GyengChul Kim

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Integrated Bus-Subway Operation in Seoul

- Bus interval management
- Safe operation
- Providing dynamic information to public

---

Bus Rider Data Collection System

Fare Settlement Center

Subway Rider Data Collection System

---

Boarding a BUS
- Line Number
- Stop Location
- Boarding Time
- Type of Riders

Getting off the BUS
- Stop Location
- Time
- Distance Traveled
- Tentative Fares

Transfer to Subway
- Station Location
- Time

Finishing the Trip
- Station Location
- Time, Total Distance
- Final Fares
Electric Fare System (Smart card)

• Distance based fare (no change for transfers)

• Data collection for traffic management

• Non-transit applications (e.g. retail purchases, mileages)

Seoul (2004-)

Singapore (2002-)
Innovating Transport Systems

CUTE Matrix: Shift + Improve

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</tr>
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<td>Improve alternative modes</td>
</tr>
<tr>
<td>Instrument</td>
<td></td>
<td></td>
<td>Improve road network</td>
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<td></td>
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<td></td>
<td>Improve vehicles and fuels</td>
</tr>
<tr>
<td>Technology</td>
<td>TOD</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Compact city</td>
<td>Access permits</td>
<td>TDM</td>
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<tr>
<td></td>
<td>Mix land use</td>
<td></td>
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<tr>
<td>Regulation</td>
<td></td>
<td>Car ownership &amp; parking control</td>
<td>Emission standard</td>
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<td>Telemarketing</td>
<td>Car sharing</td>
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<td>Awareness campaign</td>
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<tr>
<td>Information</td>
<td>Local Subsidy</td>
<td>IT/ITS operation system</td>
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<td>Eco-drive</td>
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<td></td>
<td></td>
<td>IT / ITS</td>
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</tr>
<tr>
<td>Economy</td>
<td>Road pricing</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Car Ownership Control

Singapore

Vehicle Quota System (VQS)
- Introduced in 1990
- Certificate of Entitlement (COE)
  - valid for 10 years
  - Bid the COE

Shanghai

License Plate Auction System
- Introduced in 1997
- Bid license plates of vehicles
- The price exceeds 60,000 yuan ($9,540) in 2012

(Sun, G., LTA)
Off-Street Parking Control in London

- Maximum car parking space by land use
  - Employment car parking standard

<table>
<thead>
<tr>
<th>Location</th>
<th>Marginal floor area (m²) to add one parking space</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central London (CAZ)</td>
<td>1,000 – 1,500</td>
</tr>
<tr>
<td>Inner London</td>
<td>600 – 1,000</td>
</tr>
<tr>
<td>Outer London</td>
<td>100 – 600</td>
</tr>
</tbody>
</table>

Residential car parking standard

<table>
<thead>
<tr>
<th>Predominant housing type</th>
<th>Car parking provision</th>
</tr>
</thead>
<tbody>
<tr>
<td>4+ bed units</td>
<td>2 – 1.5 spaces</td>
</tr>
<tr>
<td>3 bed units</td>
<td>1.5 – 1 space</td>
</tr>
<tr>
<td>1 – 2 bed units</td>
<td>1 to less than 1</td>
</tr>
</tbody>
</table>
On-Street Parking Control in Tokyo

- In principle, parking is prohibited on the road
- Parking meters are installed in some of the road
- Management by the police

Number of cars parked in the streets in Tokyo

[Graph showing the number of cars parked in Tokyo from 2004 to 2010, distinguishing between 4-wheel and 2-wheel vehicles]

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Road Pricing in Singapore

Area Licensing Scheme (ALS)
- Implemented in 1975
- Reduced traffic entering the Restricted Zone (RZ)

Electronic Road Pricing (ERP)
- Implemented in 1998
- Replaced manual ALS
Electronic Road Pricing (ERP)

- ERP is a congestion management tool
- Pay-as-you-use principle
- Review speed range at 3-month interval, adjust ERP rates

Expressways

- Increase ERP rate
- 65 kph
- Decrease ERP rate
- 45 kph

Arterial Roads

- Increase ERP rate
- 30 kph
- Decrease ERP rate
- 20 kph

Application of ITS

traffic.smart

Courtesy of Mohinder Singh, LTA
Road Pricing in London

Congestion Charge
• Implemented in 2003
• The Zone of City Centre
• Exemption introduced in 2011 for LEVs (EURO5, EV/PHV etc)

Low Emission Zone
• Implemented in 2008
• Freight vehicles and coaches
• The whole city (GLA)
• EURO3 standard
# Innovating Transport Systems

## CUTE Matrix: Improve

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<td>LEV</td>
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<td>Locationa l Subsidy</td>
<td>Fuel tax</td>
<td>Rail / bus fare</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Road pricing</td>
<td>Road pricing</td>
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</tr>
</tbody>
</table>

### Japan

**Top Runner Program**

- Emission Standard
- IT / ITS
- LEV subsidy
- LEV preferential tax
Atmospheric Concentrations of NOx and PM around roads in Japan

The “Top Runner” program: Efficiency improvement (Ministry of Economy, Trade and Industry)

Top Runner Program with vehicles

Fuel Efficiency (km/L)

- 15km/L
- 17km/L
- 19km/L

at the time of standards establishment

Target year

Weighted average value for each product category

16

Passenger Vehicles
Freight Vehicles
Air Conditioners
Electric Refrigerators
Electric Freezers
Electric Rice Cookers
Microwave Ovens
Fluorescent Lights
Electric Toilet Seats
TV Sets (CRT, LCD, Plasma)
Video Cassette Recorders
DVD Recorders
Computers
Magnetic Disk Units
Copying Machines
Space Heaters
Gas Cooking Appliances
Gas Water Heaters
Oil Water Heaters
Vending Machines
Transformers

List of the Specified 21 Appliances

Target year

19km/L
18km/L
17km/L
15km/L

14km/L
13km/L
12km/L

7June2012

Hayashi Laboratory, Nagoya University
## Innovating Transport Systems

### CUTE Matrix: Improve

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Avoid</th>
<th>Shift</th>
<th>Improve</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Reduce need to travel</td>
<td>Reduce car use</td>
<td>Improve road network</td>
</tr>
<tr>
<td>Instrument</td>
<td></td>
<td></td>
<td>Improve vehicles and fuels</td>
</tr>
<tr>
<td>Technology</td>
<td>TOD, TOD friendly urban design</td>
<td>Rail/bus infrastructure</td>
<td>IMTS</td>
</tr>
<tr>
<td>Regulation</td>
<td>Compact city, Mix land use</td>
<td>Access permits</td>
<td>TDM</td>
</tr>
<tr>
<td>Information</td>
<td></td>
<td></td>
<td>Eco-drive, IT/ITS</td>
</tr>
<tr>
<td>Economy</td>
<td></td>
<td></td>
<td>IT / ITS</td>
</tr>
</tbody>
</table>

### Japan

- Greening Taxation
- LEV subsidy
- LEV preferential tax

July 2012

Hayashi Laboratory, Nagoya University
Effects of Tax and Subsidy Policies

Fuel economy [km/l]

- Observed Sales base
- Real running Ownership base
- Estimated Greening taxation

No. of vehicles

- Methanol-fueled vehicle
- LPG-fueled vehicle
- Natural gas vehicle
- Hybrid vehicle
- Electrical vehicle

Year

Top Runner Program

Greening taxation

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Hayashi Laboratory, Nagoya University

Yoshitsugu Hayashi, Nagoya University
Increase in Low Emission Cars

[Graph showing the increase in low emission cars from 2004 to 2010.

- HV (Hybrid Vehicles): 1,418,400 (2.54% of total passenger cars)
- EV (Electric Vehicles): 16,800 (0.03% of total passenger cars)

Hayashi Laboratory, Nagoya University]
Scenario for Improvement of Power Source and Fuel in the Case of Bangkok

- Scenario for CO2 Emission Factor Improvement was set based on estimation in Japan
- Production of electricity will be estimated based on scenario “increased use of renewable energy”

**CO2 Emission Factor for Passenger Vehicle**

- Result of the study of Nagoya Univ.
Scenario for Low-emission Vehicle Diffusion

Based on Estimation in Japan, passenger car using gasoline will be 0% with the scenario that motorcycle will sift to passenger car.

* Result of the study of Nagoya Univ.
Identifying A Necessary Policy Package

Extensive Measures Needed for Low-Carbon Transport

Mitigation from:
- AVOID
- SHIFT
- IMPROVE

CO₂ emissions from passenger cars in Bangkok (Mt/year)

Do Nothing

CO₂ mitigation Scenario

70%

Extensive Measures Needed for Low-Carbon Transport

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Comprehensive Strategy to Achieve CO2 Emission Reduction Target

From the view point of energy consumption

Energy Source

Modal Share

Gasoline

Electricity

CNG

Diesel

Public Bus

Rail MC

PC

Biomass

Diesel

CNG

Electricity

Gasoline

From the view point of energy consumption

Electricity

Diesel

CNG

Gasoline

Comprehensive Strategy to Achieve CO2 Emission Reduction Target

-30%

-50%

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Decomposition of Urban Transport Emission

Total Emission = AVOID × SHIFT × IMPROVE

Urban area

Concentration of urban activity

Transport Frequency

Emission

year

Trip Generation

Total Trip Length

Degree of Car dependence

Modal Share

Technical Level

Emission Factor

year

Public Transport Improvement

Road Improvement

Level of congestion

Fuel Economy

LEV Ratio

Emission Factor

year

Avoid

Shift

Improve

Reduce need to travel

Shift to low-emission mode

Improve emission intensity

Compact Development

Development of Public Transport

LEV diffuse

Regulation of Sprawl

Road Pricing

IT/ITS

Fuel Tax

Economy

Technology

Regulation

Information

Policy Matrix

CUBE

Total Trip Length

year

Modal Share

year

Fuel Economy

LEV Ratio

Avoid × Shift × Improve

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Conclusion

• **CUTE Matrix**: (Strategy) x (Instruments) for **Innovating Transport Systems**

• **Decomposition** for understand Urban Transport Emission: **Avoid, Shift and Improve**

• Back-casting approach for seeking **effective combinations**

• Scenario and Roadmap
Conclusion

- To realize the low-carbon society, leapfrog development is necessary in Asian developing cities.
- Thus, the future vision of low-carbon society which will achieve huge reduction of CO2 emission should be established firstly.
- Impacts of each avoid, sift and improve measures should be clarified.
- Then, their effective combinations should be examined through backcasting approach.
- Finally, the available scenario should be set up for the roadmap of each city.