Urban Transport Energy Use in the APEC Region - Phase II

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Study Background

Rising Oil Import Dependence in APEC

- APEC’s net oil import dependence will jump from the current 36 percent to 52 percent by 2030.

Continued Dependence on Oil Products

- The transport sector will continue to drive up oil demand barring a major technological breakthrough.
  - By 2030, the transport sector will lead about 70 percent of incremental oil demand growth.
  - By 2030, oil is expected to continue to be the major energy source for the transport sector.
  - By 2030, road transport is projected to account for about 80 percent of total transport energy demand.

Climate Change and Transport

- Transport is one of the fastest growing sector in terms of CO2 emissions.

  - The IPCC’s fourth assessment report identified modal shift as the key mitigation practices.

Urban Population Growth

- About 25 million population in APEC move from rural to urban areas annually.
# How to reduce oil use in the transport sector

<table>
<thead>
<tr>
<th></th>
<th>Policy Instruments</th>
<th>Economic Instruments</th>
<th>Technology/Infrastructure</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Land Use</strong></td>
<td>Urban Planning, Zoning Regulation, Parking Requirements</td>
<td>Fixed Property Tax (?)</td>
<td>Mass Transit System, Road Infrastructure Development</td>
</tr>
<tr>
<td><strong>Traffic Flow</strong></td>
<td>Traffic Demand Management, Priority Lanes for Buses</td>
<td>Road Pricing</td>
<td>Intelligent Transport System (ITS), Teleworking?</td>
</tr>
<tr>
<td><strong>Fuels</strong></td>
<td>Regulation for Emissions</td>
<td>Gasolin/Diesel Tax</td>
<td>(Technology for Refinery)</td>
</tr>
</tbody>
</table>
Findings from the phase I
Findings - from the first phase of study

- Passenger transport energy consumption results from diverse socioeconomic factors.
  - Income, Length of road
  - Accessibility to alternative transport modes
  - Urban form, population density

- Accessibility to rail/subway is the key component that can reduce passenger vehicle dependence and improve energy intensity of the urban passenger transport sector in Asia.

- City planners, especially at the early stage of development, need to appropriately assess their future transport requirements and plan appropriate timing in investment towards rail/subway infrastructure.

- Smaller systems in the US require twice as much energy per passenger-km as an automobile requires, while larger ones utilise less energy per passenger-km as an automobile requires.
  - System ridership is the key to improve energy intensities of urban mass transit systems.
Cities in Group I represent relatively high accessibility to subway/rail stations – key to offset growth in road energy consumption.

Cities in Group II have relatively high vehicle stocks compared with income levels, while accessibility to subway/rail is low.

Cities in Group III are at the early stage of development.

(Source) APERC Analysis (2007)
Transport Energy Intensities in the US Cities
(Average 2002 and 2005)
Energy Requirements to Produce Electricity for Rail/psk vs Bus/Car Energy/psk

(Source) APERC Analysis (2007) based on data from National Transit Bureau
(Note) Energy intensities for heavy rail, light rail and commuter rail represent energy requirements to produce electricity for a unit of passenger km.
Findings from the phase II
Study Objectives in the Second Phase

- To analyse energy/CO$_2$ intensities of urban mass transits in the major APEC cities
- To analyse financial performance of mass transits
- To quantify socio-economic benefits of mass transits
- To analyse the institutional issues in developing urban mass transits
Urban Mass Transit Energy Intensities in the APEC Region

APEC passenger-vehicle average intensity

(Source) APERC Analysis (2008)
Urban Mass Transit CO₂ Intensities in the APEC Region

Urban Mass Transit Carbon Dioxide Emission Intensity in the APEC Region
(2000-2006 averages)

(Source) APERC Analysis (2008)
# Urban Mass Transits - Characteristics by Mode

<table>
<thead>
<tr>
<th></th>
<th>Metro</th>
<th>Light Rail</th>
<th>Suburban Rail</th>
<th>Bus Rapid Transits</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Initial Capital Cost</strong></td>
<td>15-30 at-grade</td>
<td>10-30</td>
<td>-</td>
<td>1-5</td>
</tr>
<tr>
<td>(Million US$/km)</td>
<td>30-75 elevated</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>60-180 underground</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Capacity</strong></td>
<td>60,000</td>
<td>10-12,000</td>
<td>30,000</td>
<td>10-20,000</td>
</tr>
<tr>
<td>(Passenger/hour/direction)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Operating Speed</strong></td>
<td>30-40</td>
<td>20</td>
<td>40-50</td>
<td>17-20</td>
</tr>
<tr>
<td>(km/hour)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Construction Time</strong></td>
<td>10 Years for</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>(Years)</td>
<td>19km Line</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Risks affecting Mass Transit Projects

- Cost overrun during construction period
  - Unexpected ground conditions
  - Rise in material and equipment costs
  - Disruption in financial and labour supply

- Lower number of passengers than expected
  - Planners tend to produce overly optimistic passenger numbers
    - Real ridership of mass transits in Asia (Bangkok, Manila and KL) in the first year - about 25 percent of forecast

- Currency risk
  - Financial crisis in Asia -> huge debt repayment problem
Financial Performance of Major Rail Systems

Generally, fare revenue does not cover the expenditure.

Hong Kong, Taipei, Tokyo systems add extra revenue through business diversification.

<table>
<thead>
<tr>
<th>City</th>
<th>Revenue</th>
<th>Expenditure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bangkok</td>
<td>$5.87</td>
<td>$1.90</td>
</tr>
<tr>
<td>Hong Kong</td>
<td>$3.51</td>
<td>$4.17</td>
</tr>
<tr>
<td>Manila</td>
<td>$2.00</td>
<td>$1.68</td>
</tr>
<tr>
<td>SF Bay (BART)</td>
<td>$6.54</td>
<td>$1.04</td>
</tr>
<tr>
<td>Seoul (SMRT)</td>
<td>$0.52</td>
<td>$0.90</td>
</tr>
<tr>
<td>Singapore (SBS)</td>
<td>$0.72</td>
<td>$0.61</td>
</tr>
<tr>
<td>Singapore (SMRT)</td>
<td>$0.46</td>
<td>$0.80</td>
</tr>
<tr>
<td>Taipei</td>
<td>$2.20</td>
<td>$1.30</td>
</tr>
<tr>
<td>Tokyo (Toei)</td>
<td>$1.42</td>
<td>$1.30</td>
</tr>
<tr>
<td>Tokyo (Metro)</td>
<td>$0.80</td>
<td>$1.00</td>
</tr>
</tbody>
</table>

(Source) APERC Analysis (2008)
Costs and Benefits of Mass Transits

- **Costs**
  - Capital investment
  - Operational cost
  - Interest payment

- **Benefits**
  - Energy saving
  - CO₂ emissions saving
  - Time saving
  - Vehicle operational cost saving
Costs and Benefits of Mass Transits - Framework of the Analysis

Macro Economic Assumptions by 2030 (GRP, Population)

Provision of Mass Transit’s Target Share in Modal Split (2030)

Passenger Demand (person-trip, person-km)

With Mass Transits Case
- Energy
- CO2 Emissions
- Time
- Vehicle Use

Without Mass Transits Case
- Energy
- CO2 Emissions
- Time
- Vehicle Use

Infrastructure Requirements (Length)

Capital Investment

Operational Costs

Ticket Price

Net Savings $ \times$ Monetary Value

Economic Internal Rate of Return (EIRR) and Financial Internal Rate of Return (FIRR) Estimation
Infrastructure requirements are estimated based on the following equation.

\[ Y = 0.0766 + 1.509 \times X \]

- **Y**: Length of metro/urban land area
- **X**: Metro Share in Modal Split

(Source) APERC Analysis (2008)
## Basic Assumptions

<table>
<thead>
<tr>
<th></th>
<th>Bangkok</th>
<th>Hanoi</th>
<th>Jakarta</th>
<th>Manila</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2005</td>
<td>2030</td>
<td>2005</td>
<td>2030</td>
</tr>
<tr>
<td>Target Metro Share in Modal Split [%]</td>
<td>4%</td>
<td>20%</td>
<td>0%</td>
<td>10%</td>
</tr>
<tr>
<td></td>
<td>2005</td>
<td>2030</td>
<td>2005</td>
<td>2030</td>
</tr>
<tr>
<td>Metro Length [km]</td>
<td>43</td>
<td>197</td>
<td>108</td>
<td>132</td>
</tr>
<tr>
<td></td>
<td>2005</td>
<td>2030</td>
<td>2005</td>
<td>2030</td>
</tr>
<tr>
<td>Urban Land Area [km²]</td>
<td>700</td>
<td>636</td>
<td>661</td>
<td>636</td>
</tr>
<tr>
<td></td>
<td>2005</td>
<td>2030</td>
<td>2005</td>
<td>2030</td>
</tr>
<tr>
<td>Income [US$ PPP, 2000]</td>
<td>25,896</td>
<td>37,574</td>
<td>1,599</td>
<td>10,215</td>
</tr>
<tr>
<td></td>
<td>2005</td>
<td>2030</td>
<td>2005</td>
<td>2030</td>
</tr>
<tr>
<td>Urban Population [Million]</td>
<td>5.5</td>
<td>7.1</td>
<td>3.2</td>
<td>7.0</td>
</tr>
</tbody>
</table>

(Source) APERC Analysis (2008)
EI RR/ FIRR Comparisons - Bangkok, Jakarta, Manila and Hanoi

- **Bangkok**
  - EIRR: 15%
  - FIRR: 15%

- **Jakarta**
  - EIRR: 15%
  - FIRR: 15%

- **Manila**
  - EIRR: 15%
  - FIRR: 15%

- **Hanoi**
  - EIRR: 15%
  - FIRR: 15%

**Ticket Price per Passenger (USD)**

- **Thailand's central bank lending rate**
  - 5%

- **Indonesia's central bank lending rate**
  - 5%

- **Viet Nam's central bank lending rate**
  - 5%

**Philippines' central bank lending rate**
- 5%
Net Savings Comparison - Bangkok, Jakarta, Manila and Hanoi

- **Oil Saving**
  - Bangkok, Jakarta, Manila, Hanoi
  - 2005 to 2030

- **Time Saving**
  - 2005 to 2030

- **CO2 Saving**
  - 2005 to 2030

- **Vehicle Use Saving**
  - 2005 to 2030

Source: Asia Pacific Energy Research Centre (APERC), Tokyo
Passenger per km and Oil Saving (Mtoe) - Bangkok and Manila

Bangkok (Metro Share Target: 20% in 2030)

- Avoided Energy/Oil Demand
- Passengers per km

1 Mtoe = About 30% of Bangkok’s gasoline consumption in 2005.

Manila (Metro Share Target: 15% in 2030)

- Avoided Energy/Oil Demand
- Passengers per km

1.3 Mtoe = About 30% of Manila’s gasoline consumption in 2005.

Densely populated cities have a big potential to save energy.
Institutional Issues

- Jakarta
  - Lack of coordination between different bus systems

- Manila
  - Weak coordination among the government agencies on transport
    - Central level
    - Central – Local levels
      - Various agencies compete for a same project
Conclusions - 1

- Urban mass transits can serve as an effective tool to improve energy intensity of urban transport, and to reduce CO₂ emissions. However, mass transits’ energy/CO₂ intensities within APEC cities vary greatly.
  - Ridership - Urban density, operational frequency and infrastructure accessibility
  - Power generation characteristics - thermal efficiency, and generation mix

- Planners and transit operators need to make efforts to increase ridership to fully realise the mass transit’s effectiveness in terms of energy/CO₂ intensity improvement.
  - System frequency, intra-system physical integration and fare system integration

- Despite the perceived benefits of mass transit systems, their financial performance tends to be low. Again, efforts are necessary to increase ridership, and government assistance is necessary to help support the financial aspect.
  - Subsidy
  - Low interest rate
**Conclusions - 2**

- Change in lifestyle – away from passenger vehicle dependence to mass transits - takes long time, typically requiring two decades.
  - Planning, pre-feasibility study, feasibility study and construction

- Earlier implementation of mass transit project may lead to bigger socio-economic benefits from the savings for time loss, energy use, CO$_2$ emissions and vehicle use costs.

- In addition, higher income cities with higher population density may enjoy larger socio-economic benefits.

- Therefore, planners need to assess the appropriate timing for introducing urban mass transits, and the appropriate mass transit modes based on the city context.
  - Economic development and density

- Planning for urban transport should be an integral part of energy and environmental policy.
  - Inter-agency coordination