Working Paper: Consultation Draft

Energy Efficiency and Climate Change Considerations for On-road Transport in Asia

May 19, 2006

This working paper was prepared under TA - 6261 (REG) : Energy Efficiency Initiative Consultation Workshop - Transport, Energy Efficiency and Climate Change by John Rogers (jarogers@adb.org) with contributions from Jerome Weingart, Charles Melhuish and Cornie Huizenga and may not reflect the views of ADB's Board of Directors. Comments may be submitted to Cornie Huizenga (chuizenga@adb.org) by 8 June, 2006

Asian Development Bank

ABBREVIATIONS

A/C	–	Air Conditioning
BRT	–	Bus Rapid Transit
CAI-Asia	–	Clean Air Initiative for Asian Cities
CDIAC	–	Carbon Dioxide Information Analysis Center, US DOE
CDM	–	Clean Development Mechanism
CI	–	Level of statistical certainty
CNG	–	Compressed Natural Gas
CO	–	Carbon Monoxide
CO_2	–	Carbon Dioxide
DFID	–	United Kingdom's Department for International Development
DMC	–	Developing Member Country
DPF	–	Diesel particle filter
EEI	–	Energy Efficiency Initiative
EPA	–	United States Environmental Protection Agency
EU	–	European Union
EURO	–	European emissions standards
G8	–	Group of Eight
GDP	–	Gross Domestic Product
GEF	–	The World Bank's Global Environment Fund
GNI	–	Gross National Income
GHG	–	Greenhouse Gas
HC	–	Hydrocarbons
HD	–	Heavy Duty
LD	–	Light duty
I&C	–	Inspection and certification
LPG	–	Liquefied Petroleum Gas
NGO	–	Non-governmental organization
NMT	–	Non-motorized transport
NOx	–	Nitrogen oxides
OECD	–	Organization for Economic Co-operation and Development
OEM	–	Original Equipment Manufacturers
PM	–	Particulate Matter
ppm	–	Part per million
PPP	–	Purchasing power parity
PRC	–	People's Republic of China
SCR	–	Selective catalytic reduction
SUV	–	Sport utility vehicle
UN	–	United Nations
UNFCCC	–	United Nations Framework Convention on Climate Change
USA	–	United States of America
WRI	–	World Resources Institute
WTW	–	Well to wheel

CONTENTS

I. RATIONALE

1. Stabilizing and reducing atmospheric greenhouse gas concentrations is essential to global sustainability and this will require intensified and ongoing efforts to increase overall global energy efficiency and a shift from fossil fuels to non-carbon energy sources.. The improvements in global energy efficiency need to be achieved in a context of a growing population and economy. In July 2005, the Group of Eight (G8) adopted the Gleneagles' Action Plan on Climate Change, Clean Energy and Sustainable Development. This Action Plan called for substantial improvements in Energy Efficiency and aims to shift a growing share of investment towards cleaner or more efficient energy technologies. Within this framework, the Asian Development Bank (ADB) has undertaken analytical work that will eventually lead to the formulation of a policy framework to guide investments and address energy efficiency and climate change in the transport sector in Asia. This paper is the first step in the formulation of such a policy framework[1].

A. Relevance of energy efficiency and climate change for on-road transportation in Asia

2. There is now extensive evidence, accepted by the international scientific community that the world is getting warmer with an increase in global average surface temperature of about 0.6°C over the 20th century (Pachauri, 2006) (see Figure 1). The atmospheric concentration of carbon dioxide (CO_2) has increased by 31% since 1750 to levels that have not been exceeded during at least the past 420,000 years.

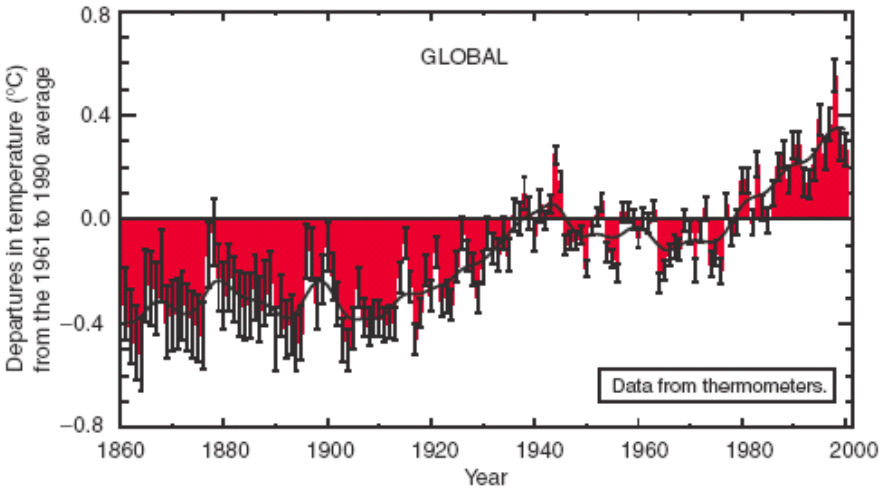


Figure 1 –Variations in the surface temperature of the planet over the last 140 years

Source: IPCC, 2001

3. While such a temperature change may seem modest it is now accepted that this is producing changes in our climate system that include an increase in precipitation in the Northern Hemisphere over most mid- and high latitudes accompanied by a decrease in rainfall

[1] ADB acknowledges the support provided by DFID for the formulation of this paper

over much of the sub-tropical land areas[2]. Warm episodes of the El Niño-Southern Oscillation phenomenon have been more frequent, persistent and intense since the mid-1970s, compared with the previous 100 years. These changes, which affect sustainable development and have severe equity implications, have been demonstrably and strongly linked to increasing anthropogenic activity and greenhouse gas (GHG) emissions[3] that principally derive from an unprecedented increase in carbon-based-energy consumption. In Asia these impacts on rainfall and agriculture are believed to be significant in addition to the overall threats for low –lying islands and coastal areas, some of which are densely populated.

4. The transport sector in 2002 used 21% of the worldwide all-sector total energy consumption and is projected to generate over 60% of the increase in total energy use through to 2025. The emerging Asian nations[4] are projected to provide much of that future growth in oil consumption – and Greenhouse Gas (GHG) emissions -- due to their strong economic and population growth. Emerging Asia (including China and India) is expected to account for 45 percent of the total world increase in oil use through to 2025 as the gap between their economies and the mature market economies substantially narrows. China's energy use for transportation is projected to grow by 6 - 9 percent per year and in India, energy demand in the transportation sector has been projected to grow at 5 - 8 percent a year over this period[5].

5. The emerging Asian economies are a net oil importer – in 2004 over half of their consumption was imported[6] -- and until recently, several governments in the region have not reflected the true increase in fuel prices to protect consumers from the impact of soaring oil costs but this has placed increasing pressure on their national budgets and balance of payments. The continued use of fuel subsidies, in Asian countries, apart from their direct costs[7], has the side-effect of retarding the development and diffusion of more fuel-efficient and cleaner technologies and policies, which hurts both global and local environmental sustainability.

6. Increasing energy efficiency in the road-transportation sector -- and the GHG emissions that it produces -- is crucial to resolving these issues. This document discusses four complementary approaches to achieve this in Asia. These approaches for the short -, medium – and long term are situated against a backdrop of rapidly increasing population and wealth and accompanied by the pressure of increasing personal mobility and the urgent need to eradicate poverty:

i. Improving the energy efficiency of individual vehicles, to increase the distance traveled per unit of fuel,
ii. Modal shift that promotes lower fuel consumption per passenger- or freight-kilometer traveled,

---

[2] Snow cover and ice extent have decreased, global average sea level has risen and ocean heat content has increased leading to increasing precipitation in the Northern Hemisphere over most mid- and high latitudes by a statistically significant 0.5 to1% per decade accompanied by a decrease in rainfall over much of the sub-tropical land areas by about 0.3% per decade during the 20th century

[3] particularly carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), halocarbon gases (e.g., $CFCl_3$ and CF_2Cl_2), and some other synthetic compounds (e.g., perfluorocarbons)

[4] Emerging Asia is used in this review to include China, India Bangladesh, Bhutan, Cambodia, Indonesia, Lao People's Democratic Republic, Malaysia, Nepal, Pakistan, Philippines, Sri Lanka, Thailand and Viet Nam.

[5] lower growth forecasts by the US Energy Information Administration International Energy Outlook 2005; Higher growth forecasts are shown in appendices 2 & 3.

[6] 2004 production of oil 7176 thousand barrels daily (8.9% world total) and consumption of oil 14,870 thousand barrels daily (18.4% world total) (British Petroleum Statistical Review of World Energy June 2005)

[7] In Malaysia despite increasing retail prices, and a reduction in subsidy levels the government expects fuel subsidies to have cost almost $ 2.2 billion in 2005, compared to $ 4.8 in 2004

iii. Urban design that reduces the need to travel, requiring fewer passenger- or freight-kilometers; and by
iv. Changing to fuels with lower GHG emissions.

B. Rationale for the development community

7. The overarching agenda of the international development community[8] is poverty alleviation. Economic growth is essential to overcome poverty. This should, however, not be at the expense of the environment and the chances of future generations to utilize Asia's natural resources. Emerging Asian economies are trying to cope with high energy demands and oil prices, which threaten to slow down economic growth. At the same time, as outlined above, the growing energy use by the transport sector is increasingly contributing to climate change. A major effort is needed in Asia, from all stakeholders, including the international development community to promote on-road transport energy efficiency and fuel diversity. Such an effort must include the goal of reducing the Asian growth-induced pressure on climate change.

8. Promoting energy efficiency, fuel diversity and climate change friendly actions transcends the boundaries of energy policy. Policies on transportation, technology, environment, finance competition and investment all have an important role to play. Whilst funding for economic development is dominated by private investment, the international development community is an important source of policy and technical advice to developing countries on these issues and functions as a catalyst for improving the use of resources in responding to the energy development challenge and dealing with climate change and adaptation. It has a particularly important role to play in enabling private participation by assisting client country governments establish and maintain clear and comprehensive legislative and regulatory systems that bring financial and technical rigor to these projects and reduce the risk to potential lenders and investors. To support efforts by countries in the Asian region the international development community must focusing more systematically on energy efficiency and climate change and step up its initiatives to strengthen its technical capacity and better align its lending framework.

9. In recognition of this situation, ADB has already initiated substantive initiatives in the areas of energy efficiency and clean air (i.e., Energy Efficiency Initiative [EEI] and Clean Air Initiative for Asian Cities (CAI-Asia) and has made good progress in starting to address energy efficiency in the industrial and power sector[9]. However, based on an analysis of ADB lending of 11.228 billion dollars to the transport sector over the last 5 years[10] limited specific attention has been given to the climate impacts of transport.

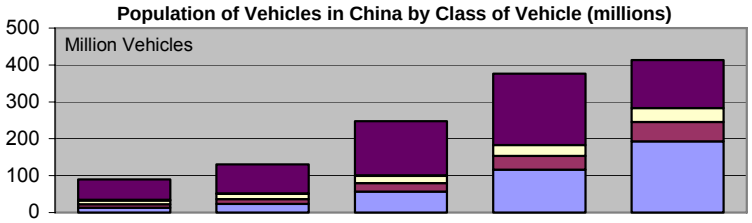
C. Rationale for the developing countries in Asia

10. Countries in emerging Asia are all pursuing policies to achieve economic growth -- which is essential to overcome poverty – led by China and India, which if they are able to fulfill their potential, are likely to become a dominant force in generating spending growth over the next few decades possibly even exceeding the gross national product of the US and Japan (for China and India respectively) in less than a generation. This, however, should not be at the expense of

[8] The development community includes multilateral and bilateral development organizations as well as international foundations and NGOs with a mandate to assist developing countries in their economic and social development.
[9] See http://www.adb.org/Documents/PIDs/39578022.ASP and http://www.cleanairnet.org/caiasia/1412/channel.html
[10] 2000 to 2005

the environment and the chances of future generations to utilize each country's natural resources.

11. All countries in emerging Asia currently have low levels of personal motorization (which in many cases is based on 2-wheelers) that is likely to increase drastically as they achieve this economic growth due to a marked increase in urban population and an increasing ability to buy 4 wheelers (cars and SUVs). The increase in demand for 4 wheelers in Asian cities is expected to grow faster than GDP.

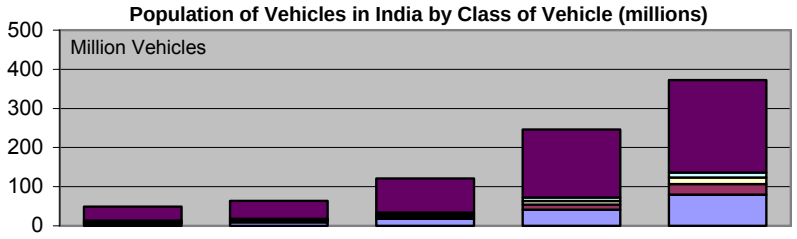


Population	2005	2008	2015	2025	2035
2-W	55.3	78.1	146.7	193.2	130.4
3-W	2.0	1.5	1.7	0.3	0.0
HCV	10.4	13.9	19.9	29.3	37.5
LCV	9.4	13.1	22.8	37.7	52.9
Car, SUV	12.9	23.4	56.8	115.8	192.7
Grand Total	90.0	130.0	248.0	376.4	413.6

Figure 2 – Forecast of vehicle populations in China[11]

12. Under a business-as-usual (BAU) scenario, the active population of cars and SUVs in China is forecast to grow to 15 times its present size in 30 years (from 12.9 million in 2005 to around 193 million in 2035; see Figure 2) whilst in India the expected increase is a mere 13 times (from 6.2 million in 2005 to around 80 million in 2035; see Figure 3). However India is expected to have a population of 236 million motorcycles (2-W) in 2035, up from 35.8 million in 2005 which reflects a larger increase than China (6.6 times for India vs. 2.4 times for China) which grows from 55.3 to 130 million in the same period. This difference reflects both the cultural and purchasing power differences between the two economies.

[11] The forecasts used in Figures 2 and 3 were developed by Segment Y plc (www.segmenty.com) based on the Goldman Sachs economic forecast in their "Dreaming with BRICs" report. In the graphs, motorcycles are shown as 2-W; 3-W are three wheelers, HCV are Heavy Duty Commercial Vehicles, LCV are Light Duty Commercial Vehicles and cars and SUVs are self explanatory.



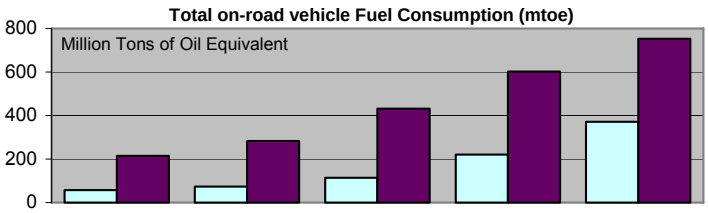
Population	2005	2008	2015	2025	2035
2-W	35.8	46.1	87.7	174.1	236.4
3-W	2.3	3.0	5.3	8.8	13.1
HCV	2.4	2.9	4.6	9.1	16.2
LCV	2.4	3.2	5.7	12.5	26.9
Car, SUV	6.2	8.8	18.0	41.6	80.1
Grand Total	49.1	63.9	121.3	246.1	372.7

Figure 3 - Forecast of vehicle populations in India

13. Such a projected increase in number of vehicles of a greater than order-of-magnitude increase in car population, will add significantly to the current congestion in the major metropolitan areas and will add to urban air pollution and a lack of road safety. Even if investment and land[12] were available, it is infeasible to consider building road infrastructure at a rate that matches the forecast growth of urban vehicle populations.

14. Economic growth which includes stimulated internal demand requires lengthening supplier and distribution chains and most of this increased required capacity in passenger and freight inter-city movement will be delivered by road transport. Thus emerging Asian economies will be faced with increasing energy demands from on-road transport that is based almost exclusively on petroleum fuels whose high prices place an increasingly heavy burden on growth and concerns for energy security.

15. Under this business-as-usual (BAU) scenario, the total fuel consumption of on road vehicles in China can be expected to grow three and a half times over the next 30 years whilst for India the fuel consumption in 2035 will be over six times that in 2005 as shown in Figure 4. These growth rates are less than those of the in-use population itself due to the anticipated improvement in vehicle fuel efficiency[13].



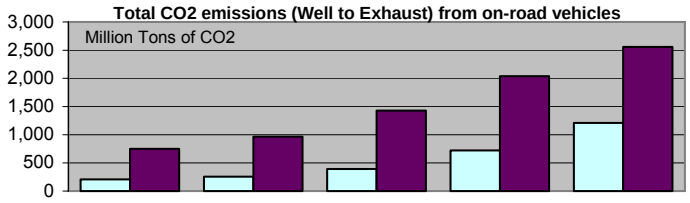
Economy	2005	2008	2015	2025	2035
China	215	284	431	602	753
India	58	73	115	221	371

Figure 4 - Total on-road vehicle Fuel Consumption (mtoe)

[12] Land availability is particularly seen as a constraint to road construction. The practice of constructing multi-layered express ways is increasingly seen as negatively affecting the quality of life and thereby also the economic attractiveness of such cities.

[13] The BAU calculations were performed using the IEA/SMP Reference Case Projection Model , L. Fulton, IEA / G. Eads, CRA; July 2004 together with the Segment Y population projections

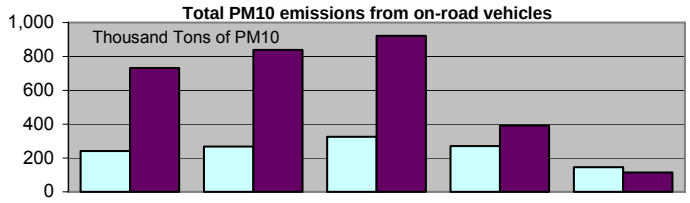
16. Correspondingly, the CO2 emissions from on-road transport can be expected to increase by 3.4 times for China and 5.8 times for India over the 30-year period to 2035 (see Figure 5).



Economy		2005	2008	2015	2025	2035
China		752	967	1,429	2,039	2,557
India		208	256	391	721	1,212

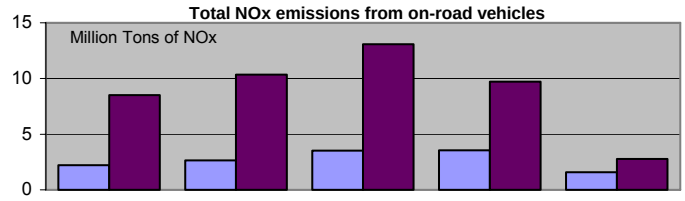
Figure 5 - Total CO_2 emissions (Well to Exhaust) from on-road vehicles

17. Expected changes in vehicle technology, however are manifested in the reduction of PM10 and NOx emissions over this period as evident in figures 6 and 7.



Economy		2005	2008	2015	2025	2035
China		732	839	922	392	115
India		241	268	326	271	147

Figure 6 - Total PM_{10} emissions from on-road vehicles



Economy		2005	2008	2015	2025	2035
China		8.5	10.3	13.1	9.7	2.8
India		2.2	2.6	3.5	3.6	1.6

Figure 7 - Total NOx emissions from on-road vehicles

18. Such considerable increases in the number of vehicles, congestion and consumed fuel threaten to severely limit the quality of life and economic growth of emerging Asia unless a different development scenario is applied in terms of on-road transport. A major effort will be required in emerging Asia, to promote the use of more efficient transport systems and fuel diversity to reduce this growth-induced pressure on both their national and metropolitan levels.

19. At the same time, as outlined above, the growing energy use by the transport sector is increasingly contributing to climate change which will have severe implications for low-lying areas in the region and will require substantial adaptation in many other areas.

20. None of these issues can be solved by one measure alone. A broad range of policies and actions with complementary co-benefits will be required to systematically address these energy efficiency and climate change concerns. The overriding rationale for most Asian countries at their national level will be energy security although the larger countries in emerging Asia are duly concerned about climate change; whilst at the metropolitan area, municipal and local levels it will be congestion, air quality and traffic safety.

D. Rationale for the private sector

21. Most of the investment in the transport sector in Asia and many of the actions required to reduce the climate change effects of on-road transport will be made by the private sector. Thus it is essential that a clear long-term signal is given of the way forward; with predictable and transparent regulations and policies. The analysis presented in this report indicates that policies and regulations for the transport sector in Asia can not be incremental in nature and that a paradigm shift is required in the thinking on mobility in Asia. Only by eliminating or reducing the risk associated with the paradigm shifts needed to systematically resolve all the problems associated with growing motorization will the private sector be in a position to invest and act in a timely manner and to the required extent.

II. TRENDS AND CHALLENGES IN ASIA

22. Emerging Asia is one of the most rapidly changing areas in the world and this directly impacts the global and local emissions from the region's on-road transportation.

A. Population growth and urbanization

1. Rapidly increasing growth in population and GDP in Asia

23. Of the approximately 6.5 billion people on the planet today, half live in emerging Asia (including India and China), compared with only about one-in-five that lives in the more developed regions[14]. By 2030 the world's population is projected to grow to around 8.2 billion people and the population of emerging Asia is expected to increase by more than 750 million (for a total of over 4 billion) (UN, 2004).

24. Economic and energy-demand growth (and GHG emissions) are tightly linked, so it is important to look at the region's expected growth in GDP. Emerging Asia's robust economic expansion is expected to continue with the rapidly expanding economies of China, India, Indonesia and Malaysia, leading emerging Asia to an average annual growth through 2030 of more than 5 percent. This will create a combined output that will approach that of Europe (IPCC, 2001). Such sustained high economic growth will be accompanied by rising incomes and

[14] More developed regions comprise Europe plus Northern America, Australia/New Zealand and Japan (see UN definition of regions).

consumption[15]. The main engines of growth are expected to be China and India, which in 2006 are expected to have a growth of 9.2% and 6.6% respectively. India has been the second-fastest growing economy in the world over the last 15 years – after China -- and surpassed the US in 2005 to become the second most preferred economy in which to invest[16].

2. Population growth and uncontrolled urbanization

25. Whilst the population of China is expected to grow from 1.27 billion in year 2000 to 1.44 billion by 2025 (13% growth) its urban population is expected to increase from 35.8% (in 2000) to 57.2% (and combining the two effects gives an 81% growth in people living in cities). India's total population is expected to grow even more (37% from 1.02 to 1.40 billion) in the same period to almost match China and its urban population is expected to increase from 27.7% (in 2000) to 37.8% (combined 87% growth in people living in cities). The urban population of the other countries in emerging Asia is expected to double in the same time-span (UN, 2004). The future urban population growth in most Asian countries will drive increasing motorization and will have serious consequences for urban road congestion and air pollution as vehicle numbers continue to grow.

26. This overall urban expansion will be reflected in large city growth. Already, emerging Asia contains 10 of the world's 25 largest cities, and these are among the fastest growing[17]. Projected populations of the largest cities in emerging Asia in 2015 show four (Bombay, Shanghai, Jakarta and Karachi) in the 20-30 million range and a further nine cities with 10-20 million[18].

27. ADB has estimated that 80% of the region's new economic growth will be generated in its urban economies (Lohani, 2005a) since these provide the bulk of jobs and employment opportunities. A large number of their residents however will remain poor. About 70% (or 800 million) of the world's poor live in Asia and although poverty is widely considered to be a rural phenomenon, the incidence of urban and peri-urban poverty is significant and growing; about 240 to 260 million poor people in Asia reside in urban areas (Lohani, 2005b).

28. The rapid growth in urbanization in Asia has been to a large extent, poorly- or un-planned. Most Asian cities lack effective metropolitan-area land-use planning due to weak institutional capacity, lack of political will and overlapping or conflicting institutional mandates. They are inadequately prepared to design and achieve a city-wide urban development that reduces the travel demand whilst coping with this explosive growth. This has led to accelerating ad-hoc urban sprawl which together with the increase in purchasing power has generated a pressure for enhanced personal mobility which is being met by rapidly increasing motorization. In the case of emerging Asia this has often resulted in purchasing 2-wheelers, which provide cheap and readily-accessible personal mobility. These now dominate the vehicle fleet in terms of absolute numbers in almost all of the cities and countries in Asia.

29. With the historic emphasis on managing traffic growth rather than reducing travel demand, most Asian countries – with notable exceptions such as Singapore -- have not resolved how to internalize the externalities of personal transport – which is "subsidized" in the

---

[15] Ifzal Ali, ADB's chief economist. Quoted on Sept 10 2005, Asia Times (2005).
[16] According to the AT Kearney FDI Confidence Index the ranking is 1-China, 2-India, 3-US. See: http://www.atkearney.com/main.taf?p=5,3,1,89
[17] WRI 1996
[18] World Bank 1998

sense that car owners (who are the minority in the population) do not pay the full cost of the resources they use or the congestion and pollution that they cause for the vast majority of passengers who have to travel by public transport. The impact of one person is small but when totaled across the population of vehicle-owners this presents considerable harm to society. This will only be resolved when urban growth is designed and managed in a way that promotes equity and improves access to goods and services whilst minimizing travel demand.

B. Transport Demand

30. Over the short term, the sensitivity of demand for vehicles to changes in GDP and in vehicle price is somewhat elastic as their purchase can often be delayed but in the long term it has low elasticity indicating that personal mobility is considered by many as essential to everyday living[19], and that it has few substitutes. In emerging Asia the price elasticity of demand for automotive fuel is slightly larger (in absolute value) than in the OECD countries, but even so, in the long-run it is inelastic (less than -0.6).In the short term, the sensitivity of gasoline demand to price tends to be very low (around -0.2) although in the longer term it may affect the decision of what size car to buy.

31. This indicates that fuel and vehicle taxation by themselves will have a less than direct impact on traffic demand (e.g.: a 10% increase in fuel prices may change the liters of fuel sold by less than 6% and vehicle-kilometers traveled by even less) and thus other measures are required as well to stem the tide of explosive growth in personal motorization and the externalities it produces.

32. There are several successful examples of transport demand management practices being enforced to shift at least part of the burden of pollution and congestion to those that produce it, but these have yet to be widely adopted.

33. The vehicle quota system in Singapore employs an open bidding process for certificates of entitlement (to own a vehicle); this is combined with a high initial registration cost (around 150% of the vehicles market value), annual road tax that increases with engine capacity and has a surcharge for older vehicles, and Electronic Road Pricing based on a spatial and temporal pay-as-you-use principle to control the movement of vehicles and ensure that congestion does not worsen. In other cities, road and congestion pricing programs, park and ride schemes and even parking fees may be used to control the movement of private motor vehicles to areas with high vehicle concentration like business districts to address congestion and access problems. At the same time this makes available an auxiliary source of funds for public transport improvements.

[19] In developed economies the short-term price elasticity of demand for cars is around -1.2 to -1.5 whilst the long-term elasticity is around -0.2 and it is expected to be not very different in emerging Asian economies. Source: Lester D. Taylor, *Consumer Demand in the United States*, 1929-1970 (Cambridge: Harvard University Press, 1966,1970); Douglas R. Bohi, *Analyzing Demand Behavior* (Baltimore: Johns Hopkins University Press, 1981)

Shanghai's Comprehensive Transportation Plan[1]

Amongst major Chinese cities, Shanghai has one of the lowest ratios of cars to population even though it has one of the highest GDP per capita. This situation has been achieved through a deliberate effort by the municipal government to preserve the city's character and environment largely through the use of regulations, incentives, and fees. Under the current five-year plan, the policy to expand automobile ownership and use is coordinated at the national level and Shanghai is therefore in the process of adjusting its planning to allow for the implications of the expected population and motorization growth.

In 1992 a consortium of municipal organizations completed the Shanghai Comprehensive Transportation Planning system, SCTP1. Since then, the population and the state of motorization have changed as a result of the economic development policies. At the end of 2000 a revised plan, SCTP2, was announced, based on the second citywide transportation research survey in 1995 and a series of other commissioned studies.

These studies highlighted a series of specific problems with the current transportation system:

- The different travel modes within the public transportation system lack integration.
- Insufficient capacity of roads and rail network coverage.
- The public transport service level is low; because the roads are crowded, bus schedules lag (and compete ineffectually with bicycles and motorcycles) and the rail transportation system is not used efficiently.
- Traffic flow and environmental quality are not good. Pedestrians, bicycles, and autos are jammed together, resulting in high accident rates and worsening pollution, particularly from motorcycles.

SCTP2 will attempt to prepare Shanghai to meet the future challenges just described, and, in doing so, will adopt a focus that extends beyond the city center to the entire metropolitan area.

The passenger transport system will embrace four distinct public transport services. The rail system will be expanded, with a capacity ratio of rail transport to buses of 6:4. The road system will have three levels: city-wide freeway, town-wide artery, and interborough main streets. Traditional public ground transportation is expected to carry more than half of the passenger trips, serving short- and medium-distance passengers and those traveling to areas not covered by rail. Within the public ground transportation system, priority will be given to buses for parking, traffic flow, and passenger transfer nodes. To help limit congestion, the number of taxis will be controlled to reduce the vacancy rate from 50 percent to 30 percent. The role of ferries also will be reduced, with an emphasis on providing more service for bicycles. Finally, terminals will be built to facilitate passenger use of the multimodal system.

The road system is being designed specifically to increase the capacity of the downtown street area. New, radial arteries will serve the new suburban cities, airports, and industrial areas, with speed limits higher than on ring roads and internodal connectors, for both passengers and freight. Part of the road system will be designated for freight to expedite commercial activity without causing excess congestion of central areas. Bicycle lanes will be constructed, and an effective separation of motor vehicles and non-motorized vehicles will be maintained. Similarly, the pedestrian environment will be protected, with walk-signals and pedestrian malls in commercial areas. A new comprehensive parking system, with fees and space designed to limit auto traffic in the city center, will include public parking lots for the transportation nodes in the suburbs.

Perhaps most important, a traffic management system will be developed to manage the time distribution and space distribution of traffic flow, using methods such as land use management, toll fees, parking restrictions, information guidance for drivers, and restricted area policies. The goal will be to create a modern traffic environment suitable for an international metropolis. The Adaptive Signal Timing System will be expanded and improved. A major feature of the new system will be an Intelligent Transportation System (ITS) based on information technology. The main information resources of the ITS will include real-time traffic flow, socioeconomic information, parking availability, vehicular traffic, freight traffic, police status, and a basic geographic information system. The ITS will enable the Shanghai authorities to monitor and respond to changes in the vehicle population and patterns of use, to employ new roads and other facilities rapidly after they are placed in service, and to evaluate continually the effectiveness of the transportation management system to provide optimal service at all times.

Safety will be a primary goal of the traffic management system, and safeguards for pedestrians and bicycles will receive high priority. Among the measures being considered are designating exclusive lanes for buses in the downtown area, controlling the emissions and noise of motor vehicles, separating motor vehicles from non-motorized vehicles and pedestrians from vehicles, optimizing signal time slots to reduce the emissions caused by deceleration and low speed, reducing the traffic accident frequency, strengthening inspection requirements for vehicles and roads, and accelerating the replacement of old, poor, and damaged cars to improve the overall standard of Shanghai's road transportation system.

[1] Source: Lu Ximing Shanghai City Comprehensive Transportation Planning Institute, reported in "Personal Cars and China" Committee on the Future of Personal Transport Vehicles in China, National Research Council, National Academy of Engineering, Chinese Academy of Engineering, 2003

C. Motorization

34. As the per-capita income of urban dwellers in Asia increases in real terms, vehicle ownership likewise will increase and generally follow a similar path to that taken by developed

countries except that Asia has a higher percentage of 2-wheelers than in most developed markets (see Figure 8). The ten countries in the world with the highest private-vehicle future demand index are in Asia including China, India, and Indonesia, three of the world's four most populous countries[20].

35. Consumer demand for personalized transportation – of which the 2-wheeler is providing an initial low-cost rung which in most Asian countries accounts for 50-80% of the vehicle fleet – will drive global sales as the ability to afford rises to match the desire to buy. Increasing individual mobility for the middle-class groups will make it particularly difficult to achieve the paradigm shift towards greater use of mass-transport without substantial governmental intervention. This highlights the danger that many countries in Asia will have difficulty in replicating the growth track in mobility that many European nations have been able to adopt which is more focused on well developed mass public transport systems whilst in other countries, such as the USA, Canada and Australia high-growth personal mobility is the norm. Singapore is a good benchmark for other Asian countries; it has demonstrated through an integrated and comprehensive approach the benefits of a long-term commitment to reducing the need for personal motorized transport.

36. International experience suggests that at the current and future income levels in emerging Asia, car and SUV ownership rates are likely to grow much faster than GDP and start to displace 2-wheelers[21]. Motorization in Asia is rising very rapidly with some countries' 4-wheeler[22] fleets doubling every 5 to 7 years. Emerging Asian countries are expected to integrate an additional thirty-five million vehicles (excluding 2- and 3-wheelers) into their fleets between 2006 and 2009 with China alone accounting for around 80% of that increase.

37. SUVs in Asia show an increasing market share, offering the key benefits of luxury cars – prestige/status, interior space and comfort, protection/safety through a combination of size and road presence not afforded by other vehicles. SUVs also offer practical benefits with the ability to handle poor road surface conditions. Unfortunately from an energy efficiency point of view, SUVs weigh more than cars and often have higher air and rolling resistance which all have a detrimental effect on fuel economy and hence GHG emissions. In the US, the market preference for SUVs has led to worsening fleet average fuel economies despite the fuel economy improvements made to individual vehicles.

---

[20] This index measures the relationship between current ownership levels and future intentions to purchase a vehicle, highlighting countries of high future demand. The 10 highest in order were: China, Indonesia, India, Thailand, Korea, Hong Kong, Philippines, Malaysia, Singapore and Taiwan; Source: Asia Leads Global Car Ownership Aspirations, Midori Matsuoka, Director, ACNielsen International Research, ACNielsen online survey 2004 published 2005.

[21] Particularly between $3,000 and $10,000 of GDP per capita in PPP terms.(International Monetary Fund February 2006 IMF (India) Country Report No. 06/56)

[22] Cars and SUVs (plus pickups used as personal transport in the US)

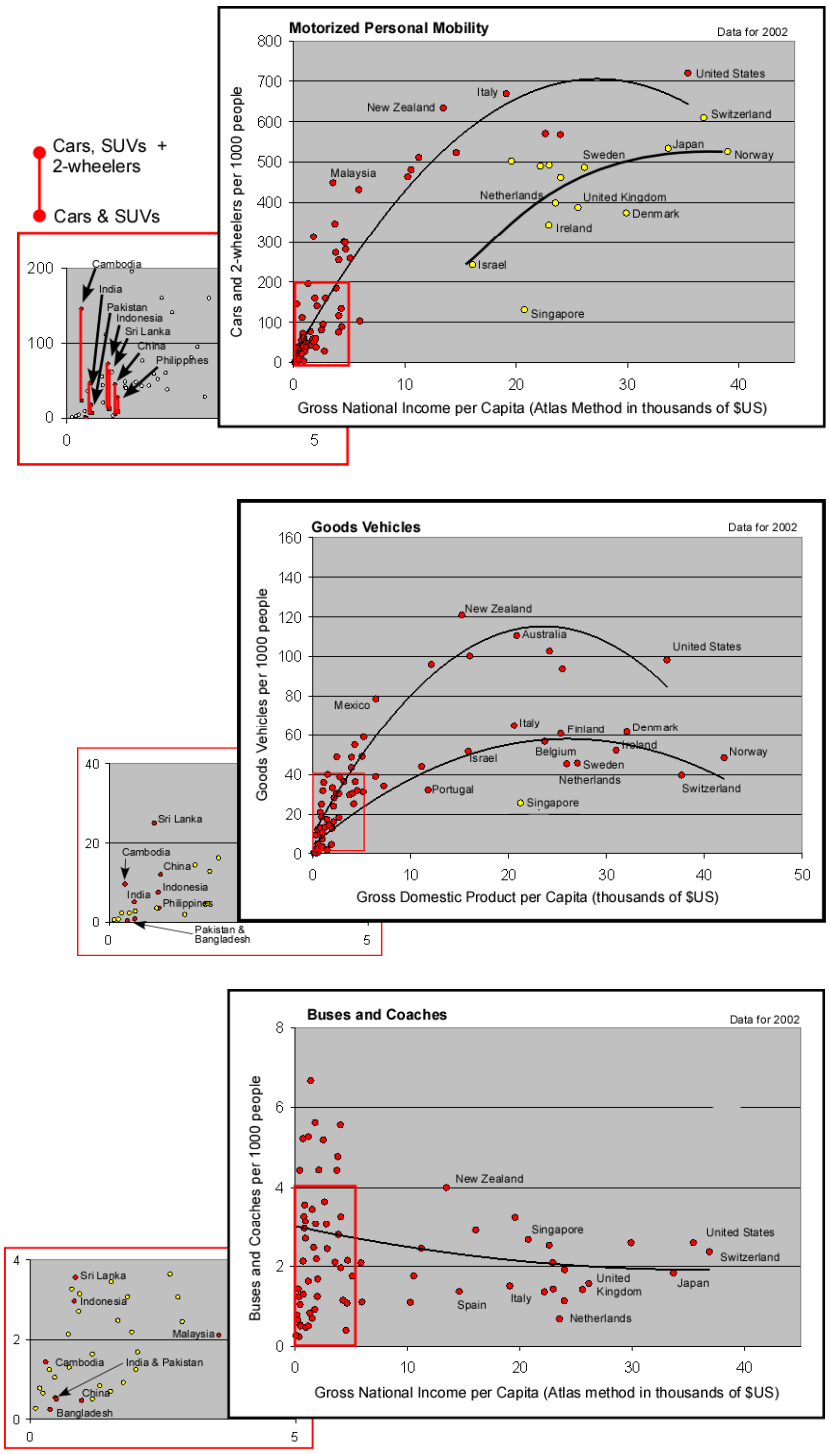


Figure 8[23] – Cars, SUVs and 2-wheelers, Goods vehicles and Buses per 1000 people

[23] Country GDI, GDP, and population are from World Bank's World Development Indicators Database (2002), Total motor vehicles and passenger cars are from the International Road Federation database (2004) complemented by vehicle inventory data from individual countries

38. The number of personal vehicles for every 1000 people in Asia currently remains modest. For example, about 45 vehicles per 1000 persons in China (of which less than 10 are 4-wheelers) versus 530 per 1000 persons in Japan (of which 430 are 4-wheelers). The sheer size of Asian countries like China and India can however lead to a situation that in a relatively short period of time China and later also India will have vehicle fleet numbers comparable to those of the USA (see Figure 8). This combination of accelerating incomes, urban growth and accelerating vehicle ownership, if left unchecked runs the risk of severely constraining the future economic advancement of Asian cities and economies.

39. Diesel vehicles in Europe have grown from 14% of sales in 1990 and now account for 44 percent of all cars sold[24] and dominate the new luxury vehicle market with a similar tendency occurring with SUVs in emerging Asia. China and Malaysia are the only markets in emerging Asia where diesel currently has a noticeably lower penetration[25].

40. For goods vehicles (short plus long-haul) a similar situation exists; China and India report 12 and 5 goods vehicles per 1000 people respectively and run the risk of climbing the high-growth curve shown in Figure 8b. Freight in Europe has historically kept to the lower growth-rate curve mainly due to the modal share of rail and shorter distances, however this is now changing; rail's modal share in Europe is dropping, as supplier and distribution networks are increasing and the largest growth in fuel use for on-road transport is expected to be from trucks and by 2010 the fuel demand for trucks is forecast to exceed that of cars and motorcycles[26]. As before, Singapore is a benchmark. In emerging Asia, as GDP increases, supplier and distribution goods transport requirements will also increase to include greater geographical coverage, requiring a marked efficiency improvement from for-hire carriers and wholly-owned fleets. In many of these countries, legislative reforms and highway construction are accelerating, but need to accelerate further to promote the more efficient operation and lower GHG emissions – on a ton-km basis -- of larger, high capacity trucks and highway tractor-trailer combinations which historically have been absent from their goods-vehicle fleets to replace the standard 10-15 ton truck traditionally used in most of emerging Asia.

41. For buses and inter-city coaches, China and India both report less than 1 bus per 1000 people. The context for public transport in Asia is complicated by the large number of public transport vehicles which are specific for Asia and the developing countries. These include motorized 3-wheelers[27] of which there are hundreds of thousands in countries like India, Pakistan, and Philippines. In 2004, India had over 3 million 3-wheelers in service, mostly with gasoline 2-stroke (61%) followed by 4-stroke (24%) and diesel (15%) engines. The Philippines has over 1 million tricycles which are motorcycles equipped with a side car for the transport of passengers and goods. Figure 8 does not transmit the fragmented nature of mass transport in emerging nations; it does not include these motorized 3-wheelers or the custom build vehicles found throughout the region[28].

---

[24] The Car Connection Website Auto News (www.thecarconnection.com)
[25] Keiko Hirota of the Japanese Automobile Research Institute
[26] DG Tren, 2003; "EU25 – Energy & Transport Outlook to 2030"
[27] Three-wheelers include small taxis such as autorickshaws in India, and Sri Lanka and baby taxis in Bangladesh – usually for carrying three passengers
[28] Such as the jeepneys in the Philippines, Tuk-Tuks in Thailand and Bemos in Indonesia

D. Impact on climate change and local emissions

1. Greenhouse Gases

42. From 1990 to 2002, the total combined CO2-equivalent emissions of China, India and emerging Asia grew from 37% to 48% of the OECD total, with the major growth component coming from China (see Figure 9).

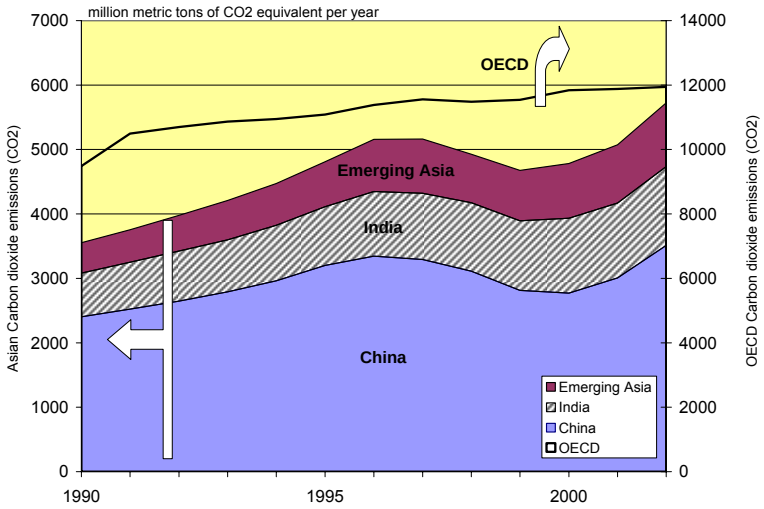


Figure 9 - Total energy sector CO_2-equivalent emissions of China, India and emerging Asia

(Note: China, India and emerging Asia relate to the scale on the left-hand side of the graph and OECD relates to the scale on the right-hand side)
Source: Millenium Indicators (CDIAC) 2005

43. Energy use in the transportation sector is currently dominated by petroleum product fuels and is growing fast. From 1990 to 2002, the combined CO_2-equivalent emissions from the transportation sector in emerging Asia grew faster than in developed economies going from 6% to 17% of the OECD total in only 12 years (see Figure 10).

44. This rate of growth is accelerating; if Asia were to follow the EU lead, and adopt similar improvements in car fuel economy as planned for the EU[29], it can be expected that with the emerging Asia fleet increasing in size more than five times by 2030, and assuming efficiency gains and favorable changes in fleet mix this would still result in a fuels and GHG emissions growth of at least three times the 2000 levels[30] . Such a decrease in the rate of growth might appear as a favorable development, but it needs to be realized that the tripling in 2000 levels does not compare well to the EU and the Japanese Kyoto commitment for the same period, which is to *reduce* GHG emissions to 1990 levels. However it is likely that the EU will not reach their target, citing as the overarching reason their high growth in GHG from transport.

[29] It is expected that the fuel economy benchmark for 2012 is expected to be 27% better than 10 years earlier (European Federation for Transport and Environment, 2006))

[30] Source calculated from IEA/SMP Reference Case Projection, L. Fulton, IEA / G. Eads, CRA; July 2004, however current projections from China and India give higher numbers

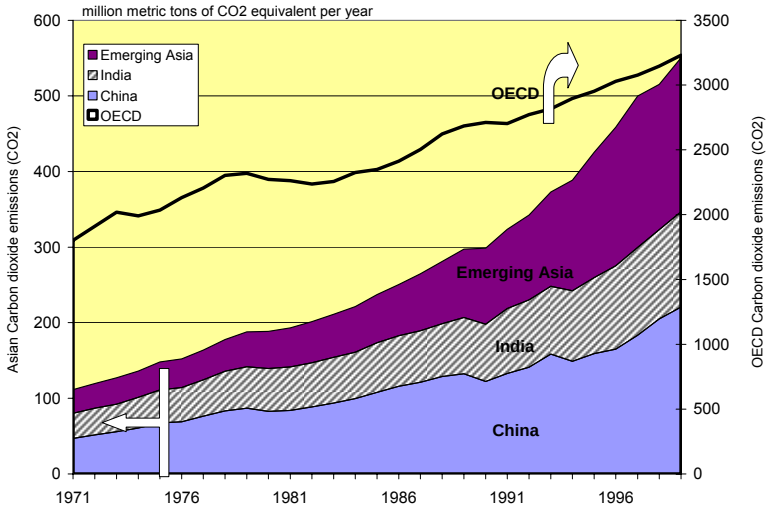


Figure 10 - CO_2-equivalent emissions from transportation in China, India and emerging Asia

(Note: China, India and emerging Asia relate to the scale on the left-hand side of the graph and OECD relates to the scale on the right-hand side)

Source: Energy Balances of OECD Countries (1960-1999) and Non-OECD Countries (1971-1999) Energy Statistics Division (ESD) of the International Energy Agency (IEA)

45. The growing number of private vehicles is a key determinant for fuel use and consequently GHG emissions. Some efforts have been made to improve the fuel economy by issuing fuel economy standards. In the EU a voluntary agreement with the association of vehicle manufacturers (ACEA) set a GHG standard for 2002 of 165 g/km CO2. This was achieved with diesel fuelled vehicles being on average10% lower in GHG emissions than gasoline (155 vs. 172 g/km CO2). The agreement set a standard of 140 g/km CO2 for 2008 with a possible extension to 120 g/km CO2 for 2012.

46. Japan also has already made a significant improvement in its fleet average fuel economy between 1995 and 2002 to tighter levels than the EU and is now in a process of proposing stricter fuel efficiency standards. Assuming no change in the vehicle mix, these targets imply a 23 percent improvement in 2010 in gasoline passenger vehicle fuel economy and a 14 percent improvement in diesel fuel economy compared with the 1995 fleet average of 14.6 km/L. According to the Japanese government, this improvement will result in an average fleet fuel economy of Japanese vehicles of 35.5 mpg by 2010.

47. In the US, the CAFE[31] program, which was established in1975 with the goal of reducing the country's dependence on foreign oil, maintains an important distinction between passenger cars and light trucks, with each having their own standard. This distinction was originally included when light trucks were a small percentage of the vehicle fleet but with the increasing popularity of SUVs this has changed. The CAFE standard for passenger cars has remained constant since 1985 at 27.5 mpg whilst the standard for light trucks has recently been increased from 20.7 mpg in 2004 to 21.0 mpg for 2005[32]. The law also allows special treatment of vehicle fuel economy calculations for certain groups of vehicles. The overall result has been a 7 percent

[31] Combined Average Fuel Economy
[32] Further standards of 21.6 mpg for 2006, and 22.2 mpg for 2007 are also established

decrease in the light-duty fleet fuel economy since 1988, associated with the rapid growth of light trucks used as passenger vehicles (Feng et al., 2004),

48. Most of the emerging Asian nations, however, with the marked exception of China, have not implemented fuel economy standards and in many countries the increase in average vehicle weight due to the desirability of SUVs – and the move from 2-wheelers to cars -- increases the difficulty of improving economy

49. Despite its large and growing contribution to overall GHG emissions, transportation is a sector where the least progress has been made in addressing cost-effective reductions. It is one of the last major sectors considered under the Global Environment Facility (GEF) and only one transport project to date has sold carbon bonds through the UNFCCC Clean Development Mechanism (CDM)[33]. All incremental actions in these fields should help to improve (reduce) the high growth perspective currently envisaged.

2. Local pollutants

50. Many of the cities in Asia face problems with urban ambient air quality. In most cases, the transport sector is one of the most significant contributors to air pollution and tends to be geographically concentrated and particularly damaging at street level, where people live and work including the poor and vulnerable groups such as the young and elderly who have limited mobility (ADB, 2003).

51. Pollutants of main concern are particulate matter (PM), especially ultra-fine particles, nitrogen oxides (NOx), and hydrocarbons (HC). Increasing NOx levels contribute to an increase in ozone levels. An ongoing study[34] by the Clean Air Initiative for Asian Cities, summarizing air quality data from 20 cities in Asia shows that, on average, there has been a moderate to slight decrease in pollution levels for PM_{10} over the last decade (see Figure 11).

[33] This is the Mexico City BRT Pilot corridor where an Emissions Reduction Purchase Agreement (ERPA) was signed in 2005 with the Spanish Carbon Fund.

[34] See CAI-Asia, 2006 “Air Quality in Asian Cities” and “Ambient Concentrations of Pollutants and Trends of SPM, PM10 and SO2 in Selected Asian Cities”

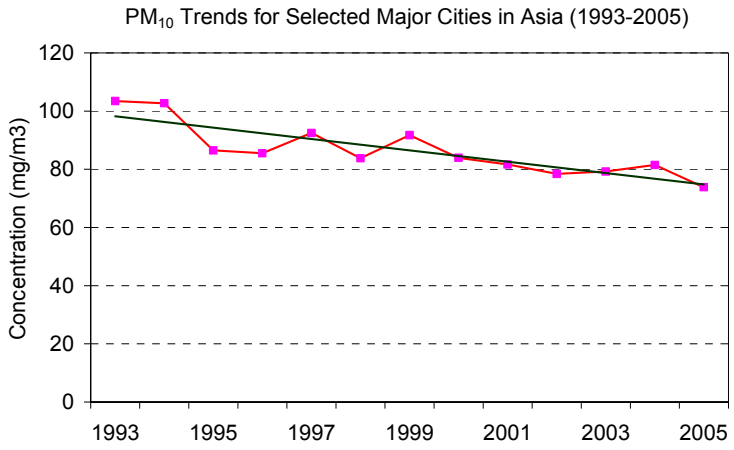


Figure 11 – PM_{10} Trends for Selected Major Cities in Asia (1993 – 2005)

52. There is an increasing burden of evidence that demonstrates the high impact of local pollution on the environment and human health. Ultra-fine particles, such as those emitted by un-controlled diesel vehicles, have been shown to have significant health impact costs and that there are insignificant differences between regions[35]. A pooled estimate of 39 studies (Borja-Aburto et.al. 2000) showed a weighted estimate of 1.01 percent increase in general, non-accidental mortality for each 10 µg/m3 increase in PM_{10}[36].

53. The costs of vehicle-generated air pollution are significant (Lohani, 2005b) and likely to increase if the growth in the vehicle fleet is faster than improvements in average in-use vehicle emissions.

3. Vehicle, engine and fuels technology

a. New vehicle technology

54. Vehicle, engine and fuels technologies are currently available to substantially reduce emissions and in many developed countries local emissions and air quality are not now considered as problems.

55. All the countries in emerging Asia now sell unleaded gasoline[37] which has enabled vehicle emissions technology changes (such as catalytic converters) to be implemented. This rapid elimination of leaded fuel is one of the success stories in Asia which demonstrates how rapidly effective policy changes can be brought about.

---

[35] A review of Asian health impacts studies conducted as part of the CAI-Asia Public Health and Air Pollution in Asia Program concluded that the Asian response to air pollution in terms of health impacts are largely the same as in Europe and the USA. See Health Effects Institute special report # 15 and the Pan-American Health Organization's report found in Epidemiology: Volume 16(5) September 2005 p S111

[36] With a 95% confidence interval of 0.83-1.18 percent change for each 10 µg/m3 increase in PM_{10}

[37] Indonesia continues to sell both leaded and un-leaded fuel.

56. In gasoline vehicles there is a clear global consensus on how to obtain very low emissions levels (advanced three-way catalysts with sophisticated electronic controls for spark timing and air-fuel management) together with the elimination of 2-stroke engines. The EU is combining the move to ever-stricter emission limits with a voluntary agreement with vehicle manufacturers to improve the fuel economy of light duty vehicles, however the implementation of similar technology changes in many countries in emerging Asia is slow.

57. Several countries in emerging Asia Countries have no formal fuel quality or vehicle emissions road maps in place. These include Pakistan, Bhutan and Cambodia.[38] Others, like the Philippines, Indonesia and Viet Nam have developed road maps for EURO II[39] but have not yet finalized the way forward to EURO IV. China will move to EURO IV In 2010 and India will reach EURO III nationwide although both have prior introduction in major cities[40]. Thailand and Malaysia both reach EURO IV light duty standards in 2009. So far only Hong Kong has indicated that it is considering the adoption of Euro V standards. China is the only country in emerging Asia that has implemented fuel economy standards.

58. Diesel vehicles, which traditionally have been seen as part of the problem particularly due to visible exhaust smoke and high ultra-fine PM emissions, are rapidly becoming an integral part of the solution when advanced standards are introduced following the availability of ultra low sulfur diesel, which generate emission levels comparable to the best gasoline engines and with a higher fuel economy level. Diesel-powered cars and SUVs are achieving 20-40% better fuel economy with lower GHG emissions than their gasoline powered equivalents.

59. Many new vehicle technologies also contribute to improvements in GHG emissions; reducing vehicle weight and aerodynamic drag with new structure design and materials, smaller engines, light-duty hybrids, low rolling-resistance tires, low friction lubricants, idle-stop features and advanced air conditioning technology are all leading to improvements. The limits to the higher fuel economy performance of light duty vehicles in the EU (with fleet-average GHG emissions of less than 140 grams of CO2 per km[41]) is seen to be currently defined by the restricted acceptance amongst consumers of the smaller, lighter cars. Long-term innovations are envisaged such a hybrid heavy-duty vehicles, alternative fuels and the use of hydrogen fuel cells that will achieve important improvements in per-vehicle GHG emissions.

---

[38] Source: CAI-Asia, 2005

[39], The EU adopted EURO- II, III and IV standards for light duty vehicles in 1996, 2000 and 2005 respectively and will go to EURO V in 2008.

[40] Delhi, Mumbai, Kolkata, Chennai, Bangalore, Hyderabad and Ahmedabad have EURO III standards since 2005 and Beijing will adopt EURO IV in 2007

[41] This is equivalent 18.8 km/L for a gasoline vehicle on the US Combined Average Fleet Économy (CAFÉ) test cycle

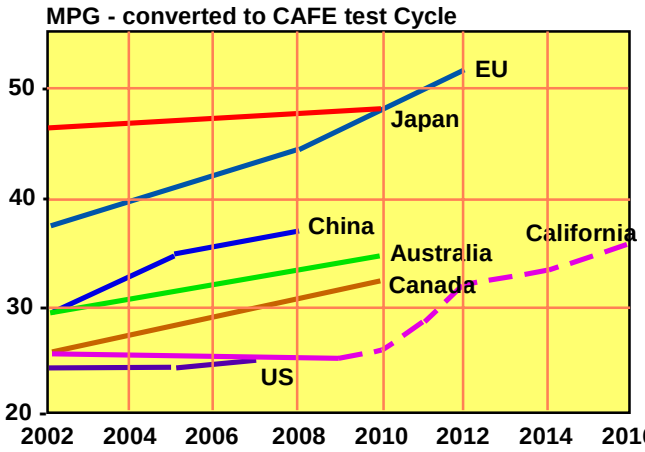


Figure 12 - Comparison of fuel economy and GHG emission standards normalized by CAFE-converted mpg

Source: Feng, et.al. 2004

60. This combination of engine and vehicle technology has allowed several countries to enact fuel economy and GHG emission standards. Figure 12 shows that the European Union (EU) and Japan have the most effective light vehicle fuel economy standards followed by the new PRC standards. The impact of these standards is relatively small at first but grows significantly as the new-technology vehicles replace older vehicles in the in-use fleet.

61. Air conditioning systems in vehicles are particularly prone to leakage and most use a hydrofluorocarbon called R-134a which has a GHG warming potential 1,300 times more potent than CO2. By 2010 the use of R-134a is expected to contribute more than 4% to total GHG emissions[42]. Recognizing this, the EU published a new regulation this year to phase out the use of R-134a in new cars beginning in 2011. It is likely to be replaced with other hydrofluorocarbon refrigerants with lower warming potentials or new technology, possibly employing CO2 as a refrigerant (Fairley, 2006).

62. The EU has not placed the same emphasis on reducing emissions from motorcycles[43]. As of 2006 all new motorcycles in the EU have to meet EURO III limits which can be achieved quite easily with current automotive technologies, such as fuel injection systems and catalytic converters. Even when these most stringent of currently agreed requirements are applied, motorcycles will be required to reach EURO III emission standards whilst passenger cars are already on the stricter EURO IV.

[42] This impact rises to 7% if the extra fuel consumption due to the use of Air Conditioning is included.
[43] Although motorcycles are not a major means of transport in most of Europe, Global annual motorcycle production in 2003 was around 30 million units according to JAMA Motorcycle Industry New Year's Discussion, (JAMA, 2006.)

Vehicle Fuel Efficiency Standards in China[1]

In recent years, the fast economic (GDP) growth of China coupled with the need to activate internal consumption has fueled a rapid expansion of the Chinese vehicle fleet. In 2005, China had an active population of around 32 million vehicles (of 4 or more wheels) plus 57 million 2- and 3-wheelers. Over the coming 20 years the vehicle population is expected to grow by almost 5 times to 183 million plus 194 million 2- & 3-wheelers[2]. This growth will cause vehicle fuel consumption to increase substantially and cause major fuel security, traffic congestion and pollution concerns.

China is a country with scarce oil resources and became the net oil importer in 1993. The domestic supply of crude oil is stable at about 160 million metric tons per year but is expected to drop within this 20 year period whilst on-road transportation, by itself, could be expected to require around 300 million metric tons by 2025 unless a systematic control strategy is put in place to correct this tendency.

The government decided in 2002 to establish a framework including government cooperation, research team and international support to develop vehicle fuel efficiency standards and regulations. After two year of studies and negotiations, the first fuel efficiency standard – Fuel Consumption Limits for Light Duty Passenger Vehicles was published on September 2, 2004, for implementation as of July 2005. The main goal of this regulation was to help control the national total oil consumption to less than 400 million metric tons per year.

The components of the vehicle fuel efficiency standard were (i) the development of weight-class based maximum fuel consumption standard; (ii) An overall per-distance fuel consumption reduction of 15%; and (iii) a more stringent standard for heavier vehicle classes to prevent a shift to heavier vehicles and to encourage the use of economic compact cars. The first phase of the standard, targeting a reduction of 5% in per-distance fuel consumption was implemented in 2005, and a second phase, with a goal of 10 percent reduction in fuel consumption for each weight category in 2008. Figures 1 and 2 show the final standards for manual transmission (MT) and automatic transmission (AT) light duty vehicles respectively. This Chinese standard is more stringent than the US standard given that the limits are maximum values instead of average values and that the phase two standard is for 2008 model-year vehicles. However the technical requirements of this standard are not as stringent as those of the EU or Japanese standards.

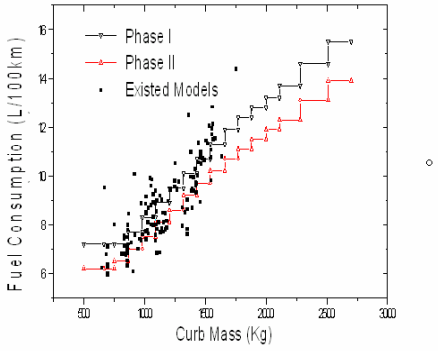


Figure 1 Fuel consumption standards for MT Cars

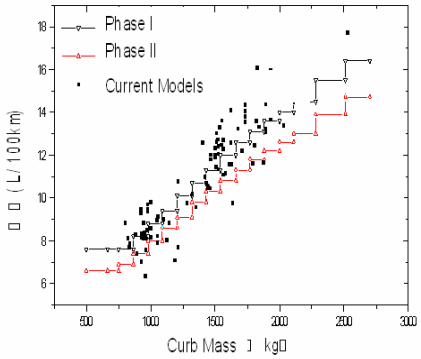


Figure 2 Fuel Consumption Standards – AT Cars, SUVs, and 3+ Rows Minivans

With the implementation of this fuel economy standard, it is forecast that 13 million tons of fuel will be saved in 2020 and 31 million tons in 2030. However more stringent fuel economy standards need to be put into force after 2009. A further reduction of 25% in vehicle fuel consumption to 5.6 L/100km (the European requirement for 2008) should be established by 2012 for light-duty passenger cars and a fuel consumption level of about 4.8 L/100 km should be developed to catch up with Europe and Japan by around 2016. If this were implemented, an additional 19 million tons oil would be saved in 2020 and 60 million tons in 2030.

[1] Sources: Chinese policy practice in developing vehicle fuel efficiency standard by Professor HE Kebin and Ms. LIU Huan, Ms. Zhang, and Mr. YAO Zhiliang, Tsinghua University, China

[2] Vehicle population forecast for 2025 developed by SegmentY plc (see www.segmenty.com)

63. Both China and India have adopted strict limits for motorcycles with 1.5 g/km (HC + NO_x)[44]. These limits are causing 2-stroke engines to phase out due to difficulty in meeting the standard without a catalytic converter. In 2003, 91% of the production of motorcycles in China was already 4-stroke[45]. India will go to a limit of 1.0 g/km (HC + NOx) in 2008/10 which will require further technological improvement[46]

64. The lower capacity motorcycles which dominate the Asian market have a clear advantage in GHG emissions which tend to be less than half those of small cars since substantial development has taken place focused on improving their fuel economy even though their emissions performance generally lags behind that of the EU (BMF, 2003).

65. There has been substantial development of 3-wheeler engines towards gaseous fuels. Cities like Delhi and Dhaka have banned 2-stroke 3-wheelers giving substantial advantages both in local pollutant and GHG emissions[47].

66. The major lessons learnt from the past twenty-five years highlight the advantages of reducing the implementation lags in introducing tighter standards as much as possible. It can be seen that emerging Asia is catching up in terms of technology standards but still has a lag of 5 or more years in most countries and vehicle segments compared to the EU. Since improvements in emissions performance and fuel economy are being developed in parallel particularly in the EU and Japan, local air quality and climate change both can benefit from a rapid incorporation of new technology and from other measures that promote fleet renewal. The expected high growth in light duty Asian fleets assists in this per-vehicle improvement although the near-term vision is not so clear for heavy-duty fleets.

b. Diesel

67. As diesel emission standards ramp-up to technologically demanding levels the sulfur concentration in the fuel needs to be progressively reduced. The EURO III and IV intermediate standards require better than 500 ppm and 50 ppm sulfur content respectively. The major emissions advances occur however with the introduction of ultra-low sulfur fuel (<10 ppm) which allows advanced exhaust after-treatment devices to be used that can reduce emissions by up to 95%.[48]

68. It is argued by many[49] that the considerable investment required to equip refineries and fuel distribution systems to be able to deliver diesel with these low levels of sulfur can be reduced by leapfrogging directly to the ultra-low levels. Even though the required investment is high, in the USA context and following US accounting practices, the ratio of benefits to costs ranged from 5:1 to 40:1. In China a ratio of benefits to costs ranged from 7:1 to 22:1 over a time frame of 2020-2030 with small positive net benefits even in 2010[50].

---

[44] However the drive cycle is different between the two countries. The limits as of 2005 for 3-wheelers in China is 1.9 g/km (HC + NO_x)

[45] Dr. Prof Fu, Lixin, Tsinghua University, Beijing China, May 2004, Hanoi

[46] N.V. Iyer, Adviser (Technical), Bajaj Auto Ltd, Pune, India

[47] Approximately 16% of the Indian 3-wheeler market consists of 4-stroke CNG fuelled units.

[48] Europe (EURO V) has chosen slightly less stringent emissions standards than the US and by using mainly selective catalytic reduction (SCR) techniques are further improving diesel fuel economy and GHG emissions.

[49] M. P. Walsh, ICCT and Enstrat, 2003 (Cost of Diesel Fuel Desulphurisation for Different Refinery Structures Typical of the Asian Refining Industry),

[50] Sources: Cost Benefit Analysis of Low Sulfur Fuels, Katherine Blumberg, ICCT, Partnership for Clean Fuels and Vehicles, November, 2005

c. Biofuels

69. Internal combustion engines will continue to be the dominant on-road transport power source in 2030, using mostly liquid fuels. Within the range of liquid fuels, biofuels provide the best option to reduce the GHG footprint of transport fuels by replacing a significant share of these fossil fuels[51].

70. The principal biomass-derived liquid fuels commercially available today and suitable for road transport are ethanol -- for spark ignition (gasoline) engines -- and vegetable oil-based diesel substitutes for compression ignition (diesel) engines. Ethanol is derived primarily from corn (United States) and sugar (Brazil), but can also be produced from sugar beets and wheat. The diesel substitutes are made from a wide range of vegetable oils (e.g., rapeseed, soy, palm, coconut and jatropha) to fuels that are completely compatible with fossil diesel fuel, both as a mixture of any fraction and in pure (neat) form[52]. Fuel additives are also produced from biomass; Bio-ETBE (Ethyl-tertio-butyl-ether) produced from bioethanol and Bio-MTBE (Methyl-tertio-butyl-ether) produced from biomethanol are used as additives to increase octane rating of gasoline and to reduce knocking.

71. Whilst biofuel programs started over 3 decades ago in a few countries, it is only recently that they gained broad based interest, this mainly due to the increase in oil prices and governmental incentives making investments profitable and to address national foreign exchange, fuel diversification and security concerns. In 2004, 33 billion liters of ethanol were produced accounting for about 2% gasoline production worldwide[53]. 2.2 billion liters of biodiesel (accounting for around a third of one percent of worldwide diesel production) were also produced that year principally in Germany, France, and Italy with small amounts in the Philippines and Malaysia[54].

72. “Second generation” biofuels are now being developed from a wider range of feedstock that increase the fraction and reduce the cost of the avoided CO_2 by utilizing biomass fractions that are presently discarded and making the best use of the whole plant. Figure 13 and 14 show the current and next generation of liquid biofuels for substituting gasoline and diesel as transport fuels, together with their principal feedstocks and conversion processes, net energy balances, and GHG emissions reductions. Since different amounts of energy are used in producing a bio-fuel to a petroleum based fuel, a life cycle analysis (LCA) must be used to compare the net GHG emissions performance of different fuels.

73. The present production of ethanol from corn in the US yields limited GHG savings[55], but these savings could be increased if biomass residues from corn production are used for heat

---

[51] Source: “Biofuels in the European Union a vision for 2030 and beyond”; Final draft report of the EU Biofuels Research Advisory Council

[52] These are principally vegetable methyl esters (VME); in some countries (e.g., UK), waste oils and greases are used to produce biodiesel fuel.

[53] 15 billion liters of ethanol from sugar cane in Brazil, 13 billion liters from corn in the United States, 2 billion liters from China, 0.2 billion liters from Thailand and the rest from other countries compared to gasoline worldwide production in 2004 of 1,200 billion liters.

[54] Respectively from coconut oil and palm oil

[55] Up to about 13% according (Farrel , 2006)

and power generation in the ethanol production process[56]. Prof. Eric Larson of Princeton University in the GET STAP report concluded "Very broadly, grain or seed-based biofuels (e.g., corn ethanol or RME) might give 20-30% GHG reductions per vehicle-km relative to petroleum fuels, sugar beets might give 40-50% reductions, sugarcane (average SE Brazil) gives 90% reductions, future advanced cellulosic conversion (to ethanol, FT, or DME) from perennial energy crops might give 80-90+% reductions. Biofuels production with carbon capture and storage (a longer-term option) will give >100% reductions."

74. In Asia there is increasing investment in new biodiesel production capacity with coconut oil, palm oil, and jatropha as feedstock. The Philippines has a commercial coco biodiesel (coco methyl ester) industry producing the equivalent of about 1% of diesel fuel use (Karunungan, et.al. 2005), and Malaysia is gearing up for increased production of palm oil and the development of a palm oil biodiesel production capacity. However, it is likely to be several decades before a strategically important share of liquid fuels for road transport can come from biofuels, and that assumes that the economic and policy signals are supportive of production and use of these fuels.

[56] The reduction achieved by using corn-based E85 is only moderate because (1) significant amounts of GHG emissions are generated during corn farming and in corn ethanol production plants; (2) diesel fuel, LPG, and other fossil fuels are consumed during corn farming; (3) a large amount of nitrogen fertilizer is also used for corn farming, and manufacture of nitrogen fertilizer and its nitrification and denitrification in cornfields produce a large amount of GHG emissions; and (4) usually, NG or coal is used in corn ethanol plants to generate steam.
Source: Norman Brinkman, Michael Wang, Trudy Weber and Thomas Darlington. "Well-to-Wheels Analysis of Advanced Fuel/Vehicle Systems — A North American Study of Energy Use, Greenhouse Gas Emissions, and Criteria Pollutant Emissions". (May 2005).

Figure 13 - Bioethanol for replacing petrol: a Climate Change Perspective

Feedstock	Production Status and Regions	Current life cycle GHG Emissions reduction relative to gasoline	Biofuels yield per hectare	Costs	Net energy balance
Grains (wheat, maize)	Large-scale & commercial (US, Europe, China)	None to moderate with maize but improvements possible	Moderate	Moderate	Currently low
Sugar beets	Large-scale & commercial (Europe)	Up to 50%	Moderate	Moderate	Currently low
Sugar cane	Large-scale & commercial (Brazil, India, Thailand)	Brazilian ethanol has highest GHG reduction (92%) and lowest cost. Biomass energy used in the production process.	High	Low	Medium
Ligno-cellulosic biomass	"Next Generation" bio-fuel. Pilot plants in Sweden, Spain, Denmark	High; 70 – 90% estimated; can be close to 100% in principle	High	High	High (expected)

Source: IEA, 2004

Figure 14- Biodiesel fuels for replacing diesel: a Climate Change Perspective

Feedstock	Production Status and Regions	Current GHG Emissions reduction relative to petrodiesel	Biofuels yield per hectare	Costs	Net energy balance
Oil seeds (rape, soy)	Medium-scale, mature and evolving (US, Europe)	78% reduction (soybean base), 40 – 60% for rape	Low	Moderate	3.2 for soy biodiesel vs. 0.8 for petrodiesel
Coconut oil to CME	Medium commercial (Philippines)	No LCA has been conducted yet (Expected to be moderate)	Moderate to High	Low-moderate	LCA needed
Palm oil	Small-scale, commercial (Malaysia, Indonesia)	No LCA has been conducted yet (Expected to be moderate)	Moderate to High	Low-moderate	LCA needed
Jatropha	Pilot-scale, pre-commercial (China, India)	No LCA has been conducted yet (Expected to be moderate to high)	Moderate to High	Low-moderate	LCA needed
Biomass to liquids	"Next Generation" bio-fuel. Fischer-Tropsch biodiesel pre commercial (Demo plants in Germany and Sweden)	High (IEA)	High	High	LCA needed For many combinations

Source: IEA, 2004

d. CNG and LPG

75. **Natural gas** is a mixture of hydrocarbons, mainly methane (ca. 90% CH_4), with smaller amounts of ethane, propane and CO_2. It is collected from gas wells and produced as a co-product in refining petroleum oil. Compressed natural gas (CNG) is used to run buses and light duty vehicles, including 3 wheelers mainly in urban environments, propelled by energy security concerns and air quality consideration with the goal of minimizing tailpipe particulate emissions to negligible levels.

76. Several studies suggest that at current engine and vehicle technology levels, the use of CNG reduces CO_2 emissions up to 20% compared to gasoline and has the potential to reduce CO_2 emissions by up to 5–10% compared to diesel, but this is strongly dependent on fuel system design and conversion quality and actual emissions in some cases will be higher than before conversion. Methane has a global warming potential 21 times greater than CO_2 and any methane leakages, especially in refilling and end-use, can potentially negate all GHG savings from using CNG as fuel.

77. As of 2005, approximately 4.75 million natural gas vehicles are estimated to be in use worldwide with over 1 million in emerging Asia[57]. Growth in CNG vehicle populations has been very rapid over the last 2 years in Bangladesh, China, Malaysia, and Thailand. The Thai government is aiming to convert half a million vehicles to run on compressed natural gas (CNG) by 2010, to help reduce the country's dependence on oil[58].

78. In India, The Supreme Court ruling in 1998 mandated CNG as the fuel for public transport in Delhi to control pollution. In 2002 a further ruling directed the Union government to give priority to the transport sector for CNG and a further 4 cities have implemented programs for urban transport[59].

79. **Liquid Petroleum Gas** (LPG) consists mainly of propane with propylene, butane, and butylenes in various proportions according to its origin. The components of LPG are gases at normal temperatures and pressures and the fuel is easily stored in a steel cylinder as a liquid. Its ease of transport and storage makes it applicable even in smaller vehicles and LPG presents an opportunity as a vehicle fuel for cities that do not have pipeline or sea access to CNG.

80. In 2004 there were approximately 10 million LPG vehicles in use worldwide concentrated in few countries. It is widely used in Europe and in 5 countries, LPG accounts for more than 10% of the total automotive fuel demand[60]. Fuel diversity and security issues have enticed governments to offer attractive incentives for its use; in South Korea more than 10% of all registered vehicles are fuelled by LPG, in Japan over 90% of the taxi fleet uses this fuel, Thailand introduced this fuel to the Tuk-Tuk 3-wheeler segment and Hong Kong is replacing 18,000 diesel taxis to achieve important reductions in PM and NOx emissions[61].

81. Whilst these gaseous fuels do impact local emissions, their contribution towards meet the combined energy policy targets of enhanced long-term supply security and significant CO_2 emission mitigation in Asia is limited now and will continue to be limited in the future[62].

e. Need to Control in-use vehicle emissions

82. Proper maintenance is important to control emissions over the life of the vehicle, however in most parts of Asia, owners generally do not give much consideration to maintenance. It has been shown that a fully implemented and enforced inspection and

---

[57] Of which Pakistan has 700,000; India, 220,000; China, 97,000; Bangladesh, 23,000, Malaysia, 18,000 and Thailand about 9,000 vehicles. Source: Asian NGV Communications (February 2006). Vol 1, #3

[58] Source: just-auto.com Editorial Team, 15 March 2006

[59] These are Ahmedabad, Lucknow, Kanpur and Hyderabad. If the national gas grid is implemented, 22 cities will be enabled.

[60] South Korea is followed by Japan, Poland, Turkey and Australia account for more than half the world on-road transport consumption however in South Korea, Bulgaria, Turkey and Lithuania LPG represents more than 10% of the total vehicle fuel consumption. (WLPG)

[61] Sources: M.P. Walsh, "Sustainable Transport, a source-book for policy makers in developing cities" GTZ; Alternative Fuel use, US Department of Energy, Vol 6 #2; Kong Ha Hong Kong Environmental Protection Department, CSE conference New Delhi 2004.

[62] In light duty vehicles a fuel economy improvement of between 3.5% and 12.6%[62] was reported in Arizona USA due to the implementation of a vehicle inspection and maintenance program when their vehicle fleet had a technology level similar to that found today in many parts of emerging Asia. Since it can be expected that the vehicles in Arizona were on the whole better maintained than their counterparts in emerging Asia, similar or larger gains should be possible today in Asia (Gielen, et.al., 2005)

certification (I&C) program supported by adequate maintenance can bring about reductions in NOx emissions of 2-5%, PM_{10} emissions of 2-15%, and fuel consumption and GHG emissions by around the same amount (2-17%) with the higher numbers being for the less advanced vehicle fleets as commonly found in Asia.

83. In Bangkok, privately owned urban bus fleets have de-rated their engines to avoid fines for visible smoke, which combined with driver training and a driver incentive scheme to use less fuel has improved their fuel economy by over 30%[63]. In India's "golden triangle" traffic police empowerment has virtually eliminated the smoky diesel problem. B.E.S.T, the Mumbai bus operator has also reported substantially improved fuel consumption through better maintenance and driver training originally incorporated due to pressure to eliminate visible smoke.

84. Studies performed in Jakarta indicated that the wide scale adoption of preventive Inspection and Maintenance programs for in-use vehicles can help improve overall fleet fuel efficiency by 3-4 per cent and substantially reduce exhaust emissions (Pramono, et.al., 2001). Under a separate Swisscontact program in Jakarta - 5245 buses from 9 companies were subjected to I&C testing and an improved maintenance regime over a two year period resulting in a 5.5% improvement in fuel efficiency and SIAM, in India reported a fuel economy improvement of up to 17% from their 2-wheeler voluntary clinics[64].

85. All these examples illustrate the fact that well-managed I&C programs can have a considerable positive impact on vehicle fuel efficiency if implemented across the entire in-use vehicle fleet. However the majority of I&C programs in Asia have been of an ad-hoc nature. Few of the countries in Asia have been able to implement a structured and well-enforced I&C program which targets large numbers of gross polluting in-use vehicles on a regular basis. Effective I&C programs require setting in-use emission standards that are achievable by a majority of vehicles with good maintenance, and tightened them over time with the objective of removing gross polluting vehicles from the road. Such programs can lead to the replacement of damaged catalytic converters, and can be used (with the corresponding regulatory measures) as a low cost means of preventing the import of grossly polluting used vehicles into the country.

86. Many cities and countries are now actively promoting the retrofitting of high urban usage diesel vehicles with particulate filters. Though costly, the impact on emissions appears to be very favorable but such retrofits do not have a positive impact on fuel economy. Other retrofit programs that are piloted at present in the Philippines can have regional importance by installing direct injection systems to in-use 2-stroke 2- and 3-wheelers. In this case both emissions and CO2 emissions may improve greatly.

E. Congestion and road safety

87. The substantial growth in vehicle populations is clearly evident in the urban areas throughout the region in the form of increased congestion, and road safety concerns particularly for the poor.

88. Many of Asia's megacities have now realized that it is physically impossible to build road infrastructure capacity faster than the growth rate in vehicle ownership and thus to reduce

[63] Interviews with owners of privately operated buses running on routes concessioned from the Bangkok Mass Transit Authority, April 2003

[64] See "Sustainable Transport: A Sourcebook for Policy-Makers in Developing Cities, Module 4c Two- and Three-Wheelers; GTZ, Main contributors: Jitendra Shah (The World Bank) and N. V. Iyer (Bajaj Auto Ltd)

congestion. The recently adopted Urban Transport policy in India calls for a more equitable road space focusing on people rather than vehicles (GOI-MUD, 2006). Other more innovative and equitable solutions are required. The UN (1999) and Allport (1996) amongst others have also recognized that simply providing more road space, even if the associated land and capital could be made available, is not a solution. Given the substantial private-vehicle future demand and ever-increasing space requirement caused by the move from 2- to 4-wheelers, any attempt to increase road space will quickly be absorbed by higher car ownership and use, with no long-term improvement in traffic speeds, air quality or GHG emissions[65].

89. Ten years ago the peak-hour average speed for Asian cities was estimated to be 16 km/h, with much lower speeds in many cities[66]. Evidently, cars in many Asian cities spend much of their time stationary in traffic jams and this is worsening rapidly over time. As travel time per km increases, the fuel consumption per km increases substantially (as illustrated in Figure 15) with attendant increases in air pollution and GHG emissions[67].

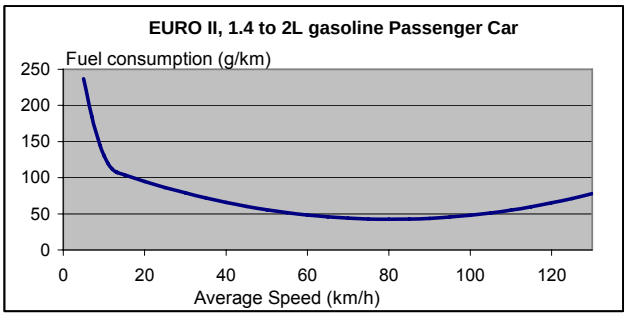


Figure 15 - Relationship between average speed and fuel consumption for a EURO II 1.4 – 2.0 liter displacement gasoline passenger car[68]

90. In Southeast Asia inadequate road safety will cause 385,000 road deaths and 24 million injuries in the next five years, incurring more than US$88 billion in economic losses, according to ADB sponsored studies. Some 75,000 persons were killed and more than 4.7 million were injured in road crashes in Southeast Asian countries during 2003, with annual economic losses estimated to be around $15 billion, or 2.2% of the region's total gross domestic product[69]. Such huge recurring losses are not socially acceptable and whilst great strides have been made to improve the safety of occupants in new vehicles, little attention – and funding – has been given in emerging Asia to improving road safety for pedestrians together with NMT and 2- and 3-wheeler users.

F. Public Transport and Non Motorized Transport

1. Public Transport

91. Most cities in emerging Asia can be characterized as having large-scale and growing urbanization with high-density inner city areas and inadequate road space with a large part of

[65] Source: Car travel: “Asia cannot follow Australia's path” Road & Transport Research, Jun 2000 by Moriarty, P
[66] Kubota 1996; World Bank 1998
[67] World Bank 1998
[68] using the EEA, COPERT II formulae
[69] Road Crashes Costing Southeast Asian Countries US$15 Billion Per Year, Charles Melhuish, Lead Transport Sector Specialist ADB see http://www.adb.org/Documents/News/2004/nr2004155.asp

the growth taking place at the edges of the cities resulting in a decrease in overall density. They typically still have a high modal share of public transport which is used by all of the population that does not own a car or 2-wheeler and the rapid growth in motorization in most cities is causing the relative share of public transport to decline.

92. Although there are shining exceptions, most of the cities in emerging Asia offer a low quality of service in their public transport which although low cost and relatively fast, is overcrowded, often dirty and highly polluting and with important personal security and safety issues. Accessibility issues are often evident, where high entrance deck height on buses, for example, effectively barring entry to women with small children and the elderly.

93. Whilst most of the cities in emerging Asia have formal bus services, a greater percentage of the passenger trips are conducted on informal buses and para-transit vehicles. These provide a service to the traveler that is cheap and convenient with a large number of vehicles – far more than would be needed if they were all full size buses – that are willing to pickup and drop passengers at any point along the route. However these large numbers of informally-operated and often inadequately maintained vehicles, competing for passengers, obstruct the flow of traffic and are a substantial source of criteria and GHG emissions.

94. Over the last years several cities in the region have put in place rail based public transport systems, either in the form of light rail, (e.g. Bangkok, Manila, Shanghai) and metro (e.g. Delhi, Beijing, Shanghai, Nanjing) and many cities have planned to put in place such systems. Rail based public transport systems tend to have a high public profile, but they are responsible for a relatively low numbers of the overall number of trips (usually less than 10%) while in all cases requiring large subsidies for construction and operation. These are supported by taxis and 2- and 3-wheelers; motorbikes in Thailand, motorbikes with sidecar in the Philippines, autorickshaws, Bajaj in India, Tuk-Tuks, and of course human-powered rickshaws etc that are also informally operated.

95. A current trend in many cities is towards Bus Rapid Transit (BRT) which consists of high capacity (usually articulated) buses operating on exclusive segregated bus lanes with rapid loading and un-loading of passengers at stations that provide electronic fare pre-payment and obstacle-free waiting areas and level access to the buses. The System includes centralized coordinated fleet control providing monitoring and communications to schedule services and real-time response to contingencies and is usually accompanied by traffic-flow improvement measures including bus-priority traffic lights, elimination of left turns, continuity given to right-turns, and improved sign-posting. These ground-level modern, high-quality bus corridors are often the result of a public-private partnership (PPP), in which the public sector is responsible for the investment to deploy the required infrastructure and have been demonstrated to supply carrying capacities rivaling metro[70] without the need for subsidized operation.

96. Informal public transport is characterized by many owner-operators or small to medium size operations where staff is employed mostly on the boundary system without health benefits and avoiding tax. The vehicles typically operate all day (independent of the demand) with ad-hoc scheduling and informal maintenance that stretches the operational life of each vehicle. They compete for passengers, occupy multiple road lanes and are a major cause of congestion

[70] The Transmilenio system in Bogotá, Colombia has demonstrated the ability to carry a peak flow of up to 36,000 passengers per hour per direction

and air pollution. They are usually a major source of employment and actively defend the status quo.

97. Although some cities (such a Hanoi and Bangalore) report increasing bus ridership (after having lost almost all bus services after the large scale introduction of 2 wheelers), generally in emerging Asia, mass transit is not an attractive option for anybody that has access to personal transport (car SUV or 2-wheeler). Many modern routes (for example the Skytrain in Bangkok or the metro in Delhi) lose attractiveness when the journey end-points are far from stations. Modernization of the transport system, preferably as a door to door solution, to attract passengers that own vehicles is substantially more difficult when the majority of mass transit vehicles are in the informal sector.

98. The informal sector is generally not interested in promoting or accepting long-term transport policies and severally hampers the mobilization of additional capital. Whilst it is now realized that mass transit systems need to be improved[71], in any move forward (i.e. the introduction of BRT) the emphasis needs to be on shifting operators from the informal to the formal sector and on public-private partnerships (PPP). BRT (as in Beijing, Kunming, and Xi'an in China[72] and Jakarta, Indonesia) is seen as a valid option for improving bus operation at high flow levels without the need for continuous external subsidies; something that rail, light-rail and metro cannot live without. Currently there are more cities in Asia that are planning BRT systems than rail-based solutions.

99. The largely informal nature of public transport in emerging Asia restricts modernization in other ways; most cities do not have any mechanism in place to monitor the performance of the transport system (modal split, passenger- and vehicle-kilometer-traveled, activity data by sub-sector and routes, environmental performance, safety and access etc) and there is often no clear guidance on the role of public versus private transport and associated with this, the incentives/disincentives to develop public- versus private-transport.

100. When strong governmental action is taken as in Delhi and Dhaka[73] the externalities of public transport can be substantially improved. Modern buses can generate orders-of-magnitude less emissions per passenger-km than private cars, and substantially reduce congestion if car usage within the metropolitan areas is inhibited and modal shift is induced.

101. In Sept, 2005 the PRC State Council Office issued a nationwide “Suggestions on giving the highest priority to urban public transportation development”[74] that assigns top-priority to developing urban public transportation as an important measure to increase energy efficiency in the transport sector and alleviate congestion, These guidelines directly promote the development of multi-mode intelligent public transportation systems (including BRT) with priority treatment being given to public transport, over private vehicles. The need to modify laws, regulations and standards is emphasized to promote well-regulated development and reform the

---

[71] The Hon. S. Jaipal Reddy, India’s Union Minister of Urban Development, stated in his opening remarks at the Conference on Alternative Technologies for Public Transport held in New Delhi, India, from March 21-23, 2006; "There is no escape from Bus Rapid Transit" when authorities at the national and local level must make choices to improve urban transport. The Minister also emphasized the need to reduce private car use.

[72] The Energy Foundation a partnership launched in 1991 by major foundations has initiated a sustainable transportation project in China. See “Promoting Bus Rapid Transit in China” at www.ef.org

[73] see 3a and 3c above

[74] Submitted by the Ministry of Construction, the National Development and Reform Committee, The Ministry of Public Security, the Ministry of Finance, and the Ministry of National Land and Resource as summarized and translated by Li Shuang, Apr.25, 2006

investment and financing support for privately operated, government supervised urban public transport systems.

2. Non-motorized transport (NMT)

102. Walking and non-motorized transport are traditionally the main means of transport in emerging Asia but these are becoming more difficult and less socially acceptable in many Asian cities. Many bicycle lanes built in China and Vietnam in the 1960s and 1970s are now being taken over by cars or are being systematically removed. Bike and becak lanes were also built in several Indonesian cities, such as Surabaya, in the 1970s, and have subsequently been removed. In Hanoi it is currently commonly accepted that only students use bicycles and these change to motorized 2-wheelers as soon as it is financially feasible. In many cities, rickshaws are restricted to certain streets because they slow the traffic for cars and SUVs. Recently, however there has been resurgence with Bangkok, Kuala Lumpur, and Manila all constructing new separated bicycle facilities in the 1990s. In India in recent years modern human-powered rickshaws have been introduced in several cities such as Agra, Delhi, Lucknow, Jaipur, and Vrindavan. The 2006 India Urban Transport policy makes specific reference to the need to maintain and expand the share of NMT in urban transport.

103. Urban walking in most Asian cities involves threading one's way along narrow, uneven (or nonexistent) pavements through street vendors, urban furniture and parked cars in a noisy polluted environment where it is difficult to advance at a steady speed. The revival of walking and NMT as effective mobility options is necessary but will require a change in vision for many Asian cities to actively build pro-pedestrian zones and pavements free of obstructions and promote segregated walk- and bike-ways to provide the safety and user-friendliness that these activities require.

When increased pedestrian areas and non-motorized vehicles are bundled with high speed public transport it is possible to reduce GHG and local emissions and provide a more enticing urban environment and economy as in the Dongshan District government in Guangzhou where the street was raised to a single flat pedestrian level giving people, not cars, the intrinsic right of way (Lohani, 2005b). An elevated pedestrian network in Bangkok, underneath the Skytrain stations, shields pedestrians from traffic and noise and links shopping centers in the nearby buildings, generating income both for the stores and for Skytrain. This is similar to the elevated network of pedestrian walkways at the Ayala Center in Makati City, Metro Manila which is linked to the MRT station, providing better access and comfort to commuters.

Application of ASIF framework in South Asian cities

Three South Asian cities - Bangalore, Dhaka and Colombo - were selected as case study sites to analyze the transportation, energy demand and emissions scenarios over the next fifteen years (to 2020) using the ASIF analytical framework. Although the types of data available in the three cities vary widely and there are deficiencies and inconsistencies in the available data, analysis of the results show in each city roughly doubling of motor vehicle populations due to the forecast rise in income levels in the business-as-usual scenario, and tripling of fuel use and CO2 emissions between 2005 and 2020. Analysis of the city data shows further strengthening and augmenting bus services, with commensurate increases in ridership, will provide multiple benefits – reduction in traffic congestion, fuel savings, pollution reduction and CO2 mitigation.

- An increase in public transport share from 62% to 80% in Bangalore leads to a fuel saving of 765,320 tonnes of oil equivalent, which is equivalent to about 21% of the fuel consumed in the baseline (BL) case. The other advantages that ensue are a 23% reduction in total vehicles (642,328) and creating a road space (equivalent to 418,210 cars off the road) and reduce traffic congestion. Air pollution in the city drops significantly -- 40% drop in CO, 46% HC, 6% NOx, and 29% PM. The total CO2 mitigation potential over the next 15-year period would be 13%.

- An increase in public transport share from 24% to 60% in Dhaka leads to a fuel saving of 106,360 tonnes of oil equivalent, which is equivalent to about 15% of the fuel consumed in the BL case. The other advantages that ensue are a 39% reduction in total vehicles (99,294) and creating a road space (equivalent to 78,718 cars off the road) and reduce traffic congestion. Air pollution in the city drops significantly -- 24% drop in CO, 26% HC, <1% NOx, and 13% PM. The total CO2 mitigation potential over the next 15-year period would be 9%.

- A marginal increase in public transport share from 76% to 80% in Colombo leads to a fuel saving of 104,720 tonnes of oil equivalent, which is equivalent to about 3% of the fuel consumed in the BL case. The other advantages that ensue are a 5% reduction in total vehicles (47,716) and creating a road space (equivalent to 62,152 cars off the road) and reduce traffic congestion. However, air pollution in the city does not drop much as the city already depends heavily on public transport and the CO2 mitigation potential is around 2%.

G. Conclusion

104. The trends and challenges presented in this chapter, are each by themselves already serious, taken together they show the lack of sustainability of the mobility model that has been followed in Asian cities in the last few decades and which unless a paradigm shift occurs will prevail in the years to come. Emerging Asia is faced with these challenges that need to be resolved for high economic growth to continue and improvements in quality of life to be sustainable. The growth of GHG emissions is directly related to GDP-inspired increases in passenger and freight inter-city transport and increasing personal mobility which also cause other national concerns – in terms of energy security and imports – and local problems such as congestion, pollution and road safety, that together seriously risk restricting the high economic growth that originally caused them. Many of these challenges, even in the most optimistic scenarios will get worse. A series of policy interventions that have co-benefits in each of these areas need to be urgently implemented for emerging Asia to reach its true potential.

105. Any vision on economic development, urbanization and motorization for the period to 2025 involves a “post-Kyoto” view in which countries in emerging Asia will have to buy into the facts of climate change. Within this timeframe the largest countries will be solidly established amongst the largest worldwide emitters of GHG and will have to face the paradigm shift that is

presented here. Delaying action and doing so at considerably higher levels of personal mobility (as currently forecast based on historic tendencies will cause a greater cultural and economic shock than taking action today. Any delay in generating this paradigm shift will have severe long term implications for the social and economic development of Emerging Asia.

Greenhouse Gas Scenarios from Road Transportation in Delhi

Delhi is a rapidly expending mega city which had over 13 million people in 2001 and is expected to surpass 22 million by 2020. It had about 2.6 million motor vehicles on-road – 200 for every 1,000 inhabitants in the year 2000, a rate far higher than most cities with similar incomes. Rising incomes, combined with demand for greater personal mobility and inadequate public transport, will inevitably result in continuing increase in personal vehicle utilization and ownership, especially inexpensive scooters and motorcycles, but also cars.

In Delhi, GHG emissions from road transportation are expected to soar.

Two GHG scenarios were created to characterize what is likely and what is possible. First (high-GHG) scenario is an extrapolation of trends in Delhi, modified to reflect policies and commitments, but without taking into account the Supreme Court directives.

Second (low-GHG) scenario is an extrapolation of trends in Delhi taking into account the Supreme Court directives and is premised on strong political and institutional leadership to enhance the economic, social, and environmental performance of Delhi's transportation system. In this scenario, conventional-sized cars drop from 30 to 19 percent of motorized travel between 2000 and 2020, and mass transit increases its share from 49 to 53 percent. More efficient scooters and mini-cars account for most of the remaining motorized travel, and bicycling becomes more important, especially for the poor.

Following important observations stand out:

- Greenhouse gas emissions is expected to go up more than four-fold in the high-GHG, or business-as-usual, scenario; but only double in the low-GHG scenario.
- Transportation policies are readily available that will not only slow emissions growth, but also significantly improve local environmental, economic, and social conditions.
- Improved technology would maximize the efficiency of automobiles, buses, and other modes of transportation and could play a key role in reducing emission increases.

Keeping many travel mode options available—including small compact cars and new efficient scooters and motorcycles—will help individuals at various income levels meet their mobility needs.

In summary, GHGs associated with road transportation will increase dramatically in Delhi in the coming decades, but many opportunities to slow the growth in vehicle use, pollution, GHGs, and traffic congestion are at hand at modest cost. Stong leadership is needed.

Source: Bose and Sperling, 2001

III. VISION AND POLICY FRAMEWORK

A. The Vision

106. Asia has to promote economic growth -- necessary for poverty reduction and improving the quality of life -- and account for a rapidly growing transport demand within the overall context of social development with improved equity and zero environmental impacts.

107. This will require accelerated urban reform together with innovative transport-demand management and access-and-mobility planning (travel demand management) that respects the differences between countries, cultures and cities and integrates a specific vision and action plan for each one. Faster implementation of new technology is needed, both regionally developed and adopted, with improved sharing of knowledge on a regular basis both North-South and South-South.

108. Future efforts in urban planning (to reduce the need to travel and promote NMT) combined with structural changes to the transportation system and improvements in the fuel economy of vehicles, could cause the accelerating growth-rate of GHG emissions in Asia to slow. It must be assumed, however, that GHGs from the transport sector in Asia continue to grow. This means that overall global climate goals can only be accomplished if absolute reductions are achieved either in other sectors in Asia or in other parts of the world.

B. Barriers

109. Accomplishing a reduction in the growth of GHGs in the transport sector will require that substantial barriers to change are overcome. Availability of congruent and consistent knowledge of international best practices on climate change and sustainable transport for national, state and local government planners and decision makers is one of the greatest barriers to change.

110. The currently weak empowerment and linkages in many metropolitan areas between urban planning, transport planning, traffic management and enforcement of planning, environmental and other transport related regulations provide a substantial barrier to effective changes that are focused, amongst other things, on reducing the climate change effects from transportation.

111. Inadequate accounting tools that fail to take into consideration the true cost of the externalities of on-road transport (congestion, pollution, climate change, travel cost and time etc) severely limit corrective actions. Charging the externalities of private motorized transport and achieving modal shift to public transport will require restraint of private transport demand and in many cases legislative reform that may be opposed by many current or potential private vehicle owners unless consultation and awareness programs are implemented with positive outcomes.

112. The lack of information to the consumer of the true per-km cost of private transport (including the components of vehicle depreciation and replacement, interest value of capital, insurance, taxes, maintenance, parking etc) restricts his/her ability to make rational choices. Awareness among different stakeholders on the need for urban reform and a paradigm shift in transportation planning contributes to a lack of grass-roots support for urban and transport reform which can negate its inclusion in the political agenda at the highest level.

113. Access to capital is also a barrier particularly where different administrative areas need to collaborate within the same transport development program. Lack of incentives to invest in better transport systems and new technology delay the adoption of new technologies and contribute to a continued lagging behind of certain countries in emerging Asia compared to Europe and other parts of the world. Difficulties in developing an optimum investment framework for more climate friendly transport systems are augmented by the currently limited relevance of the clean development mechanisms (CDM) for transport-related projects.

C. Principal policy interventions to reduce GHG emissions

114. If policy interventions to reduce GHG emissions from on-road transport were adopted these would improve access to goods and services whilst requiring fewer passenger- or freight-kilometers, reduce fuel consumption per passenger- or freight-kilometer traveled increase the distance traveled per unit of fuel for individual vehicles and adopt fuels with lower GHG emissions. This requires that the DMCs recognize the GHG emissions are a problem and strengthen their effective planning to mitigate them.

115. To accomplish this vision an integrated set of policy interventions need to be implemented. Policy interventions are required at the long, medium and short term as shown in Figure 16. The principal policy approaches can be divided in four categories:

(i) Promote Urban Reform and Land Use Planning to ensure Urban design that reduces the need to travel, requiring fewer passenger- or freight-kilometers;
(ii) Adopt Integrated Transportation Planning to ensure Modal shift that promotes lower fuel consumption per passenger- or freight-kilometer traveled;
(iii) Improve Vehicle Engines and Fuel Technology to improve the energy efficiency of individual vehicles, to increase the distance traveled per unit of fuel
(iv) Introduce Biofuels with lower GHG emissions

116. It is only if all of these policy interventions are implemented that Asia will be able to reduce the growth in GHGs from the transport sector. In other words decision makers do not have the luxury of choice but rather they need to develop the support and capacity to take on all the policy interventions outlined below.

117. Whilst the policies need to be all adopted within the short term the time required for successful implementation and that impacts start to materialize in a sizable manner varies between the policy options identified. Changing the urban design is the most challenging and will take the longest while the improvement of maintenance of in-use vehicles can be introduced immediately with a measurable impact.

118. There is also the need to strengthen the interventions by emphasizing the co-benefits of linked programs to facilitate the buy-in of (i) national governments, (ii) local governments and (iii) civil society even though each has different priorities including energy security, congestion, air quality and equality of access.

119. An important contribution of the development community in the adoption and implementation of these four policy approaches would be the strengthening of a continually-updated shared knowledge base as input into these decision processes and the development of

common tools that allow surrogate regional default parameters to be evaluated for hard- or costly-to-measure variables and for inter-comparison and accumulation of cities and countries. The development community also has an important role to play in the accelerated implementation of new technology (closing the gap) by encouraging technology development by areas and the adoption of leading worldwide standards. It can assist the DMCs to share technology development, and knowledge on a regular basis both N-S and S-S.

1. Urban Reform and Land-Use Planning

120. .The greatest GHG mitigation can be achieved in the long term through travel demand management linking urban development and land use with transportation planning to improve access to goods and services whilst minimizing the need to travel. The village concept of high-density urban planning within the region's mega-cities can, by integrating residential, business, commercial and light industrial areas, improve the quality of life and substantially reduce the need to travel. Linking villages with fast public transport and promoting electronic communities can enhance economic and social development while reducing consumption of transport fuels. Long-term, inter-sectoral regional policy frameworks need to be established for this to happen.

121. Within the framework of an exploding urban population, Asia needs to more actively promote the development of livable and sustainable, community- and health-centric, green cities that reduce the demand for personal motorized transport. Many inner cities would benefit from being revitalized to create a livable mixed-land-use environment that focuses on reducing emissions (including GHG), facilitating the new economy, saving landscapes and rebuilding communities through equity of access to goods and services, education and environmental empowerment. Electronic, networked communities that alleviate the need to travel should also be further promoted

2. Transportation Planning

a. Integrate Urban Transportation Planning with Land Use Planning

122. Urban transportation planning has to be well integrated with land use planning, community and educational development to promote increased mobility and a reduced demand for cars through a greater use of intelligent transport systems and the use of market instruments that equitably internalize the cost of public infrastructure usage (e.g.: roads and parking), pollution and congestion. These may include tax reform and deregulation, road and congestion pricing, active traffic management with car-free zones and cities, modal shift and the promotion of car sharing.

123. This is the component that can generate the largest GHG mitigation in the medium term. It involves charging the true cost of externalities such as congestion, pollution, climate change and use of public infrastructure – roads and parking – to the use of private motorized transportation (cars and motorcycles). It involves providing efficient and high quality public mass- and non-motorized alternative transport. Reducing subsidies to the private vehicle provides an important incentive to promote change and offsets some of the costs of improvements to public transport (rolling stock and infrastructure).

b. Charge the externalities of private motorized transport

124. Traffic demand management with a fiscal package that combines, increased fuel tax, carbon-based annual road charge (where low powered, low-emissions, hybrid and newer vehicles pay less than the higher powered, higher emissions and older vehicles), parking charges together with variable road-use pricing (congestion charging) are all tools that can charge the private vehicle owner for the climate change, local emissions, congestion and infrastructure externalities that his vehicle's operation creates or uses. Additional up-front private vehicle registration fees coupled with purchase limitations (such as the publicly managed open-bid Vehicle Quota System operating in Singapore) can further entice a market-priced efficient use of public road space. The creation of an urban transport fund can ensure that these charges and fees collected are used to improve public transport which considerably enhances the public acceptance of the policies and accelerates the change process.

c. Improve public transport

125. Safe, secure, rapid and user-friendly public transport systems (including para-transit, buses, metro, rail and new alternatives such as BRT) need to be further developed to promote modal shift from private transport and integrate with pedestrian and non-motorized transport to equitably provide efficient door-to-door connectivity.

126. Bus, metro and elevated light rail have traditionally been seen as the public transport option to private transport but increasingly the low-investment, low-operating-cost alternative provided by BRT operating on segregated roadways is gaining adherents. BRT can offer substantially higher-speed user-friendly mass transit at high carrying capacities[75] than traditional buses but with a considerable reduction in per-km investment vs. metro or light rail that allows substantially more routes to be developed for subsidy-free operation within a politically accessible timeframe[76].

127. The significant GHG and emissions reductions that can be achieved through modal shift from private vehicles to high occupancy public transport vehicles can in many cities in Asia be incremented substantially from improved traffic flow for the other private vehicles on the main route due to the elimination of interference from local bus or para-transit operation. Not only is travel time important to users; accessibility, reliability, safety and security issues need to be addressed. Where effective mass public transport crosses political jurisdictions, a regional policy framework is essential for development to occur.

128. Public transport systems need to provide door-to-door solutions for end users thus the feeder bus and para-transit routes into the main mass transit routes are equally important components of the overall system and need to receive the same attention to detail.

d. Maintain or increase Non motorized transport

129. Safe, secure, user-friendly modern rickshaws, together with pedestrian zones and walkways, segregated cycle paths and park-and-ride car and bike parks need to be created as

---

[75] 36,000 peak passengers per hour per direction has been achieved on a two-lane-per-direction corridor in Bogotá, Colombia

[76] A study for Bangkok showed that an investment of one billion US dollars could buy 7 km of subway or metro; 14 km of elevated rail or 426 km of BRT (Wright, et.al. 2006).

an integral part of the transport system to cater to both rich and poor although each has different needs.

e. Address increased Freight transport

130. Economic growth generates, and requires, greater long-distance connectivity in the supplier and distribution chains which should be further promoted through improved intra- and inter-city infrastructure (roads and depots) for efficient larger-capacity long-distance carriers. Modal shift to proficient, less-GHG-intensive transport channels (such as railways) should be actively encouraged by fiscal measures and fine-tuned freight transport management policies. More control needs to be imposed in urban areas with well-defined trucking routes and spatial and temporal truck restrictions in other zones.

f. Integrate Inter-city road passenger transport with urban transport systems

131. Long-distance passenger travel needs to be closely integrated into the urban environment facilitating fast traveler-friendly mass-transport access to well-located terminals and airports. Carefully planned highway system improvements are required to reduce travel times for goods and passengers whilst improving road safety, congestion, fuel consumption and emissions.

3. Vehicle, Engine and Fuels Technology

132. Vehicles that are sold today will contribute local and GHG emissions to the atmosphere during the next 10 – 15 or more years. Asia would benefit by minimizing the implementation lags in achieving the "world-standard" automotive fuel specifications[77] to accelerate the incorporation of clean vehicle technologies into the active fleet.

a. Improve Energy Efficiency

133. GHG emissions reductions would benefit if energy efficiency standards were implemented (or improved) throughout emerging Asia for all forms of motorized personal transport following China's lead[78]. The implementation timetable and cost structure of the technical changes could be optimized if country-specific development were not required from the vehicle manufacturers and their supply chains. There is a powerful logic to adopting uniform "worldwide" standards even though the implementation schedule may differ on a per-country basis due to limitations in fuel supply. As can be seen in Figure 8, the fleet averaged fuel economy of EU vehicles is now approaching 60+ percent improvement over US fleets.

b. Fuel and Emissions standards

134. Synergy is achieved when the introduction of fuel economy standards is directly linked with vehicle and engine emissions standards. Emerging Asia would do well to issue vehicle technological requirements in line with the EURO specifications with implementation timeframes

[77] With ultra-low sulfur content as specified for US-EPA and EURO emissions standards

[78] China has fuel economy standards in place for light duty vehicles, and standards for light duty trucks will come later this year or early 2007 closely followed by fuel efficiency standards for heavy duty vehicles and agricultural vehicles

that depend on fuel availability amongst other considerations. It is important that the "world-wide" standards are adopted completely, including any durability requirements etc, so as not to provide a perverse incentive to manufacturers to cut cost and deliver a sub-standard product in terms of emissions. A medium-term objective for emerging Asia would be to reduce the implementation gap to zero.

135. Vehicle energy efficiency and emissions standards are intrinsically linked to fuel standards. Introducing tighter energy efficiency and emissions standards requires sufficient unleaded and low sulfur fuel to supply new vehicle consumption (i.e.: for the growth component of automotive fuel sales) accompanied by a fiscal policy that does not promote cross-fuelling[79]. It is important the policies be established to influence fuel use on differential pricing terms and environmental grounds.

136. If emerging Asia were to adopt EURO energy efficiency and emissions standards for light and heavy duty vehicles it would benefit directly from the worldwide automotive industry's research and development efforts, minimizing both development costs and implementation timeframes whilst improving its competitive position as a manufacturing base in the international vehicle market.

137. Since emerging Asia is the largest producer and consumer of motorcycles of less than 150 cc engine displacement and 3-wheelers, further promotion of research and development through advanced energy efficiency and emissions standards that drive technology could increase its leadership in these market segments.

c. Inspection, certification and maintenance

138. If in-use vehicles do not receive adequate maintenance (in quality and frequency) their emissions – both local and global – will suffer. Most emerging Asia does not have a solid maintenance ethic. In many countries, formal workshops staffed with trained mechanics equipped with diagnostics equipment are hard to find for out-of-warranty vehicles and a wide variety of replacement parts that are readily available for their repair do not meet OEM specifications.

139. Strict visual-smoke rules empower traffic police to issue fines to smoking gross emitters and have catalyzed fuel economy improvements in many fleets in developing countries.

140. Vehicle inspection programs that are correctly implemented and rigorously enforced can detect the gross emitters and ensure that they are repaired. Such Inspection and certification programs are particularly well suited to include fitness and safety inspection of the older vehicle with a resultant reduction in road accidents. Such programs can be beneficially linked to accelerated scrap page programs that remove older, less-efficient, contaminating and/or unsafe vehicles from the fleet and promote their substitution with new technology vehicles.

---

[79] If "dirty" fuel is cheaper than clean fuel it provides a perverse incentive for users of new vehicles to permanently damage their vehicles by using an inadequate fuel. On the other hand if the "clean" fuel is cheaper demand can outstrip supply.

141. These benefits can be accompanied by substantially reduced local emissions, especially from older diesel and gasoline-fuelled, carbureted vehicles. It is important to incorporate used vehicles that are imported into this framework.

d. Retrofit

142. Tightened emissions, safety and fuel economy control on older vehicles also provides an important incentive to fleet renewal. Modern heavy duty trucks are substantially more fuel efficient than units produced 15 years ago. Operators in Mexico have reported that the fuel saved is sufficient to cover the cost of the monthly interest payments on the new truck[80]. Particularly for heavy duty vehicles, retrofitting a new engine into an existing vehicle can provide important fuel consumption -- and emissions -- benefits. Direct-injection retrofit options are being developed for 2-stroke 2- and 3-wheelers that provide substantial fuel economy benefits.

143. These fuel economy improvements from in-use vehicles will not occur without government providing incentives, establishing inspection requirements and empowering enforcement.

4. Biofuels

144. Unless there is a paradigm shift in current tendencies, the transport sector in emerging Asia is forecast to demonstrate almost unmanageable growth over the next 25 years in private vehicle populations, fuel consumption and GHG emissions. Even in Europe with relatively stable vehicle fleets, it is expected that 90% of the increase in GHG emissions between 1990 and 2010 will be attributable to transport and one of the main reasons that EU is failing to meet their Kyoto targets[81].

145. An ambitious, congruent and realistic vision in emerging Asia to convert a substantial portion of on-road transport to clean and CO_2 efficient biofuel provided by competitive private industry would assuage part of the fuel security and GHG pressures. However, the required scale of production to make a significant difference is far greater than that proposed in other continents. The EU vision[82] of providing 25% of their transport fuel needs by 2030 from biofuels requiring 4-13% of the total agricultural land to be dedicated to this use, pales in comparison to the long-term GDP-growth driven increase in personal mobility in emerging Asia and its accompanying fuel requirements. Co-benefits such as additional rural employment need to be balanced against potential competition with food production, sustainable forestry, and the impact on the environment of substantial crop changes.

146. For biofuels to supply a significant proportion of fuel for on-road transport, government needs to provide a clearly marked roadmap driven by market incentives and assurances in which a premium is established for those feedstock/process combinations that generate the largest life cycle analysis GHG emissions reductions relative to conventional fuels. It is important that the policies do not limit development to one crop and process type, but create an environment in which diversity in crops and technologies can evolve.

---

[80] Interview with Joaquin Montiel, Managing Director of Transportadora Estrella, Mexico 2003

[81] Source: Biofuels in the European Union – a vision for 2030 and beyond by the Biofuels Research Advisory Council 2006

[82] as provided for in EU Directive 2003/30/EC

D. The co-benefits of climate change mitigation

147. In moving towards this vision, most of the development, and poverty alleviation goals directly impact on-road transportation and hence GHG emissions from this sector. Adding to the complexity is the reality of a highly dynamic moving baseline powered by population and economic growth placing heavier burdens on the road-transport system. This sector currently uses around 21% of the world's total energy consumption; over the short and medium term is the most tied to petroleum products and emerging Asia by itself is expected to account for 45 percent of the total world increase in oil use through to 2025. Despite this, the GHG potential of on-road transport in emerging Asia is yet to be seen by many as a priority area, within itself, for sectoral reform and development.

148. An effective and sustainable transport system for people and goods is a prerequisite for consistent long-term economic growth. Equity and poverty alleviation both require such a sustainable system. Asian countries and cities urgently need a policy reorientation that develops new institutional capacities and bridges between sectors to improve land-use planning and promote integrated transport infrastructure schemes based on affordable, environmentally-friendly public transport and non-motorized transport. There are many co-benefit linkages within this framework however that inextricably relate economic, efficiency and quality-of-life enhancements to improvements in GHG emissions.

149. All of the policy interventions shown in Figure 16 that are required to mitigate climate change have important co-benefits at the regional and local level. Improvements in air quality and health, traffic and congestion, quality of life, economic development, road safety and transport efficiency will be generated to a greater or lesser degree by most of the climate change interventions and these provide an important opportunity to tailor the proposals to each stakeholder's constituents and interests.

150. Policy changes in urban development and awareness campaigns are needed for longer term benefits to be seen. Most of these changes will be instigated based on this series of co-benefits relating to equity and quality of life; very few will be based solely on global environmental concerns. The DMCs would benefit from a strengthening of common modeling tools using continually updated and shared knowledge bases in their decision-making processes to optimize their climate change mitigation efforts from on-road transport.

Figure 16 - Co-benefits and principal stakeholders

Effectiveness	Policies	Co-benefits							Principal Stakeholders					Investments by the international development community
		Climate Change	Air Quality and Health	Traffic and Congestion	Quality of life	Economic Development	Road Safety	Transport Efficiency	Int. Development Community	National, State, Provincial Gov't	Local, City , Municipal Gov't	Community Groups & NGOs	Private Enterprise and Investors	
Continuous	Strengthening continually-updated shared knowledge bases and common tools to assist DMCs in optimizing their climate change decisions for urban development, transport systems and biofuels	★★★	★★★	★★★	★★★	★★★	★★★	★★★	✓	✓				Non-lending regional assistance to develop and maintain a climate-change focused shared knowledge base and tools (models) for optimizing option selection in urban development, transport systems and biofuels.
Long Term	Improving access to goods and services through integrated urban planning and travel demand management	★★★	★★★	★★★	★★★	★★★	★★★	★★★	✓	✓	✓	✓	✓	TAs to strengthen and promote governance, legal, structural and institutional reform and awareness building. Strengthen administrative and functional linkages at city and municipal levels. Develop standards and sustainable indicators. Large investment requirement in urban development and transport systems
Medium Term	Reducing the fuel consumed per passenger- or freight-kilometer traveled through traffic demand management 1. Charge the externalities of private motorized transport 2. Mass-transit improvements 3. Non motorized transport	★★★	★★★	★★★	★★★	★★★	★★★	★★★	✓	✓	✓	✓	✓	

Effectiveness	Policies	Co-benefits							Principal Stakeholders					Investments by the international development community
		Climate Change	Air Quality and Health	Traffic and Congestion	Quality of life	Economic Development	Road Safety	Transport Efficiency	Int. Development Community	National, State, Provincial Gov't	Local, City , Municipal Gov't	Community Groups & NGOs	Private Enterprise and Investors	
Medium Term	Fuel efficiency standards for new vehicles 1. Energy Efficiency standards 2. Emissions standards 3. Fuel standards 4. Research and Development	★★★	★★★		★★	★★	★★	★★	✓	✓		✓	✓	TAs to advance the technological automotive roadmap and promote the development of new vehicle energy efficiency, emissions and fuel standards. Reinforce research and development in technology for 2-wheelers and to use non-carbon-based fuels (hydrogen etc). Large investment requirement in clean-fuel production capacity
Medium Term	Provide a substantial part of on-road transport's fuel requirements with clean and GHG efficient biofuels.	★★★	★★★		★★	★★			✓	✓	✓		✓	Technical, policy, and focused financial assistance to promote the large scale production, distribution, and use of biofuels and biofuel-compatible vehicles. Support for research and development to create an environment in which diversity in crops and technologies can evolve to large-scale biofuel production
Short Term	Improving Fuel Efficiency in existing vehicles 1. Inspection, certification and maintenance 2. Retrofit	★★★	★★★		★★	★	★★	★★	✓	✓	✓	✓	✓	TAs to promote governance, capacity and awareness building and to establish and effectively enforce in-use vehicle emissions standards. TA support for pilot demonstration projects.

E. Stakeholders

151. The accelerated growth in Asia of urban population, motorization, congestion, road safety concerns and pollution – including the GHG component – urgently require a change in focus for most Asian metropolises in their approach to urban and transportation planning and the actions required to face these problems are the same actions required to reduce the accelerated impact of Asian on-road transport on climate change.

152. The major stakeholders in this process are:

- *The international development community*: whose overriding interest is poverty alleviation and social development through sustainable economic growth with a reduced carbon footprint
- *National, state and provincial governments*: who share the international development community's concerns of poverty alleviation and social and economic development combined with concerns of energy security in the light of increasing demand and costs with an ever greater imported component.
- *Local, City and Municipal governments*: faced with unfettered urban growth and sprawl with growing congestion, pollution and safety concerns that restrict their ability to attract business and improve the quality of life.
- *NGOs and Community Groups*: that will be faced with a lowering of expectations towards the common "good" unless paradigm shifts are achieved.
- *Private Enterprise*: depending on the availability of well functioning and affordable transport systems to generate further economic growth and
- *Investors*: in need of clearly defined regulations and long-term policies to reduce the risk and enable the paradigm shift changes that they must promote.

153. Of these, the development community and some NGOs are most likely to buy in to the proposed action plans purely because of their climate change implications, however the identified co-benefits of all the proposed action plans directly impact major problem areas that countries and cities in Asia are currently facing.

154. Public awareness-raising to improve the understanding and knowledge of the different stakeholders is very important for climate change in general and transport-related climate change in particular and this needs to be promoted by the development community as well as by national and local stakeholders. Separate strategies are required for each different stakeholder to inform and promote the co-benefits associated with each policy intervention.

155. An area of special concern needs to be the limited capacity among all stakeholders in analyzing current trends, developing integrated policies for transport and climate change and effectively implementing and monitoring the policy approaches outlined in this report. Establishing priorities for climate and transport is still relatively new for both the development community and Asian countries and cities. In those few cases where such priorities have been established it has been within units with an environmental mandate rather than urban development or transport. This implies that before large training programs are initiated, the institutional mandates of different governmental agencies at both the national and the local level need to be adjusted. Since this is a new topic it is also important that sufficient capacity is created in the private sector both to guide decision making in the private sector and to act as a consultant to the government and the international development community. For a regional

approach to be promoted it is important that such capacity is not limited to individual cities or countries but is also consistent at the regional level.

156. In order for the stakeholders to engage in a productive dialogue and implement common programs and projects it is important to develop a better set of tools and instruments that can be used to identify and analyze trends and plan for the future. The development of the policy recommendations in this report was hampered by the lack of comparative data for Asian countries (for example modal split) and the overall absence of reliable data in specific areas such as the number of different vehicle types in use and the number of people making use of NMT.

F. Investment

157. Urban development and expansion of the transport systems in emerging Asian countries will require large amounts of funding. A joint ADB - JBIC - World Bank study in 2005 estimated that the creation of additionally required infrastructure for Asia at $165 billion per year for the next five years (2006-10), out of which $37 billion comprises investments required for roads and rails subsectors.

158. Investments are required for short, medium and long term. In general most of these investments would be needed in any case (e.g. for urban expansion, infrastructure generation, public transport and fuel supply). Ensuring the right type of investments so that GHG emissions are minimized can prevent economic damages through health impacts, congestion and road accidents. Since all these investments have important co-benefits including air quality and health, traffic and congestion, quality of life, road safety, transport efficiency and economic development, over the long-term, similar investments would probably be required even if the climate change component were not considered. It is encouraging that key components of the policy approaches identified as being more climate friendly also are less-costly to implement. For example a BRT is in many cities a more appropriate solution than a metro and is far less expensive to construct and to operate and maintain.

159. The economic benefits of investments in reducing air pollution from the transport sector or improving road safety have been well established. The limited financial returns often prevent the quick adoption of cleaner technologies such as low sulfur fuels. In order for such measures to be taken it is important to promote a willingness–to-pay attitude among the general public by undertaking extensive awareness raising campaigns. This will help to increase the possibility for consumer financing. At the same time it is important to ensure that the externalities of transport are well understood and reflected in any type of incentives and disincentives used in the transport sector. China recently modified the sales tax on light duty vehicles and introduced a system of 6 classes whereby cars with a small engine displacement (and low GHG emissions) are lightly taxed relative to cars with larger engine displacement.

160. To develop a medium to long term investment plan for transport in Asian cities will require addressing the status of the informal sector. As described in this report in many cities the informal sector is currently providing a large part of the public transport. The time perspective of this sector is limited. The sector does not generate enough cash internally to modernize fleets and it does not have established linkages with formal external sources of capital. Without regulating and formalizing this sector it will be difficult to develop integrated investment strategies and plans.

161. Introducing a climate change priority requires re-focusing many investment components and this demands an additional effort from the development community to build awareness, develop capacities and technical expertise, strengthen linkages, and promote inter-sectoral collaboration and technology development. It requires an increased knowledge base to encourage enlightened decision making that proactively evaluates the GHG implications of co-related projects.

162. Close monitoring of the results from research and development conducted by internationally or commercially supported efforts outside of emerging Asia can allow the countries in emerging Asia and the development community to optimize their funding within the region as a whole and within individual countries to catalyze investments in areas that remain behind and threaten to undermine the overall success of implementation of the action plan. Informed decision-making when selecting future action plans to mitigate climate change from this sector will thus require a knowledge base that closely monitors worldwide technological pathways and best-practices.

163. To catalyze investment to support the policy approaches proposed in this paper it is important to have dedicated funds available, this in addition to regular funding for urban development and transport described above. Such funds can help in overcoming the institutional, technological and knowledge related barriers and help finance pilot projects. It is not expected that such special funds will be able to take over the role of regular financing of urban development and transport as stated is in many cases undertaken by the private sector. Such dedicated funds could be financed from a range of sources, including:

i) Earmarked funds from special user charges such as a congestion charge. The London congestion charge has helped to fund the expansion and modernization of the bus fleet and has resulted in a modest modal shift away from private cars towards public transport. Other possibilities which can be introduced quicker and more widely include road user charges and fuel taxes. Both are already fairly widely used and can be redirected, most likely in part, towards providing incentives for more sustainable transport systems. This would require that governments, especially the Ministries of Finance, no longer regard such charges as instruments to raise the general revenues but as targeted policy instruments which both aim to restrain private car use and at the same time promote integrated land use and transport planning and the expansion and improvement of public transport. Another instrument which is not yet widely used in Asian countries is parking charges. Parking policies at present are in most cases ad-hoc and as in the case of other user charges do not have a transport related policy objective ;
ii) Linkages to GEF and CDM mechanisms could help raise interest. Currently there are no dedicated funding windows available for financing energy efficiency in transport unlike other areas where there are a range of special funds. If the global community is serious about moving forward with energy efficiency in the transport sector it will have to create similar funds to catalyze knowledge management, capacity building and policy development.
iii) Development agencies have over the last years either formally or informally adopted targets on for example renewable energy or water and sanitation. Embracing such targets, which are usually the outcome of international discussions have helped to prioritize funding in development agencies. It could be considered to encourage the adoption of targets on urban development and transport, e.g. improving share of trips undertaken by public transport and/or

NMT. At present less than 10% of transport related lending in ADB is for the development of urban transport systems and the large majority of funding is for road construction.

164. The danger of dedicated funding is that a dependency develops which prevents a wide scale replication and dissemination of successful sustainable transport solutions. A financial model whereby IFI financing is required as bridge financing might be attractive in the short term but needs to be avoided for the medium and long term.

165. It is important for those stakeholders who will be expected to take the lead in formulating and implementing transport programs and projects what the support is that will be provided by the national government. Few countries in emerging Asia have come out with a clear policy in this respect. A notable exception is the recent National Urban Transport Policy in India in which the national government formulated clear criteria for the support to be provided: (i) 50% of the cost of preparing comprehensive city transport plans and detailed project reports; (ii) equity participation and/or viability gap funding to the extent of 20% of the capital cost of public transport systems; and (iii) 50% of the cost of project development whenever such projects are sought to be taken up through public-private partnerships, so that a sound basis for attracting private partners can be established, whereby the remaining funds would have to come from the city development authority.

166. Most of the investment requirement for the international development community and to a lesser extent the governments in Asia is in institutional development and knowledge management. The private sector will be the source of the greater proportion of implementation investment, and for this to occur in the timeframe and to the required extent, very clear and transparent regulations and long-term policies need to be established. It can be expected that public private partnerships will increase especially with respect to the provision of urban public transport. This will require the establishment or improvement of a regulatory institutional framework. Currently few of the countries in Emerging Asia have effective independent regulators for public transport in place.

IV. ACTION PLAN

167. A multi-sectoral action plan needs to be developed as a roadmap for GHG reduction and co-benefit improvements on a regional – emerging Asia – level and for each individual country and city. The action plan presented in Figure 17 to Figure 21 can guide the individual countries and cities but countries and cities will have to ensure that their action plans reflect their particular situation.

168. The following action plans, as previously discussed, are presented below:

A. *To improve access to goods and services through an integrated urban plan*
The greatest GHG mitigation can be achieved in the medium to long term through linking urban development with transportation planning to improve access to goods and services whilst minimizing the need to travel.

B. *To reduce the fuel consumed per passenger- or freight-kilometer traveled through modal shift*
This is the component that can generate the largest GHG mitigation in the medium term. It involves modal shift; promoted by charging the true cost of externalities such as congestion, pollution, climate change and use of public infrastructure – roads and parking – to the use of private motorized transportation (cars and motorcycles) and providing efficient mass-transit and non-motorized alternative transport.

C. *To establish and implement fuel efficiency standards for new vehic*les
Energy efficiency standards need be implemented throughout emerging Asia for all forms of motorized transport.

D. *To massively increase the use of GHG-friendly biofuels for on-road transport*
Changing to fuels that have a lower carbon footprint in sufficient quantities would have a major impact in GHG emissions from on-road transport.

E. *To improve Fuel Efficiency in existing vehicles*
Improving the maintenance condition of in-use vehicles (in terms of quality and frequency) can generate an improvement in the short term for both their global and local emissions.

169. These action plans must be updated on a regular periodic basis as part of a continually improving multi-faceted process that respects the social and economic differences between countries and cities but maintains regional congruence and consistency. To support this process there is a need to establish an institutional mechanism in each country and city to discuss, evaluate and apply an action plan to address GHG emissions.

170. Similarly members of the international development community should formulate their own action plan to outline steps that will be taken by them to assist in Asian countries and cities to move away from the current mobility paradigm and replace it with one which takes into account the impact of transport on climate change.

Figure 17 - To improve access to goods and services through an integrated urban plan

Effectiveness	Institutional development	Investment and financing	Operation
A. To improve access to goods and services through an integrated urban plan			
*Most of these actions will generate visible results in GHG mitigation in the **medium to long term.*** *The short-term targets of capacity and awareness building and institutional integration and reinforcement should be identifiable within a shorter term political timeframe.* *The international development community together with national governments is key in catalyzing climate-change-friendly sustainable improvement of urban and transport development programs at the state, provincial and metropolitan-area levels*	• Support the formulation of metropolitan area development strategies that integrate all cities or municipalities within the area. • Promote via training and best-practice definition the development of a long term urban and transport structure plan for each major Asian metropolitan area and ensure that all short and medium term projects are on meeting these long term goals. • Strengthen the linkages at city and municipal levels between urban planning, transport planning, traffic management and enforcement to minimize functional and jurisdictional impediments to policy integration. • Charge the externalities of private motorized transport to improve NMT and mass-transport by actively promoting private transport demand restraint via spatial and time-variant pricing and non-financial measures. • Promote the involvement of local community groups and NGOs in the strategy design and project implementation via well-informed, opportune consultation. • Promote the application of consistent sustainable development indicators at the national, state and provincial levels to evaluate the urban and transport progress at city and municipal levels towards meeting these long term goals for each major Asian metropolitan area. • Promote GHG reduction as a “sine qua non” basis for all traffic management and urban and transport development projects	• Actively promote investment in infrastructure, safety and security, capacity and awareness building that develops NMT via a network of segregated routes and integrated areas in the urban environment. • Promote private sector investment that is consistent with the strategic framework. Provide capacity and awareness building to the private sector. • Promote multi-agency financing packages and programmatic lending to cities where different administrative areas need to collaborate within the same transport development program. • Ensure that all bank lending for urban development and road infrastructure projects have a long-term energy efficiency improvement component.	• Promote private sector operation of public transport. Provide technical assistance in the design of franchised, route-based urban transport concession contracts and controlling regulations. • Ensure that all urban development that is a high trip generator (such as shopping malls) has optimized public transport access with special attention to the modal interchanges (e.g.: private to public). • Evaluate bank investment projects on the basis of how they improve access and mobility of persons to goods and services, not on the basis of traffic improvements. • Strengthen sustainable urban development and transport planning training institutions and promote the retention of skilled professionals in evangelistic centers of excellence

Figure 18 - To reduce the fuel consumed per passenger- or freight-kilometer traveled

Effectiveness	Institutional development	Investment and financing	Operation
B. To reduce the fuel consumed per passenger- or freight-kilometer traveled through modal shift			
*These actions can generate visible results in GHG mitigation in the short to **medium term**. The deployment of BRT is achievable within a **shorter political timeframe**.* *The international development community together with national, state and provincial governments is key in catalyzing climate-change-friendly sustainable improvement of urban and transport development programs at the metropolitan-area and city or municipal levels*	As above plus: • Promote mass transport developments that work towards meeting a goal of improved door-to-door connectivity. Stand-alone routes will never substantially change the number of vehicles per 1000 population. • Promote collaboration between different administrative functions within the metropolitan area to create transport systems that integrate and cross administrative barriers. Provide education and guidelines to ensure that all the local agencies involved (land transport, urban development, traffic police etc) work towards a common vision and goal. • Develop technical expertise at the local levels of government to facilitate improved transport integration within a city-wide and regional development framework particularly for NMT to mass-transport interfaces. Promote best-practice development. • Assign responsibility at the highest level for traffic safety and for safety and security in all mass transport, and associated pedestrian and NMT development. • Strengthen the focus for access of the urban poor and mobility-impaired to transportation systems. • Reinforce traffic management and enforcement skills at the local level. • Develop metropolitan-area-wide policies that favor mass transport over private transport	• Focus and give preference to investments in transport programs that reduce the fuel consumed per passenger- or freight-kilometer traveled. • Procure investment for mass-transit projects and instigate policies that promote modal shift from private personal transport. Seriously consider low investment options that allow extensive coverage such as BRT operating on segregated roadways. • Consider public-private partnerships where the infrastructure investment for mass transit is provided by the government and the rolling stock is operated by well-regulated franchised private operators. (a franchised bus route can generate notable less GHG emissions (direct and indirect) than free competition between individual bus operators). Most urban transport systems can benefit from private operation. • Place emphasis on sufficient investment on infrastructure and improvements for pedestrians and NMT in all urban transport and development programs.	• Place emphasis on the development of financially sustainable transport systems which allow the system operator to invest in growth and continual system maintenance and rolling stock replacement. • To enable efficient and sustainable transport operations, it is desirable that subsidies to meet other sectoral objectives (health, education, etc) be financed directly through the budgets of these other sectors. • Since fares must be affordable, a well regulated mass transport system may require the franchised operator to internally subsidize a less profitable low cost service with a higher fare service on the same route (for example by operating seat-only A/C and higher passenger density non-A/C buses on the same route at regulated frequencies).

Figure 19 - To establish and implement fuel efficiency standards for new vehicles

Effectiveness	Institutional development	Investment and financing	Operation
C. To establish and implement fuel efficiency standards for new vehicles			
*These actions can generate noticeable results in GHG mitigation in the **medium term**. Whilst changes in standards, if implemented, can bring about considerable changes to fuel efficiency, their impact in overall results depend on the speed of incorporation into the in-use vehicle fleet.* *The international development community together with national governments is key in catalyzing climate-change-friendly sustainable improvement of fuels and vehicle technology*	• Promote the evaluation and open discussion of the health cost associated with automotive emissions and the participation of private and mass-transport in criteria- and GHG-emissions inventories at the local -- metropolitan area – and regional levels. • Promote the development of future scenarios of motorization based on population and urban growth and determine its expected impact on criteria- and GHG-emissions. Provide technical assistance with capacity and awareness building. • Develop a national technological automotive roadmap that defines and regulates the availability of no-lead and low sulfur fuels together with advanced engine and vehicle technology to mitigate the health cost and climate change impacts of road transportation.. • Establish the energy efficiency and vehicle emissions standards together will their associated fuel standards reducing the technology implementation gap for vehicle and fuels with a goal of reaching current “world-wide” standards in the shortest feasible timeframe (closing the gap). • Promote research and development. Assume a leadership position for 2- and 3-wheel vehicles and for the future use of non-carbon-fuels (e.g.: hydrogen). • Promote the involvement of local community groups and NGOs in the strategy design and roadmap implementation via well-informed, opportune consultation. .	• Promote an investment strategy that allows these standards to be implemented whilst reinforcing the international competitiveness of private sector stakeholders. Promote the accelerated substitution of old vehicles in the fleet with new cleaner, higher efficiency vehicles.	• Promote the involvement of local community groups and NGOs in the strategy design and roadmap implementation via well-informed, opportune consultation the future use of non-carbon-fuels (e.g.: hydrogen). • Actions need to be taken by private enterprise;- refineries, engine and vehicle manufacturers • Support the formulation of energy efficiency and vehicle emissions standards and their accelerated implementation. • Promote the accelerated replacement of old vehicles in the fleet with new cleaner and more efficient vehicles • Optimize the international competitiveness of refineries and manufacturing plants in Asia • Promote professional vehicle maintenance through training, parts availability and diagnostics

Figure 20 - To massively increase the use of GHG-friendly biofuels for on-road transport

Effectiveness	Institutional development	Investment and financing	Operation
D. To massively increase the use of GHG-friendly biofuels for on-road transport			
*These actions can generate noticeable results in GHG mitigation in the **long term**.* *The short-term targets of capacity and awareness building should be identified.* *The international development community together with national governments is key in creating a harmonized environment that promotes development and large scale production of biofuels within an evolving framework of diverse feedstocks and processes.*	• Promote via training and best-practice definition the development of a long term policy that creates a regional framework and incentivize GHG-friendly biofuel production for each major Asian economy. • Promote the development of regionally harmonized biodiesel quality standards and tariff policies congruent with international developments and standards that stimulate investments in large-scale production and facilitate international trade in biofuels, both within Asia and with markets outside the region. • Establish the appropriate legal framework at national and state levels to minimize functional and jurisdictional impediments to policy integration. • Promote GHG reduction as a “sine qua non” basis for all biofuels development projects.	• Actively promote the research and development of innovative feedstock and processes including integrated refining schemes. • Promote private sector investment that is consistent with the strategic framework of providing a substantial substitution of fossil fuels for on-road transport. • Provide capacity and awareness building to the private sector. • Promote multi-agency financing packages and programmatic lending to DMCs for the development of biofuels programs.	• Promote private sector operation of all phases of biofuel feedstock and production processes. • Evaluate bank investment projects on the basis of how they contribute to a mitigation of GHG emissions. • Strengthen sustainable fuels training institutions and promote the retention of skilled professionals in evangelistic centers of excellence. • Strengthen biofuels and raw materials trading on regional and world markets.

Figure 21 - To improve Fuel Efficiency in existing vehicles

Effectiveness	Institutional development	Investment and financing	Operation
E. To improve Fuel Efficiency in existing vehicles			
These actions can generate noticeable results in GHG mitigation in the short term. *The international development community together with national governments is key in catalyzing the political will-power required to get these programs off the ground.*	• Promote extensive capacity and awareness building on the health cost and additional fuel costs associated with inadequately tuned and repaired vehicles. • Promote and incentivize the political will-power in local – city and metropolitan area – governments to establish and effectively enforce in-use vehicle emissions standards. • Establish the appropriate legal framework that allows sanctions to be applied for failure to correctly perform the mandatory testing protocols and strengthen the linkages at city and municipal levels between environment and traffic enforcement to minimize functional and jurisdictional impediments to effective implementation. • Develop and establish a mandatory and well-enforced inspection and certification program focused on improving the emissions and fuel economy performance of older and intensively used vehicles in the fleet. Develop priority programs for municipal and urban bus fleets. • Evaluate the inclusion of mandatory vehicle fitness and safety inspection on older and intensively used vehicles in the fleet to directly promote increased road safety. • Evaluate retrofit as an option to achieve improved emissions and fuel economy performance from existing heavy vehicles at a lower cost and in a shorter timeframe than would be achievable through vehicle replacement.		• Promote improved vehicle maintenance through training, parts availability and diagnostics.

V. NEXT STEPS

171. This study presents one of the first comprehensive efforts to analyze the relationship between the transport sector and climate change in Asia over the next 25 years. The results of the analysis make it clear that even the most optimistic scenarios, integrating all expected technological improvements, will lead to a tripling of CO2 emissions over this period. At the same time the growth model for the transport sector on which these estimates are based will also result in an increase in air pollution from the transport sector, increase congestion to levels which seriously hamper the ability to move people and goods in an effective manner. In short, any continuation of historic tendencies or variations thereof, are not sustainable and should not be used as the basis for policy making and investments in urban development and transport.

172. A paradigm shift will be required which should result in a new Asian consensus on economic development mobility which can guide policy making and investment decisions. The international development community plays a key role in placing energy efficiency and climate change from transportation on the agenda. It needs to promote this change in vision together with the co-benefits of the proposed action plans that directly impact several of the major problem areas that the countries in emerging Asia are currently facing. The international development community through its assistance can help to get buy-in to the need for a paradigm shift by presenting and discussing the policy recommendations of this study in the continuation the deliberations on the G8 Gleneagles' Action Plan on Climate Change, Clean Energy and Sustainable Development as well as in regional meetings such as the upcoming second Regional Environmentally Sustainable Transport Forum in September 2006 in Indonesia, and the First Governmental Meeting on Urban Air Quality also in September 2006 in Indonesia. The ADB Regional and Sustainable Development workshop on "Energy Efficiency and Climate Change Considerations for On-road Transportation in Asia" in May 2006 is an important initial step for awareness-raising.

173. To promote the discussion at the national and local level it is important that the recommendations are in parallel also discussed at the regional level. The future of urban development and transport is being shaped now. In this context it will be helpful if multilateral development organizations make the topic of transport and climate change a more substantive part of their policy dialogues which they conduct on a regular basis in support of the development of their assistance and lending programs.

174. Whilst the development community should continue to provide advice on all modes of transport, greater importance should be given in future lending to programs that work towards integrally planned urban development and mass transport systems that increase mobility and access to goods and services whilst reducing vehicle-kilometers-traveled.

175. The international development community has a leading role to play in reducing the knowledge gap for developing countries by strengthening a continually-updated shared knowledge base on urban development and transport planning towards sustainable climate-friendly access to goods and services.

176. The international development community also has a leading role to play in the development of common tools that allow surrogate regional default parameters to be evaluated for hard- or costly-to-measure variables and for inter-comparison and accumulation of cities and countries.

177. A core set of monitoring parameters for the climate change components of on-road transport and associated co-benefits needs to be agreed between participating stakeholders to enable progress to be measured and reported – both at the local and regional levels – for each distinct action plan. This will most certainly require some field measurements to populate the baseline data where this is currently absent, and the development of supplementary parameter sets to cover specific local requirements.

178. Additional analysis needs to be performed with individual countries with particular reference to inclusion as a pilot case study in a few major metropolises and medium-sized cities. Here the international community should assist in the development of a strategic urban development and transportation plan, with selective support of small bus and para-transit operators, the development of private-public partnerships in mass transit and reducing the negative consequences of private motorization. The pilot cities should be chosen based on the individual countries interest and ability in undertaking the needed institutional reforms and building the required inter-sectoral linkages.

179. The international development community should also extensively reinforce research and development on the incorporation of bio- and non-carbon-based fuels (e.g.: hydrogen) for future use in on-road transportation.

VI. REFERENCES (to be updated)

Asian Development Bank (ADB). 2003. *Action Plans for Reducing Vehicle Emissions*.

ADB. 2005. Asian Development Outlook Update. Manila. Available: www.adb.org/documents/books/ado/2005/update/default.asp

Asian NGV Communications. February 2006. Vol. 1, No. 3.

AT Kearney FDI Confidence Index. Available: http://www.atkearney.com/main.taf?p=5,3,1,89

Biofuels in the European Union a vision for 2030 and beyond. 2006. Final draft report of the EU Biofuels Research Advisory Council

Borja-Aburto, VH, Rosales-Castillo, JA, Torres-Meza, VM, Corey , G, and Olaíz-Fernández, G. 2001. *Evaluation of Health Effects of Pollution*.

Brinkman, N., Wang, M., Weber, T., and Darlington, T. May 2005. *Well-to-Wheels Analysis of Advanced Fuel/Vehicle Systems — A North American Study of Energy Use, Greenhouse Gas Emissions, and Criteria Pollutant Emissions*.

British Motorcycle Federation, 2003, Motorcycle Emissions - Bikes Go Greener, 21 December 2003. Available: http://www.bmf.co.uk/briefing/Bikes-Go-Greener.html

British Petroleum Statistical Review of World Energy. June 2005

CAI-Asia, 2006. *Air Quality in Asian Cities* and *Ambient Concentrations of Pollutants and Trends of SPM, PM10 and SO2 in Selected Asian Cities*. Available: www.cleanairnet.org/caiasia/1412/article-59689.html

Fairley, P. 2006. *Automotive AC Makers Are Sweating* Technology Review, May 08, 2006; Available: www.technologyreview.com/read_article.aspx?id=16782&ch=biztech

Farrel. A., 2006. *Ethanol Can Contribute to Energy and Environmental Goals*. Vol. 311, SCIENCE. 27 January 2006. Available: www.sciencemag.org

Feng, A and Sauer A. (2004). *Comparison of Passenger Vehicle Fuel Economy and Greenhouse Gas Emission Standards Around The World*. Pew Center on Global Climate Change. December 2004

Fulton, L., Howes, T., and Hardy, J. 2004. *Biofuels for Transport: an International Perspective*. Paris: International Energy Agency.

Gielen, D. and Unander, F. 2005. *Alternative Fuels: An Energy Technology Perspective*. IEA/ETO Working Paper ETO/2005/01. International Energy Agency Office of Energy Technology and Research and Development. March 2005. Available: www.iea.org/textbase/papers/2005/ETOAltFuels05.pdf

GOI-MUD. 2006. National Urban Transport Policy. Government of India, Ministry of Urban Development. Available: www.urbanindia.nic.in/moud/programme/ut/nutp.pdf

GTZ (2003). *Sustainable Transport: A Sourcebook for Policy-Makers in Developing Cities, Module 4c Two- and Three-Wheelers*. GTZ. Main Contributors Shah, Jitendra and Iyer, NV.

HEI. 2004. *Health Effects Institute Special Report # 15*

Improving fuel efficiency of new cars in the EU. January 2006. Submitted by the European Federation for Transport and the Environment to the ECCP2 Working Group on the Integrated Approach to reduce CO2 emissions from light duty vehicles T&E, Brussels.

International Energy Outlook 2005. Energy Information Administration, Office of Integrated Analysis and Forecasting U.S. Department of Energy. Report #:DOE/EIA-0484(2005), Released Date: July 2005

International Monetary Fund. February 2006. *IMF (India) Country Report No. 06/56.*

International Road Federation Database. 2004.

International Panel on Climate Change. 2001. Third Assessment Report. Available: www.ipcc.ch/pub/spm22-01.pdf

JAMA. 2006*. Global annual motorcycle production in 2003.* January 2006. JAMA Motorcycle Industry, New Year's Discussion, URL: http://www.jama-english.jp/motor/200601.pdf

Karunungan, E. 2005. *The Philippine Biofuels Program*. Presented at Alternative Fuels and Energy Choice 2005, Kuala Lumpur. December 2005.

Lohani, B. 2005a. *Financing the City: ADB's Perspective*. Paper presented at the Asian Development Bank 38th Annual Meeting at Istanbul, Turkey. 3 May 2005.

Lohani, B. 2005b. *Asian Urbanization, Transport Development and Environmental Sustainability: Is Sustainable Transport Still Possible for Asian Cities?* Regional and Sustainable Development Department, Asian Development Bank. August 2005

Matsuoka, Midori. 2005. *Asia Leads Global Car Ownership Aspirations.* ACNielsen International Research, ACNielsen Online Survey 2004.

McRae, Robert. 1994. *Gasoline demand in developing Asian countries*. The Energy Journal. Jan 1994.

Moriarty, P. 2000. *Car travel: Asia cannot follow Australia's path*. Road & Transport Research. June 2000.

Pan-American Health Organization report found in Epidemiology: Volume 16(5) September 2005 p S111

Pramono and Heuberger, 2001. Available : www.cleanairnet.org/caiasia/1412/articles-70500_study.doc

Promoting Bus Rapid Transit in China. www.ef.org

United Nations (UN).2004. *World Population Prospects: The 2004 Revision* and *World Urbanization Prospects*. Population Division of the Department of Economic and Social Affairs of the UN Secretariat.

United Nations Millenium Indicators 2005. Carbon dioxide Emissions (CDIAC). April 2005

World Bank Development Indicators

Wright, L. and Hook, W. (eds.). 2006. *Bus rapid transit planning guide*. New York: ITDP.

www.just-auto.com

www.ngvglobal.com

www.itdp.org - Institute for Transportation and Development Policy (ITDP).

www.segmenty.com - Segment Y plc.

www.thecarconnection.com

www. worldlpgas.com – World LPG Gas Association