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CHALLENGES AND OPPORTUNITIES FOR AN ENVIRONMENTALLY SUSTAINABLE ROAD FREIGHT SECTOR IN ASIA

(Plenary Session 4 of the Provisional Programme)

Final Draft

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About CAI-Asia

The Clean Air Initiative for Asian Cities (CAI-Asia) promotes better air quality and livable cities by translating knowledge to policies and actions that reduce air pollution and greenhouse gas emissions from transport, energy and other sectors. CAI-Asia was established in 2001 by the Asian Development Bank, the World Bank and USAID, and is part of a global initiative that includes CAI-LAC (Latin American Cities) and CAI-SSA (Sub-Saharan Africa).

Since 2007, this multi-stakeholder initiative is a registered UN Type II Partnership with almost 200 organizational members, eight Country Networks (China, India, Indonesia, Nepal, Pakistan, Philippines, Sri Lanka, and Vietnam) and the CAI-Asia Center as its secretariat. Individuals can join CAI-Asia by registering at the Clean Air Portal: www.cleanairinitiative.org. Its flagship event, the Better Air Quality conference, brings together over 700 air quality stakeholders.

LIST OF ABBREVIATIONS

ADB	Asian Development Bank
CO	Carbon monoxide
CO_2	Carbon dioxide
DPF	Diesel particulate filter
DPWH	Department of Public Works and Highways (Philippines)
EST	Environmentally Sustainable Transport
GHG	Greenhouse gas emissions
GPS	Global positioning system
JICA	Japan International Cooperation Agency
NO_x	Nitrogen oxides
Pb	Lead
PM	Particulate matter
RFID	Radio frequency identification tags
SO_x	Sulfur oxides
UNCRD	United Nations Centre for Regional Development
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific
VOCs	Volatile organic compounds

EXECUTIVE SUMMARY

The efficient movement of goods and services is important in achieving sustainable development. All main modes of freight – road, water, air, and rail – have impacts on the economy, environment, and society that need to be managed. Freight now accounts for 35% of the world's transport energy use, and heavy-duty diesel vehicles are the biggest fuel consumers in Asia. This in turn, accounts for an equivalent emissions of air pollutants and as well as carbon dioxide (CO_2).

This paper focuses particularly on the road freight sector as it is the dominant mode of freight in Asia. The main sustainability issues and challenges facing the road freight sector are:

- <u>Fuel consumption</u>, which is becoming an increasing problem due to looming oil shortages, dependency on fuel imports and fluctuating prices
- <u>Emissions</u>, including air pollutants, greenhouse gas (GHG) emissions and noise, which affects people's health and causes climate change, amongst others
- <u>Truck driver health</u>, as particularly long-distance drivers are at high risk of getting sexually-transmitted diseases such as HIV/AIDS
- <u>Road accidents</u>, which are exacerbated because of truck overloading, lack of maintenance or old age, coupled with unsafe behavior of the drivers.

The main challenges that Asian countries must overcome to effectively address these issues relate to:

- <u>Policies and institutional arrangements</u>. Policies that deal with the environmental performance of trucks and the trucking industry are often lacking or limited, and poorly enforced. Furthermore, freight is seldom included in the design and planning of urban transport systems and in policy development, which results in ad hoc policies to mitigate problems associated with urban freight. The wide range of government agencies with a stake in the freight industry makes it difficult to assess and develop policies to develop the sector more sustainably.
- <u>Freight sector</u>. The road freight sector is highly fragmented with a majority owner-driver trucks, which makes it difficult for government agencies to reach them with information and policies on, for example, new technologies. The high percentage of empty hauls combined with systemic overloading of trucks is common and results in economic loss, higher fuel use and emissions, and safety issues.
- <u>Technologies and financing mechanisms</u>. The adoption of cleaner technologies is vital for developing Asia as many trucks are old and poorly maintained. Driver training and technologies can render significant fuel savings, which is important in developing Asian countries where the fuel costs are the largest component of truck operational costs. Challenges for wide-spread technology adoption are limited availability, a fragmented suppliers' network, and the presence of few case studies for Asia. Certain technologies face particular challenges, such as aerodynamics technologies as these work only at higher speeds, or diesel particulate filters (DPFs) because high sulfur diesel will corrode the filters. Financing green technologies is hampered by high investment costs (despite potential large savings and short payback periods), the reluctance of banks and financiers to lend money to trucks drivers and small companies, the lack of experience of ESCOs (energy service companies) with trucking fleets. Financiers often do not know how to appraise financing of technologies for trucks and policymakers have minimal experience in applying economic instruments the trucking sector.

An integrated approach employing avoid, shift and improve strategies is needed in addressing the road freight transport issues in Asia.

- *Avoid* strategies reduce the need to travel or the travel distance for road freight vehicles. Examples are promotion of local production and consumption, co-location of facilities within the same supply chain and with ports for goods that are to be shipped abroad, improved logistics that involves shippers, carriers, logistics centers, and manufacturers or end-users, and load management.
- *Shift* strategies refer to those which transfer freight activity to more energy-efficient and/or environmentally-friendly modes. Examples are optimization of railways and inland waterways, especially in developing Asian countries which are still developing their freight systems, and different vehicle types that better match the loads to be carried.
- *Improve* strategies are the ones which improve the energy efficiency of the current road freight transport modes, their operations and technologies. Examples are the adoption of fuel economy standards, stricter implementation of anti-overloading laws, and the use of technological tools, such radio frequency identification tags (RFID), global positioning systems (GPS) and vehicle routing software

The government plays an important role in setting policies and providing the right incentives that favor more sustainable freight practices.

1. INTRODUCTION

The efficient movement of goods and services is important in achieving sustainable development. All main modes of freight – road, water, air, and rail – have impacts on the economy, environment, and society that need to be managed. Before the advent of the internal combustion engine, most of the world's freight relied on shipping and heavy rail. During the economic development in the early to mid 1900s, some countries focused on improving the road network. Since then, freight has gradually shifted from shipping and rail to road. Today, many of the world's economies highly depend on their road networks as the primary means in transporting freight.

Freight now accounts for 35% of the world's transport energy use, and heavy-duty diesel vehicles are the biggest fuel consumers in Asia. This in turn, accounts for an equivalent emissions of air pollutants and as well as carbon dioxide (CO_2).

The United Nations has been leading the promotion and development of sustainable transport policies with Asian governments. Since 2005, through the United Nations Centre for Regional Development (UNCRD), they have organized the Environmentally Sustainable Transport (EST) Forum attended by senior government officials. The United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) has a lead role in transport facilitation and logistics, including a program on Eco-efficiency in Freight Transportation and Logistics.

This paper aims to provide an introductory overview of road freight issues in Asia with an emphasis on environmental impacts. It also identifies challenges and opportunities to reduce emissions and improve efficiency in this sector. This paper acknowledges the need to look at the freight sector holistically, including all modes, but it focuses particularly on the road freight sector as it is the dominant mode of freight in Asia and is an area where immediate interventions can lead towards huge benefits, particularly in terms of reducing fuel consumption and emissions.

2. BACKGROUND TO THE ROAD FREIGHT SECTOR IN ASIA

The increase in economic activity in Asia will be accompanied by an increase in the number of vehicles on the road. In the case of China, the total number of diesel motor vehicles is expected to grow from around 10 million in 2005 to almost 60 million in 2035. In India, a much faster growth is expected for diesel vehicles. In 2005, Indian diesel vehicles are estimated at 6 million and are projected to increase to 73 million by 2035 (see Figure 1). Trucks, buses and vans (light and heavy commercial vehicles) will continue to be the dominant diesel vehicles.

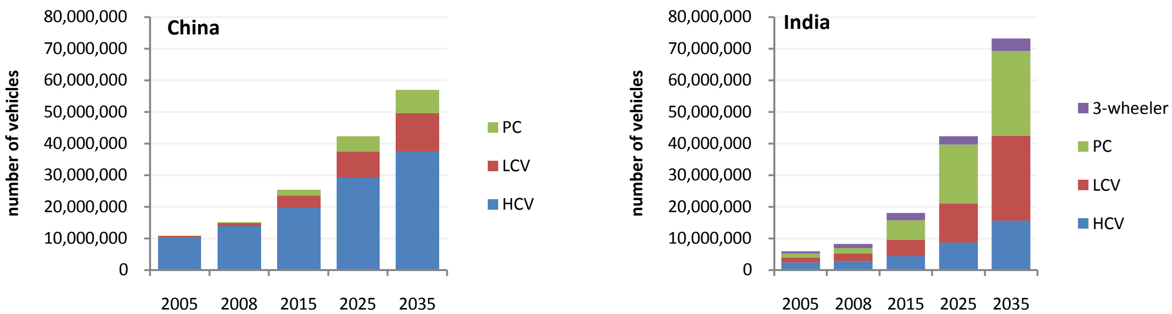

Figure 1: Expected Growth in Diesel Motor Vehicles in China and India 2005 – 2035
Source: ADB, CAI-Asia, Segment Y Ltd. (2009)
Notes: PC = personal cars; LCV = light commercial vehicles; HCV = heavy commercial vehicles

Freight movement plays a central role in economic development in Asia. As the Asian economy continues to grow at a rapid pace, an increase in freight activity is also expected. Figure 2 shows that for road freight, the travel activity (billion ton-km) of heavy and medium trucks in Asia will increase by 645% from 2000 to 2050 (as compared to 241% globally) and will comprise 29% of the global truck travel activity, from 13% in 2000.

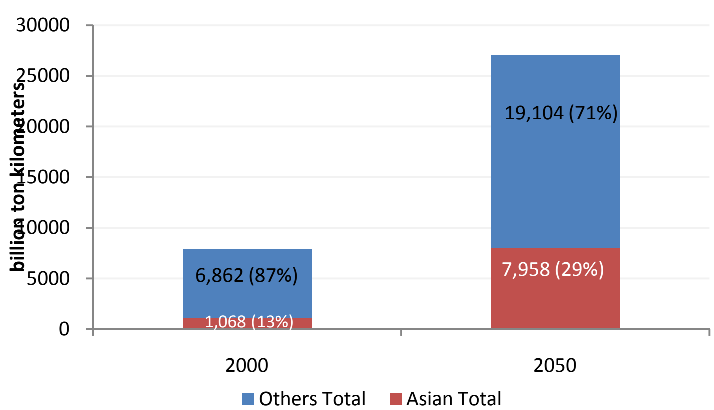

Figure 2: Travel Activity for Heavy and Medium Freight Trucks in Asia (billion ton-km)
Source: WBCSD and IEA (2004)

While other parts of the world move towards increasing the share of non-road modes in freight activity, trucks continue to dominate freight in many of Asian countries even as infrastructure for other freight modes are being developed. This is because trucks are easily available, affordable and provide flexibility of movement. For example, Figure 3 shows that the vast majority of freight in China was transported through highways in

2006 (72%) and has remained relatively stable since 1980. China's railway share decreased from 20% to 14% over the same period, although this may potentially rise in the near future.

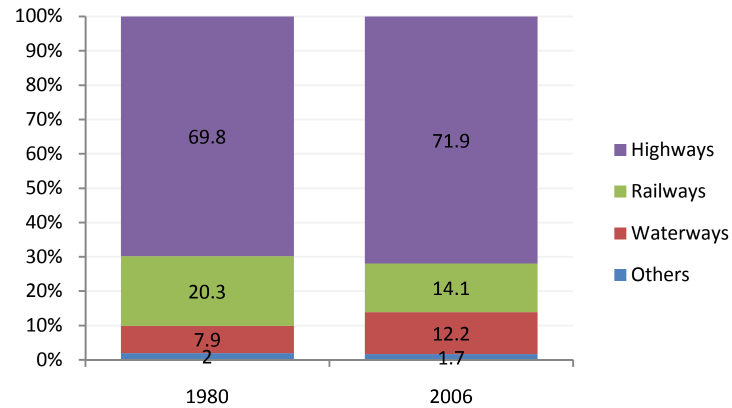

Figure 3: Freight Transport Mode Share in 1980 and 2006 in China (%)
Source: ADB (2008)

Road transportation also dominates freight in the major Southeast Asian countries such as Indonesia (90%), Thailand (89%), and the Philippines (60%). Vietnam also depends on road transport for freight with support from the river transport.[1,2,3]

Trucking is also a dominant freight mode in South Asia. In Pakistan, road transport accounts for more than 95% of freight traffic.[4] In India and Bangladesh, it is 70% and 60% of the freight market, respectively.[5]

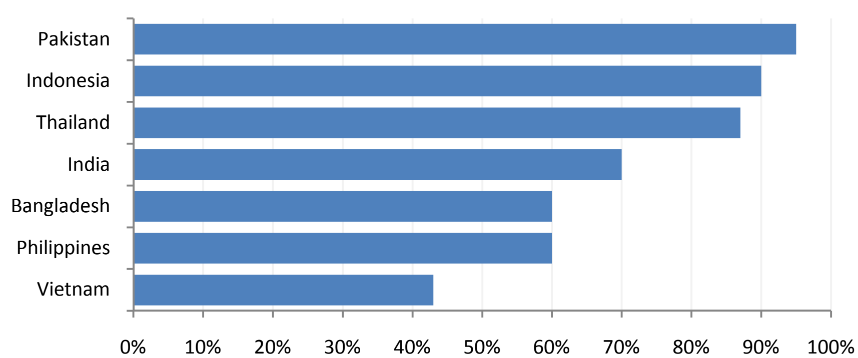

Figure 4: Percentage Share of Road Transport in Freight Activity in Selected Asian Countries
Source: Various, see footnotes 1,2,3,4,5

[1] Sopadang, A. (2007)
[2] Patdu, I. (2005)
[3] Lubis, H. and M. Isnaeni. (2005).
[4] Government of Pakistan, Engineering Development Board, Ministry of Industries, Production and Special Initiatives (2006).
[5] World Bank (2008)

3. ENVIRONMENTAL AND SOCIAL IMPACTS OF ROAD FREIGHT

This section explains the main sustainability issues and challenges facing the road freight sector, with a particular emphasis on environmental issues.

3.1 Fuel Consumption

It is estimated that by the year 2050, medium and heavy freight trucks worldwide will consume 1,240 billion liters of fuel (gasoline equivalent), 138% larger than 2000 levels.[6] The share of trucks operating within Asian countries to global truck energy use will increase from 19% in 2000 to 34% in 2050.

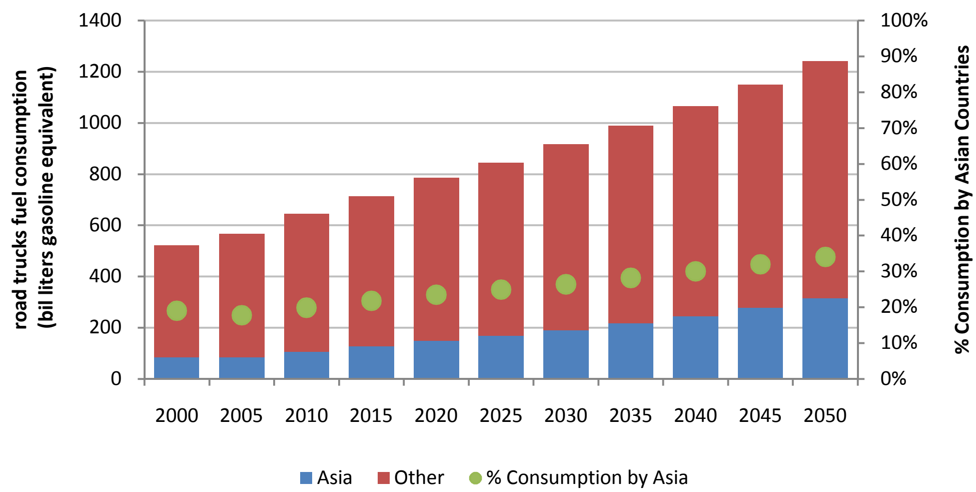

Figure 5: Road Freight Energy Use and % Consumption by Asian Countries
Source: WBCSD and IEA (2004)

This projected rapid increase in the energy use from freight trucks in Asia is a challenge that needs to be urgently addressed as Asian countries face fuel security issues. A move towards cleaner and more efficient road freight sector will clearly benefit Asian countries particularly those which are heavy importers of transport fuels. As Figure 6 shows, diesel imports in countries like Indonesia, Vietnam, and Singapore are on the rise.

[6] WBCSD, IEA (2004)

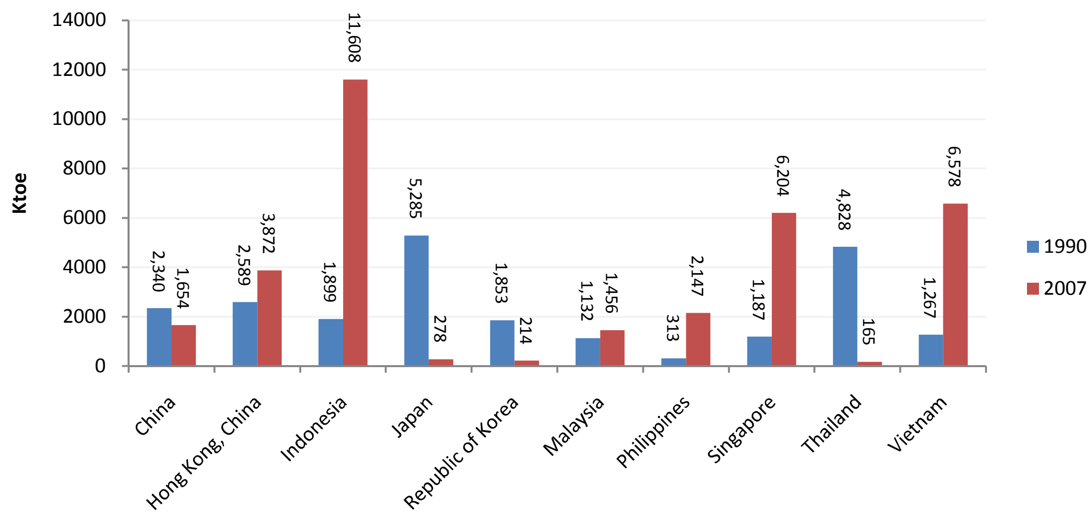

Figure 6: Diesel Oil Imports
Source: APEC Energy Database

Moving towards a more energy efficient road freight sector would be favorable not only for the environment, but also for the road freight companies. Fuel costs represent a major component of the operating costs of trucking companies. For example, in Guangzhou, China, interviews with operators reveal that fuel costs represent 40-50% of their operational costs.[7] In Indonesia, a country where fuel subsidies are prevalent, fuel costs are 28% of the vehicle operating costs of trucks.[8] Figure 7 shows how diesel prices have increased throughout Asia from 1995 to 2008.

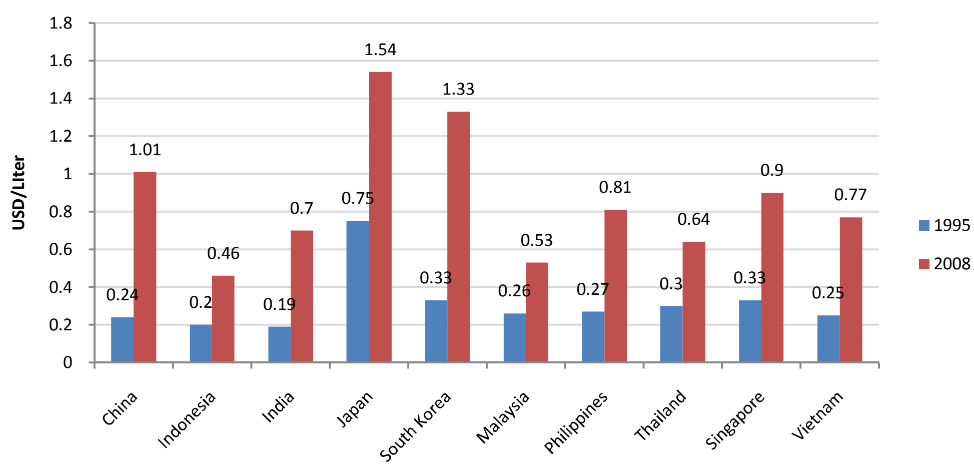

Figure 7: Diesel Pump Price (USD/Liter)
Source: Data taken from tradingeconomics.com

7 CAI-Asia Center (2010a)
8 The Asia Foundation (2008)

The risks brought about by fuel dependency can be seen in China. The 10 million trucks on Chinese roads, which are more than a quarter of all vehicles in China, are a major reason China accounts for half of the world's annual increase in oil consumption. The total energy used for passenger and freight in China accounted for 5.34% of the total worldwide in 2005 and will account for 9.9% in 2035 according to WBCSD and IEA estimates.[9] With international crude prices fluctuating from as low as USD40 to as high as USD140 a barrel in 2008, economists still expect that the long term trend of fuel prices will continue to increase.[10] China's subsidies on diesel for socio-economic reasons has resulted in a surge in diesel truck sales (in 2008 this was nearly twice as many as in the US), and subsequently diesel supplies cannot keep up with demand for diesel at service stations, causing rationing and shortages.[11]

Similarly, in India, the share of the transport sector in petroleum consumption is highest of all sectors and is expected to increase from 36% in 2001 to 64% in 2030, due to a 13.6 times increase of petroleum consumption by the transport sector. Also the oil import dependency for India will increase to 93% by 2031.[12]

Fuel efficiency is becoming more and more important as we gear towards the looming decrease in global oil production. In fact, as it can be seen from Figure 8, fuel efficiency was identified as the most important criteria in buying trucks by the year 2020 in a survey done by IBM with executives from organizations within the entire global truck value chain.[13]

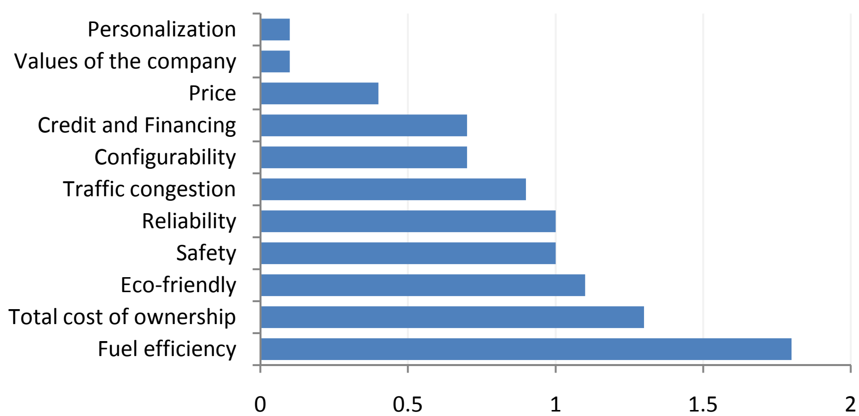

Figure 8: Change in Vehicle Buying Criteria Importance from 2008 to 2020
Source: IBM (2008)

3.2 Emissions

3.2.1 Air Pollutants

A major problem brought about by road freight is air pollution, which in many developing Asian cities, is usually considered a bigger problem than greenhouse gas (GHG) emissions. The consumption of fossil fuels

9 WBCSD and IEA (2004)
10 http://www.baq2008.org/preevent-fuels
11 Shen and Bai (2008)
12 TERI study "Energy Efficiency and Climate Change considerations for on road transport in Asia" published by ADB (2006)
13 IBM Institute for Business Value (2008)

results in emissions of air pollutants such as particulate matter (PM), Nitrogen oxides (NOx), Carbon monoxide (CO), Volatile organic compounds (VOCs), Lead particles (Pb) and Sulphur oxides (SOx).

In Delhi, about 60% of transport emissions originate from passenger vehicles and about 40% from trucks. To reduce daytime emissions, trucks are only allowed in Delhi during the night time. Initially this reduced pollution levels, especially particulate matter during the daytime. However, due to the rapid growth in truck numbers during the night time, the contribution of trucks to daytime PM levels is increasing, as night time emissions linger into the daytime.[14]

The health impacts of diesel trucks have been identified through a number of studies and summarized in Box 1. The health effects from these pollutants vary in severity and symptoms. According to the World Health Organization, 800,000 people die prematurely each year because of air pollution, with more than half a million coming from Asia. Air pollution has replaced cigarette smoking as the first cause of lung cancer in Guangzhou. In the recent decade the number of lung cancer cases has doubled.[15] In Hong Kong, approximately 1,600 people died each year as a result of air pollution, mostly from heart attacks, stroke, pneumonia, and other lung diseases.[16]

Vehicle emissions also result in the formation of secondary pollutants, which are not directly emitted at the tailpipe but are formed from the reactions of different emissions in the air. One such example is ground level ozone or photochemical smog, which is formed from NOx and VOCs. Ground level ozone can result to acute health impacts to the elderly and people with weak lungs. NOx, SOx and VOCs emissions are also precursors to the formation of $PM_{2.5}$ which are fine particles with diameters that are 2.5 micrometers or smaller. They pose greater risks to human health as compared to larger particles because they can be lodged deep into the lungs and can even go into the blood stream. Figure 8 depicts the varying contribution of vehicles to the $PM_{2.5}$ pollution in selected Asian cities.

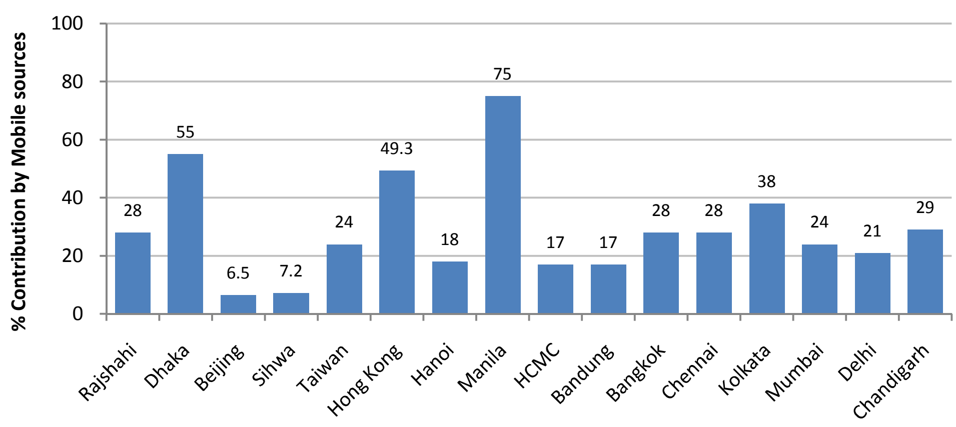

Figure 8: Relative Contribution of Vehicles to PM 2.5 in Selected Asian Cities

Source: Chowdhury, et al. 2008.

[14] Guttikunda, S., 2009. SIM-25-2009, "Photochemistry of Air Pollution in Delhi, India: A Monitoring Based Analysis" @ http://urbanemissions.info/simair/simseries.html

[15] http://www.lifeofguangzhou.com/node_10/node_37/node_85/2008/09/28/122258050352278.shtml

[16] http://www.redorbit.com/news/science/533045/pollution_costs_hong_kong_1600_lives_2bn_dollars_annually/index.html

Box 1: Health impacts of diesel emissions

The results of studies investigating exposure to diesel emissions from older and more current engines indicate effects on the respiratory, reproductive, and cardiovascular systems. Extrapolation of these findings to people exposed to much lower concentrations of diesel emission components than those used in experimental studies or in epidemiologic studies of occupationally exposed workers can be challenging.

Despite these challenges, many agencies have determined that diesel emissions are of sufficient concern to merit action to reduce emissions. New diesel engines with control systems meeting 2007 emission standards for heavy-duty on highway vehicles are now on the market. Emissions from four such engines will be characterized in detail in the Advanced Collaborative Emissions Study (ACES), which is a joint effort of the Coordinating Research Council and the Health Effects Institute (HEI); chronic and acute health endpoints will be assessed for one of the engines. Although durable older engines with higher emissions will continue to be used, these new engines, and those designed to meet the more stringent 2010 standards, will gradually become more common, with substantial replacement expected by 2030.

Source: *HEI Air Toxics Review Panel (2007)*

3.2.2 Greenhouse Gases and Black Carbon

Road freight is also contributing to the growing problem of climate change. In the EU, the total external costs of traffic accidents involving road freight vehicles amounted to 40 billion Euros in 2006.[17] GHG emissions are rapidly rising in Asia, particularly in major cities. The Kyoto Protocol covers six main greenhouse gases.[18] Air pollution and greenhouse gas emissions have similar causes (mostly energy-related), and there is increasing evidence that their effects are interacting. [19] The strongest evidence points to black carbon, the carbonaceous component of soot (particulate matter) that is produced mostly by burning of biomass, diesel and coal. In addition to its contribution to air pollution, black carbon is a dominant absorber of solar energy. Recent scientific studies suggest that black carbon is the second largest contributor to global warming following CO_2.[20] The transport sector has been identified by a recent study by the United States Agency for International Development (USAID) as the third largest source of energy-related black carbon emissions in Asia.[21] On-road diesel consumption accounts for the majority in black carbon emissions within the transport sector in Asia where many countries have moved towards being more dependent on diesel.

Table 1: Percentage of Diesel in the Transport Fuel Mix in Selected Asian Countries[22]

Country	1980	2005
Bangladesh	73.3%	79.0%
China	13.4%	40.2%
India	55.0%	66.4%
Pakistan	71.4%	84.1%
Philippines	17.6%	54.4%
Thailand	52.2%	68.6%
Vietnam	15.5%	55.6%

[17] Boer, et al. (2009)
[18] Carbon dioxide (CO_2), methane (CH_4), Nitrous oxide (N_2O), Hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and Sulphur hexafluoride (SF_6)
[19] Nitrogen oxides (NO_x), Sulphur oxides (SO_x), Carbon monoxide (CO), particulate matter (PM), Volatile organic compounds (VOCs)
[20] Ramanathan et al. (2007)
[21] USAID (2010)
[22] Data taken from IEA's Energy Balances of Non-OECD Countries as quoted by Timilsina and Shrestha (2009)

The IEA estimates that the transport sector accounted for 23% of the world's Carbon dioxide (CO_2) emissions and 13% of global GHGs.[23] Although the share of the CO_2 emissions attributable to transport sector of developing countries is currently low, it is expected to increase by 45.6% between 2005 and 2030. Unlike traditional air pollutants that can be controlled at the "tail-pipe," CO_2 emissions cannot be controlled in that way, and must be controlled through reducing fuel consumption.

Figure 9 below depicts the estimated numbers of the different vehicle types in Asia and the estimated CO2 emissions from these vehicles. It clearly shows that heavy-duty vehicles, even though very low in numbers as compared to the other types of vehicles, contribute most to the CO2 emissions.

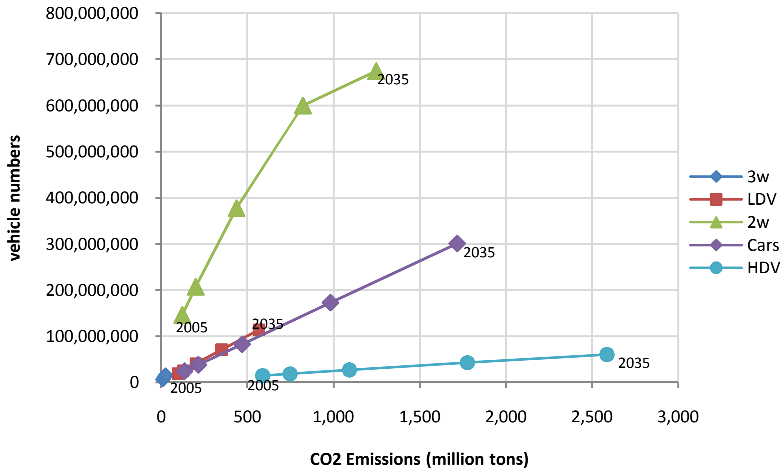

Figure 9: CO_2 Emissions and Vehicle Population from different Vehicle Types in Selected Asian Countries

(China, Indonesia, Thailand, Philippines, Vietnam)

Source: CAI-Asia, data from Segment Y

3.3. Other Impacts

Truck drivers, particularly long-distance drivers, are at high risk of getting sexually-transmitted diseases such as HIV/AIDS because of the amount of time that they spend away from home.

A study in India revealed that 87% of long distance lorry drivers were sexually promiscuous and only 11% of them used condoms during commercial sex.[24] They have an HIV infection rate of 10/1000 while the Indian national average of about 0.5/1000. A study done by the United Nations Economic and Social Commission for Asia and th Pacific (UNESCAP) involving Thai truck drivers revealed that 30% of those truck drivers who engage in commercial sex don't use condoms because of two main reasons: they don't think it is necessary and; they think condoms are too expensive. Ensuring that drivers are properly educated about the risks of engaging in commercial sex is a key towards lowering the cases of sexually transmitted dieseases. Some governments have taken action, such as in Cambodia, where questions regarding HIV/AIDS to the driving license exam were added in 2009 to make long-haul drivers aware of the diesease.

[23] 2006 estimates

[24] Dude, A. et al. (2009)

Road accidents are also an issue in the road freight sector in Asia. As trucks in many Asian countries suffer from overloading, lack of maintenance or old age, coupled with unsafe behavior of the drivers, many of them are susceptible to road accidents. Even though trucks account for only 5% of the total vehicle population in India, they are responsible for almost 30% of road accidents in the country. In Pakistan, studies suggest that trucks are involved in about 25% of road accidents.[25] In Metro Manila, Philippines, 11% of road accidents in 2009 involved trucks, while in Bangladesh, the figure is at 22%.[26,27]

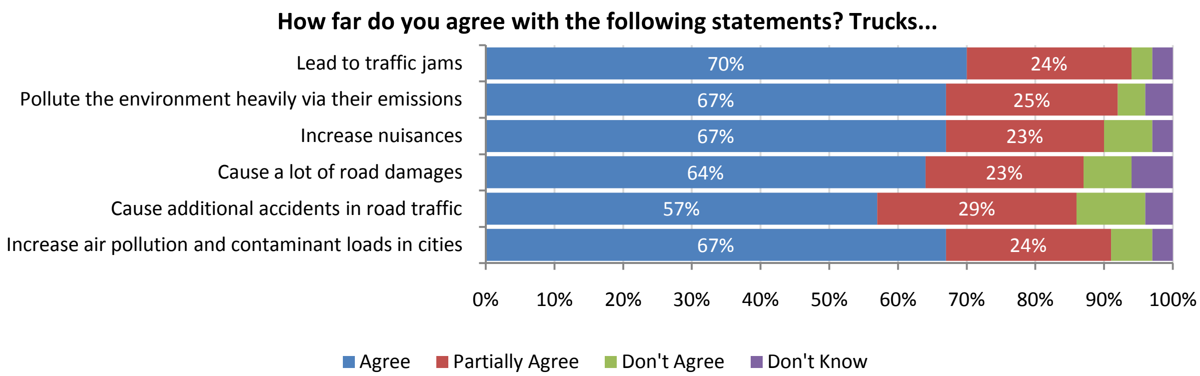

Figure 10: Perception on the Impacts of Trucks on Different Issues
Source: PWC (2008)

[25] World Bank (2008)
[26] Manila Standard (2010)
[27] Maniruzzaman K. and R. Mitra (2005)

4. BARRIERS TO A SUSTAINABLE ROAD FREIGHT INDUSTRY IN ASIA

This section provides an overview of issues that need to be addressed to make the road freight industry more sustainable. These include policies and institutional arrangements, freight sector, technologies, and financing mechanisms.

4.1 Policies and Institutional Arrangements

Most countries have policies on trade facilitation and infrastructure (e.g., improvement of ports and airports) to improve freight and cargo movement from other countries and/or regions. However, policies that deal with the environmental performance of trucks and the trucking industry are often lacking or limited.

Many countries have heavy-duty vehicle emissions standards but authorities often give insufficient attention to enforcing these. Policies for light-duty vehicles usually are introduced first and standards for heavy-duty vehicles often years later. This applies to vehicle emissions standards, fuel economy standards and most other environment-related policies. For example, in China, light-duty fuel economy standards were introduced in 2005, while the government imposes fuel economy standards for heavy-duty vehicles in 2010.

Furthermore, freight is seldom included in the design and planning of urban transport systems and in policy development. As a result, ad hoc solutions are created to mitigate problems associated with urban freight as they arise. Some of the main issues are lack of dedicated trucking routes, limited parking facilities for loading/unloading of goods inside cities, and fragmented logistics centers.[28]

Table 2 below summarizes the analysis of the World Bank (2008a) on the availability and implementation of regulations in the Indian trucking industry. The study concluded that the Indian situation is reflective of the whole situation in South Asia. It can be argued that the India situation would also apply to many other developing Asian countries.

Table 2: Availability and Implementation of Regulations in the Indian Trucking Industry

Type of Regulation	Conclusions
Price	Some States have the power but make no attempt to set and enforce rates. Local trucking associations may set rates but they do not stick when market conditions change.
Labor	For larger companies (>5 trucks), drivers are restricted to 8 hours/day but there is neither enforcement nor records. A survey estimated that two-thirds of drivers drove continuously for more than 9 hours, and 20 percent for more than 12 hours. Only 6 percent of drivers had rest periods of >8 hours
Safety	Most drivers do not receive proper training; the mandatory period is only two days. Vehicles condition is regulated but not enforced, viz. by the number of trucks without functioning rear lights. Fitness is assessed by visual inspection/judgment; there are many fake certificates and no mechanism to check them.
Insurance	Third party vehicle insurance is required but no insurance for cargo. Insurance does not work well in any of the countries. In Pakistan, it is said to be nominal, to meet legal requirements, but insurance companies rarely pay out. In India, third party insurance is provided by public sector companies which make losses on the coverage. There is no feedback between the safety record and the cost of the insurance. Drivers are largely unaccountable and insurance does nothing to improve safety standards
Axle-load and vehicle	Legal limits to axle-loads and gross vehicle weights have been established, but with little/no

[28] http://transport-solutions.blogspot.com/2010/08/urban-freight-victim-of-policy-neglect.html

Type of Regulation	Conclusions
weight	effective enforcement. Some States have, in the past, sold "Golden Passes" which absolved truckers from the legal limits. The impact of the Supreme Court directives on enforcing legal limits is not yet evident.
Environmental	Emission standards have been prescribed but not enforced; there is no system for inspection and certification.

Source: World Bank (2008a)

There are several government agencies that have a stake in the freight industry. The Ministries of Transport, Public Works, Trade, and Foreign Affairs are the agencies mostly involved in planning and facilitating trade movement. Environment ministries usually have limited involvement in the freight industry, making it difficult to assess and develop policies to develop the sector more sustainably.

The number of government agencies that truck operators and drivers in Asian countries need to deal with adds more complexity to the sector. In India, for example, a truck operator needs to face seven different government authorities for obtaining clearances and paying charges at the check post, including (a) sales tax; (b) regional transport officer; (c) excise tax; (d) forest; (e) regulated market committee; (f) civil supplies; (g) geology and mining.[29]

4.2 Freight Sector

The road freight sector is **highly fragmented with a majority owner-driver trucks**. A survey carried out at logistics centers in Guangzhou, China, found that of the surveyed drivers, 48% belonged to truck companies and 52% owned the truck they are driving. Almost 80% of surveyed drivers in Guangzhou who worked for truck companies are registered outside of Guangdong Province, which makes it more difficult for governments to control or reach out to them. Multiple logistics centers exist around many of the Asian cities, thus limiting the coordination of trucks. Furthermore, shippers seem to have a less direct relationship with carriers compared to the US because they have contracts with the factories that they purchase goods from. These factories arrange for the transport of goods to ports or storage areas through logistics firms, who hire small companies and individual drivers to carry the load. Environmentally and socially responsible companies will find it harder to reduce fuel and emissions from the road transport in their supply chain.

This is also the case for South Asian countries where the trucking industry is dominated by very small operators with one or two trucks. The World Bank states that in India, at least 80% of the trucking enterprises have only one or two trucks, while only less than 10% of them have more than 15 trucks.[30] Trucking companies prefer to have a few trucks so they can hire less than 5 drivers, exempting them from the provisions of the Motor Transport Workers Act: *"no adult motor transport worker (e.g. drivers) shall be required to work for more than 8 hours a day."*[31]

In Indonesia, the trucking sector is said to be highly competitive as well, with a large number of independent trucking companies brought about by the lack of entry barriers. There are no entry regulations for trucking firms and the operational areas of trucks are not limited by administrative jurisdictions.[32]

[29] Government of India (2007)
[30] World Bank (2008)
[31] Government of India (1961)
[32] The Asia Foundation (2008)

The highly fragmented nature of the trucking industry without strong government regulations makes it difficult to promote the use of newer vehicles and the adoption of better technologies (e.g., aerodynamic skirts, which can reduce fuel consumption).

This all contributes to the **high percentage of empty hauls** of trucks. A Chinese study found that around 50% of the miles driven by trucks are empty.[33] These empty trips result to annual losses of 8 billion USD. In the Philippines, 89% of the delivery vehicles are empty in their return trip.[34] Figure 11 details the percentage of empty hauls of trucks in India, which ranges from 37% to 46% of trips, depending on the type of truck.

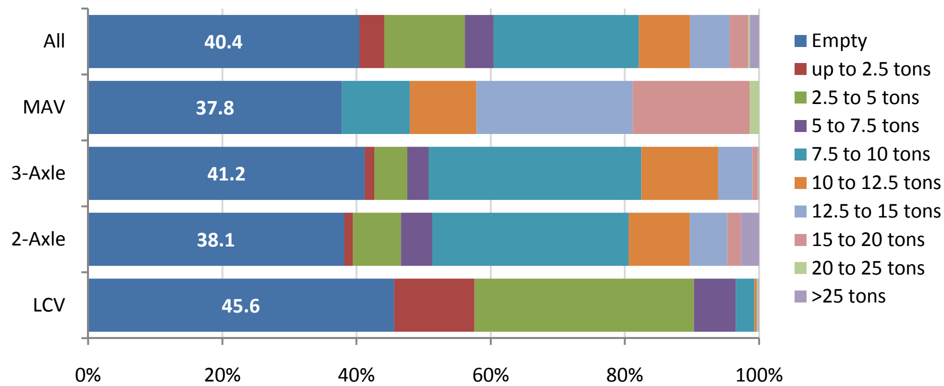

Figure 11: Load Distribution of Freight Vehicles in India
Source: Feasibility for 6-laning of NH-1 from Panipat Jalandhar in the State of Haryana/Punjab, India

Another common truck problem in developing Asia is **overloading**. A study done in Anhui province in China found that vehicle overloading is widespread and serious in the arterial highways of the province.[35] The traffic load greatly exceeds the standard bearing capacity of the pavement which causes premature damages. The study also found that the mean gross vehicle weight of the loaded trucks exceeded the limits, which means that a lot of the trucks are overloaded.

In the Philippines, several overloading hotspots were identified by the Department of Public Works and Highways (DPWH), with the documented maximum percentages at 17%.[36] The Japanese International Cooperation Agency's (JICA) Axle Load Survey in 2004 documented a range of 12- 29.5% of overloaded trucks in 10 different survey sites in the Philippines. It is estimated that it costs the Philippine government 20 to 50 billion pesos a year for the induced change in pavement thickness caused by overloading.[37] Back in May 2010, the DPWH formed the Anti-Truck Overloading Enforcement Oversight Unit to strengthen the enforcement of the anti-overloading regulations.

A recent truck survey carried out in Indonesia by the Asia Foundation revealed that 52% of trucks are overweight by an average of 45% over the payload weight limit. Most of the trucks are open-box type, which allows the owners to increase the payload beyond the maximum limit.[38] The survey also shows that the weight

[33] Xiaolin G. and Haipeng W.
[34] Garsuta, Rebecca (1995)
[35] Chang, Y. (2008)
[36] http://www.gmanews.tv/story/137731
[37] JICA (2004)
[38] The Asia Foundation (2008)

limits are often ignored and weight stations (many of them are not working) have become venues for extraction of illegal "non-compliance" fees.

The same is observed in South Asian countries where trucks are often modified – strengthening of the chassis, using larger tires, adding leaf springs to carry very heavy loads. A World Bank study identified limited engine power and severe overloading as important reasons for slow delivery times in Pakistan. It states that raising highway standards will have little impact without measures to control overloading.[39] The Engineering Development Board estimates that in Pakistan, 70% of the 2-3 axle trucks and 40% of the 4-6 axle trucks are overloaded.[40] The lack of availability of higher capacity trucks in some countries, such as in Bangladesh (out of the 300,000 truck fleet, less than 1000 trucks are capable of hauling 40ft containers), contributes to the overloading of the smaller trucks.[41] Despite the existence of anti-overloading regulations for road freight trucks, controlling overloading has proven to be hard, as these statistics show. Inefficient vehicle fleets do not only affect the operator's profitability but also affects tax payers as overloaded trucks damage the road thus requiring frequent maintenance.

4.3 Technologies and Financing

The adoption of cleaner technologies is a key towards addressing the different impacts of the road freight sector, particularly in Asia, where many developing countries have poorly maintained and/or old truck fleets. In Indonesia, for example, the average age of in-use trucks is 10 to 11 years old (with an average service life of 13 years), while in the U.S. the average is less than 7. In India, technologies first introduced in the late 1940s are still being used to manufacture trucks.[42]

Table 3 presents the average reduction potentials of different technologies. Long-range trucks have the greatest potential for fuel economy improvement and GHG emissions savings through technology applications.

Table 3: Fuel Reduction Potential of Different Heavy-duty Vehicle Technologies[43]

Technology	% Fuel Reduction Potential
Aerodynamics	3 to 15
Auxiliary loads	1 to 2.5
Rolling resistance	4.5 to 9
Mass (weight) reduction	2 to 5
Idle reduction	5 to 9
Intelligent vehicle[44]	8 to 15

Table 4 below presents the estimated potential for reductions from tire and aerodynamics technologies for the 1.23 million trucks registered in Guangdong Province in China in 2007.

[39] World Bank (2008b)
[40] Government of Pakistan, Engineering Development Board, Ministry of Industries, Production and Special Initiatives (2006)
[41] World Bank (2008b)
[42] Thukral.
[43] Transportation Research Board (2010).
[44] Intelligent vehicles combine information about the state of the vehicle, the environment around the vehicle, and Global Positioning System (technology with computers and mobile communications technologies in order to achieve fuel consumption reduction.

Table 4: Fuel and Emissions Reduction Potential from Tire and Aerodynamics Technologies for Trucks Registered in Guangdong Province[45]

Parameter	Total	Remarks
Total number of trucks registered in Guangdong Province	1,230,000	67.2% heavy duty(826,520); 19.8% medium duty(243,540); 13.0% light duty (159,900) based on the ratios found in the trucks survey
Total investment costs (tires and aerodynamics)	12,137,461,109	$12 billion dollars. Tire technologies to reduce rolling resistance included aluminum wheels (heavy duty trucks,), low rolling resistance tires, tire pressure monitoring system. Aerodynamics equipment package to reduce air resistance and drag, and consisting of a nosecone, cabin fairing, and trailer skirts.
Total fuel savings (liters/year)	3,962,456,995	4 billion liters. Fuel savings for the tire package is assumed 5% and for the aerodynamics package 3-7% compared to a US experience of 6-8% and 10-13% respectively.
Total fuel cost savings ($/year)	3,586,066,990	$3.6 billion. Diesel price $ 0.9 per liter
Total CO2 savings (tons/year)	10,233,591	10 million tons. CO2 = 2.582 kg CO2/liter
Total NOx savings (kg/year)	37,009,348	37000 tons. NOx = 9.34 g/liter
Total PM savings (kg/ year)	1,584,983	1584 tons. PM10 = 0.40 g/liter
Payback period in years	3.38	

Challenges with wide-spread adoption of technologies by the road freight sector in Asia are the following:

- The availability of technologies in Asia is much lower as compared to the US or Europe. A fragmented technology suppliers' network adds to the problem.
- High speeds needed for aerodynamics technologies to work are not always achieved. This is partly caused by traffic jams and poor conditions of highways. Another contributing factor is that long-haul trucks often travel large parts of trips in urban areas because they travel from origin to destination and fewer trucks transfer their loads to smaller trucks when entering urban areas. This leads to low speeds in urban traffic.
- Limited case study examples exist for Asia to build confidence in technologies.

Financing green technologies will be challenge for Asia for the following reasons:[46]

- Limited tax policies exist for the truck sector relevant to energy and emissions management and minimal experience of policymakers in applying economic instruments to the trucking sector.
- Investment costs are too high for many companies, even if potential savings are high and payback periods short. This is partly caused by the low number of suppliers of technologies and the low production and sales rates at this moment, making them relatively costly. Furthermore, for imported truck equipment, the Chinese tariffs on can be in excess of 110%.
- The truck sector is not considered the most reliable sector for lending, especially small companies and individual truck driver-owners.
- ESCOs (energy service companies) have been successfully established for industry but these have no experience with trucking fleets.

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[45] CAI-Asia Center (2010b)
[46] CAI-Asia Center (2010c)

- A capacity weakness exists amongst financiers as knowledge and tools for financial appraisal are lacking. This has thus far prevented the trial and introduction of innovative financing mechanisms, such as revolving funds.

A specific challenge applies to diesel particulate filters (DPF). Low sulfur diesel is required and in many Asian countries the diesel has too high sulfur levels or these DPFs to work. Secondly, while poor maintenance practices will affect the success of most technologies to some degree, it especially impacts retrofitted DPFs because without proper maintenance they risk getting blocked. Finally, DPFs cost several thousands of dollars but they do not result in fuel savings to help recover the costs, unlike many other technologies. For this reason, DPFs should either be mandated or be included in a technology package that as a whole generates net savings.

5. STRATEGIES FOR A SUSTAINABLE ROAD FREIGHT SECTOR IN ASIA

An integrated approach employing avoid, shift and improve strategies is needed in addressing the road freight transport issues in Asia.[47]

- *Avoid* strategies reduce the need to travel or the travel distance for road freight vehicles.
- *Shift* strategies refer to those which transfer freight activity to more energy-efficient and/or environmentally-friendly modes.
- *Improve* strategies are the ones which improve the energy efficiency of the current road freight transport modes, their operations and technologies. This section discusses some of the strategies that can be used by Asian governments in order to move towards a sustainable road freight sector, focusing on emissions reductions. The assessment of whether these measures can be employed by the different Asian countries must look into the total benefits (including other co-benefits) and the total costs.

The government plays an important role in setting policies and providing the right incentives that favor more sustainable freight practices.

5.1 Avoid

The reduction of road freight travel activity is heavily influenced by the nature and amount of freight demand. There are several ways in which this can be achieved:

- Promotion of local production and consumption, as well as compact land use planning can result in the avoidance of the road freight travel activity. For example, Ho Chi Minh City, Vietnam, sources 60% of its food from within the greater HCMC boundaries.[48]
- If facilities within the same supply chain are located geographically closer to each other, the need for transportation would be lower. Similarly, industries that produce goods that are to be shipped abroad should ideally be located as close to ports as possible. This can be achieved through better land use planning and industrial zoning.
- Logistics of the freight sector can be significantly improved. This includes better communication linkages between shippers, carriers, logistics centers, and manufacturers or end-users. Information and communication technologies play an increasingly important role in achieving this. Logistics centers help facilitate the efficient distribution of goods and thus the efficient use of trucks. However, in many cities, the number of logistics centers is high and their locations are selected on an ad hoc basis, often leaving the initiative with private sector operators. Reducing the number of logistics centers and re-assessing their location, as well as improving the coordination between are other options. Logistics centers can be improved to reduce the multiplicity of delivery points in urban areas by redistributing loads from large trucks to smaller ones. This would greatly contribute to reducing road freight vehicle trips, vehicles (as each vehicle's utility is maximized, fewer vehicles are needed) and vehicle kilometers travelled.[49] In turn, this would reduce supply chain cost.
- The reduction of road freight trips can also be achieved through policies and programs directed at increasing the loads carried by freight vehicles. Over the past decades many developed countries have increased the legal axle limits to accommodate such higher axle loads. India's legal single axle load

[47] Adopted from Dalkmann and Brannigan (2007).
[48] Personal communication, RSID, Asian Development Bank
[49] Brown, M. and M. Sweet. Urban Freight Consolidation Centres Final Report.

limit is now 10.2 tons, which used to be 8.16 tons decade earlier. Thailand's maximum axle load limit is 8.2 tons while the truck-load limit is 25 tons, which was increased from 21 tons in 2006. Accompanying government subsidies and regulations for encouraging truck owners to shift to vehicles with more axles in order to minimize road infrastructure deterioration must accompany this trend of increasing loads limits.[50]

Box 2: Freight Logistics Improvement in the Republic of Korea

The Republic of Korea has focused on infrastructure development aimed at removing freight bottlenecks by building eight integrated freight terminals and four inland container depots. This is supported by a logistics integrated information system that allows for electronic data interchange (EDI) and provide freight traffic information such as real-time freight and vehicle location. Furthermore, efforts focused on standardizing the logistics-related facilities and equipment by adopting the "unit load system rule" that provides standardized specifications for containers, loading equipment, freight trucks and freight packages and standardizing logistics-related facilities and equipment. This is further facilitated by tax exemptions for investments in logistics standardization. The country is also moving towards reducing the share of road freight in favor of rail-based freight and shipping.

Source: *Sunwong Lee (2001)*

5.2 Shift

Shifting current road freight activity to other modes such as rails and water-borne vessels is also a strategy that Asian countries must look into. Some of the options are

- Optimization of the railways in Asia in delivering freight can potentially lead to huge benefits in terms of reducing freight fuel consumption and ultimately tail-pipe emissions in the region. A recent study by the Asian Development Bank (ADB) revealed that railways are more efficient than roads in terms of grams CO_2 emitted per ton-km travelled. The study found that roads are at 61 g/ton-km with railways are at 23 g/ton-km.[51] In many Asian countries, rail-based freight has not been optimized. China's railway system is second only to the U.S. in terms of freight traffic (by ton-kilometers), but the lack of inter-modal links and convenient rail sidings deter Chinese companies from using trains for freight.[52] In many countries, such as the Philippines and India, rails used to be the major mode for freight in the last century but the percentage of freight carried by rail has significantly dropped. Improving the integration of the different freight modes can result to economic and environmental benefits as compared to uni-modal (in this case, truck-only) freight systems.[53] This would especially apply to developing Asian countries, as these countries are still developing their freight systems, whereas in developed countries freight systems are more established and harder to change.
- Another option that logistics companies may want to explore is shifting to other types of land-based motor vehicles. DHL, one of the world's largest logistics company, recently reported that it was able to improve its carbon efficiency by 19% in 2009 (year-on-year) and one of its strategies is replacing

[50] Sathaye, N. (2009)
[51] ADB (2010)
[52] Xiaolin and Haipeng.
[53] Kim, N. (2008)

60 four-wheelers with 75 motorbikes, thereby increasing the fleet's average fuel efficiency.[54] In Thailand, a logistics company has shifted towards using public transport (sky train and subway).[55]

5.3 Improve

There are different measures that can be employed in order to improve the efficiency of the road freight sector. Box 3 discusses some of the more popular measures involving engines and drivers in order to improve fuel efficiency and reduce emissions. The missing ingredient in the adoption of these technologies in Asia is funding. Governments in Asia must look into different economic instruments in order to stimulate the adoption of these technologies.

- The adoption of fuel economy standards will help improve the overall fuel efficiency of a nation's vehicle fleet. The development of fuel economy standards for heavy-duty vehicles is particularly important since in Asia, these vehicles have lower fuel efficiency because of vehicle age and poor maintenance practices.[56] A recent study done by CAI-Asia estimated that fuel economy improvement in the ASEAN region from 2015 to 2035 will result to a 26% reduction in CO2 emissions of light and heavy duty vehicles.[57] Currently, not many countries have adopted mandatory fuel economy standards. Regulatory standards and mandatory display of energy efficiency values have been established in Japan since 1998 and standards specific to heavy-duty vehicles were introduced in 2006. China also has mandatory standards using weight-based categories and are considered by many as the third most stringent in the world, after EU and Japanese standards. South Korea also has reference fuel economy standards for vehicles (12.4 km/l for vehicles with up to 1,500 cc displacement and 9.6 km/l for vehicles more than 1,500 cc).
- Stricter implementation of anti-overloading laws throughout Asia is recommended. Many of the Asian countries have anti-overloading policies but overloading is still prevalent. Better checks and balances in the monitoring system needs to be introduced.
- Other technological tools such as the use of radio frequency identification tags (RFID), global positioning system (GPS) and vehicle routing software can aid in improving the overall efficiency of road freight fleets and optimizing the street networks. In Thailand, for example, a company utilizes a system which finds the fastest or most cost-effective route by processing data on traffic volume and route restrictions. Avoiding congestion is of great importance for heavy-duty vehicles since idling in traffic consumes much energy without productivity and slow speeds increases emissions as well.[58]

Box 3. Technologies and Strategies for Improved Fuel Efficiency and Reduced Emissions from Trucks[59]

- **Vehicle activity and driving pattern improvement** - Fuel consumption is strongly connected with vehicle driving pattern in real-world operation.
  - **Driver training**. Drivers can be trained to follow fuel-saving driving habits or keep their highway speed a more efficient range.
  - **Reducing speed** on highways to a speed where fuel consumption is most efficient

[54] http://www.dhl.co.in/en/press/releases/releases_2010/local/120510/jcr:content.html
[55] Pomlaktong (2010)
[56] CAI-Asia Center (2010d)
[57] 20% improvement by 2020, 35% improvement by 2035, from 2005 levels. Calculations include Thailand, Indonesia, Philippines and Vietnam.
[58] A truck traveling at five miles per hour produces 318% more particulate matter than at 55 miles per hour, and 22 pounds of carbon dioxide for every hour it idles – Taken from
[59] CAI-Asia Center (2010a)

- **Reducing overloading** can also reduce the fuel consumption.
- **Improved freight logistics**. The total activity can also be reduced by better logistics management like increasing returning load and reducing empty trip. Vehicle activity is linearly correlated with total fuel consumption.

- **Enhanced Maintenance** - Truck condition can affect not only their operation performance, but also their fuel economy and emission. A routine Inspection/Maintenance (I/M) is far from enough to ensure good truck condition. Special training and improved fleet management can help contractors improve the condition of their trucks. Engine rebuilding can be regarded as the strongest enhanced maintenance strategy.
- **Vehicle body improvement** - Several strategies based on vehicle body improvement can be applied to reduce diesel consumption by reducing the drag.
    - **Truck weight reduction** is a common strategy to improve the fuel economy of a truck.
    - **Improved aerodynamics** reduces drag and thus fuel consumption.
    - **Reducing rolling resistance** through tire system modifications can also reduce the fuel consumption: single wide-based tires, low rolling resistance tires or automatic tire Inflation or tire pressure monitoring systems.
- **Reduced idling.** Several technological options can assist drivers in reducing truck idling, including auxiliary power units (APUs), automatic engine idle systems, and truck stop electrification.
- **Fuel, oil and lubricant improvement**
    - **Low-sulfur diese**l can reduce the emission of in-use trucks immediately. It's also a precondition for a successful emission retrofit program.
    - **Low viscosity lubricant** can also help improve fuel economy.
    - **Oil by-pass filtration system** improves oil life performance and indirectly contributes to fuel efficiency due to reduced engine wear.
- **Emission Retrofit** - In-use diesel retrofit with emission control devices including EGR (Exhaust Gas Recirculation), DPF (Diesel Particulate Filter) and DOC (Diesel Oxidation Catalyst) systems have been widely applied in U.S. and Europe. The selection for target trucks and technology verification is crucial for a successful retrofit.

Fleet and Engine Modernization - Fleet modernization can introduce much cleaner engines into the fleet to lower PM and NO_X emissions. Engine replacement is also a type of fleet modernization strategy

REFERENCES

ADB, 2010. Transportation and Carbon Dioxide (CO2) Emissions: Folding Them into a Unified View for Forecasts, Options Analysis, and Evaluation.

Asia Pacific Economic Cooperation (APEC) Energy Database. http://www.ieej.or.jp/egeda/database/

Asian Development Bank (ADB). 2008. Promoting Environmentally Sustainable Transport in PRC

Asian Development Bank (ADB). 2010. Reducing Carbon Emissions from Transport Projects.

Boer, et al. 2009. "Are Trucks Taking their Toll?" Delft.

Brown, M. and M. Sweet. Urban Freight Consolidation Centres Final Report.

Chang, Y. 2008. Truck Overloading Study in Developing Countries and Strategies to Minimize its Impacts.

Chowdhury, Z., A. Elizabeth, A. Cohen and M. Brauer. 2008. Current Source Apportionment Studies in Asia: An Overview. A presentation delivered at the 2008 Better Air Quality Workshop in Bangkok, Thailand.

Clean Air Initiative for Asian Cities Center (CAI-Asia) CAI-Asia Center, 2010b. Guangzhou Green Trucks Pilot Project: Technology Pilot Report for the World Bank "Truck GHG Emission Reduction Pilot Project"

Clean Air Initiative for Asian Cities Center (CAI-Asia) CAI-Asia Center, 2010c. Guangzhou Green Trucks Pilot Project: Final Report for the World Bank "Truck GHG Emission Reduction Pilot Project"

Clean Air Initiative for Asian Cities Center (CAI-Asia) CAI-Asia Center. 2010d. Improving Vehicle Fuel Economy in the ASEAN

Clean Air Initiative for Asian Cities Center (CAI-Asia) Center, 2010a. Guangzhou Green Trucks Pilot Project: Background Analysis Report for the World Bank "Truck GHG Emission Reduction Pilot Project". This is a summary of technologies and strategies available on

Dalkmann and Brannigan (2007). "Transport and Climate Change: Module 5e," *Sustainable Transportation Sourcebook: A Sourcebook for Policy-Makers in Developing Countries*, by the Sustainable Urban Transport Project – Asia (www.sutp-asia.org); at www.sutp.org/component/option,com_docman/task,doc_details/gid,383/lang,uk.

Dude, A. et al. 2009. *HIV infection, genital symptoms and sexual risk behavior among Indian truck drivers from a large transportation company in South India.* Journal of Global Infectious Diseases. 1(1): 21-28

Garsuta, R. 1995. Basic Study of Urban Goods Movement in Metro Manila: An Assessment of Physical Distribution Facilities and Commodity Flow Pattern.

Gota, S. 2010. Urban Freight Strategy and Policies – A Victim of Policy Neglect. http://transport-solutions.blogspot.com/2010/08/urban-freight-victim-of-policy-neglect.html

Government of India. 1961.Indian Motor Transport Workers Act. http://pblabour.gov.in/pdf/acts_rules/motortransport_workers_act_1961.pdf

Government of India. 2007. The Working Group Report on Road Transport for the Eleventh Five Year Plan.

Government of Pakistan, Engineering Development Board, Ministry of Industries, Production and Special Initiatives. 2006. Road Freight Strategy Paper.

Guttikunda, S., 2009. SIM-25-2009, "Photochemistry of Air Pollution in Delhi, India: A Monitoring Based Analysis" http://urbanemissions.info/simair/simseries.html

Health Effects Institute (HEI) Air Toxics Review Panel. 2007. Mobile-Source Air Toxics: A Critical Review of the Literature on Exposure and Health Effects. HEI Special Report 16. Health Effects Institute, Boston, Mass.

IBM Institute for Business Value. 2008. Truck 2020 Transcending Turbulence.

Japan International Cooperation Agency (JICA). 2004. Axel Road Survey Final Report.

Kim, Nam Seok. 2008. Assessment of CO2 Emissions for Intermodal Freight Transport Systems and Truck only System: A Case Study of the Western-Eastern Europe Corridor

Lubis, H. and M. Isnaeni. 2005. Multimodal Transport in Indonesia. Recent Profile and Strategy Development.

Manila Standard. MMDA: Road Accidents down 18%. June 25, 2010.

Maniruzzaman K. and R. Mitra. 2005. Road Accidents in Bangladesh.

Patdu, I.2005. Medium Term Land Transport Action Plan (2005-2010). Philippine Department of Transportation and Communcation.A presentation delivered at Forum on Public Transport for Sustainable Mobility Organized by UP-NCTS and USAID-ECAP in Manila, 10 May 2005. http://www.cleanairnet.org/caiasia/1412/article-59924.html

Pomlaktong. 2010. Eco-efficiency in Freight Transportation and Logistics . A presentation delivered at the Expert Group Meeting on Sustainable Transport Development last March 2010 in Bangkok.

Price Waterhouse Coopers (PWC). 2008. The truck industry's green challenge Headwind or competitive edge?

Ramanathan et al. 2007. http://www.agu.org/pubs/crossref/2007/2006JD008124.shtml; and Rep. Henry A.

Sathaye, N. 2009. Unintended Impacts of Increased Truck Loads on Pavement Supply-Chain Emissions

Shen, R. and J. Bai. 2008. China Diesel Rationed, Despite Government Pledges. http://www.reuters.com/article/idUSPEK34710120080325

Sopadang, A. 2007. Thailand's Logistics Country Report. Chiang Mai University. http://gjs.mofcom.gov.cn/accessory/200706/1181004964759.pdf

Sungwon, L., 2001. Improving Efficiency in the Logistics Sector for Sustainable Transport Development in the Republic of Korea. In: Transport and Communications Bulletin for Asia and the Pacific, No 70, 2001. www.unescap.org/ttdw/Publications/TPTS_pubs/TxBulletin_70/bulletin70_b.pdf

The Asia Foundation. 2008. The Cost of Moving Goods: Road Transportation, Regulations and Charges in Indonesia.

Thukral. Enhancing the Quality of Trucking Services in India.

Transportation Research Board (TRB). 2010. Technologies and Approaches to Reducing the Fuel Consumption of Medium and Heavy-duty Vehicles

United Nations EconoUNESCAP. 2007. Health Without Borders. Improving health and reducing HIV/AIDS vulnerability amonglong-distance road transport workers through a multisectoral approach.

United States Agency for International Development (USAID). 2010. Black Carbon Emissions in Asia. Sources, Impacts and Abatement Opportunities. http://www.cleanenergyasia.net/library/black-carbon-emissions-asia-sources-impacts-and-abatement-opportunities

Waxman, H. Committee on Oversight and Government Reform hearing on black carbon and global warming (18 Oct 2007) http://oversight.house.gov/story.asp?id=1550

World Bank. 2008. Trade and Transport Facilitation in South Asia: Systems in Transition. Volume 1: Summary and Main Report.

World Bank. 2008b. Trade and Transport Facilitation in South Asia. Volume II: Annexes

World Business Council on Sustainable Development (WBCSD) and the International Energy Agency (IEA). 2004. Sustainable Mobility Project. http://www.wbcsd.org/includes/getTarget.asp?type=p&id=MTQ0

Xiaolin G. and Haipeng W. China Logistics.