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Transport CO₂ Emissions in Emerging Economies

REDUCING TRANSPORT CO₂ EMISSIONS IN EMERGING ECONOMIES

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Introduction

It is now established with certainty that anthropogenic activities cause an increase in atmospheric concentrations of CO₂ resulting in global warming. This has adverse impacts on the climate system that include changes in rainfall patterns, decrease in agricultural yields, frequent storms and cyclones, melting glaciers, rising sea level etc. Climate change and its consequences have major equity implications, as developing countries are more vulnerable to these changes and do not have the resources to mitigate or to adapt.

The IPCC reports have demonstrably linked greenhouse gas emissions with the rapid increase in carbon based energy consumption. The transport sector is the second largest consumer of energy with a share of 26% of world energy use in 2004. According to the International Energy Agency (IEA), consumption of energy by the transport sector will grow the fastest amongst all end-use sectors in the next 25 years with a rate of growth of about 2% a year. The transport sector predominantly relies on fossil fuels that account for 95% of the total energy used by the sector. In 2004, the contribution of transport to total energy-related GHG emissions was about 23% (Kahn et al., 2007).

Over the past decade, transport's GHG emissions have increased at a faster rate than any other energy-using sector (Kahn et al., 2007). The IPCC predicts the world's fastest transport energy use increases to occur in the developing countries. The IEA projections of annual CO₂ growth rates for 2002–2030 range from 1.3% for the OECD nations to 3.6% for the developing countries. The emerging Asian countries¹, led by India and China, are projected to account for much of the future growth in oil consumption and GHG emissions due to their strong economic and population growth. They are expected to account for 45% of the total world increase in oil use through 2025. China's energy use for transportation is projected to grow by 6-9% per year, whereas India's is expected to grow at 5-8% a year over the same period (ADB, 2006). ADB projects the CO₂ emissions from on-road transport in China and India to increase by 3.4 times and 5.8 times, respectively, over a thirty-year period (2005-2035).

Transport is a key component of economic development and human welfare and transport activity will continue to grow rapidly as economies grow. Economic growth generates travel demand and the availability of transport infrastructure facilitates economic development. Transportation systems today are getting more and more complex and are built around the automobile, resulting in high per-capita energy use. As incomes grow and the value of travellers' time increases, travellers are expected to choose faster modes of transport, shifting from non-motorized to automotive, to high speed rail and air. Increasing speed has generally led to greater energy intensity and higher GHG emissions (Kahn et al., 2007). A rapid increase in transport activity together with an increase in fossil fuel consumption is resulting in urban congestion, air pollution and an increase in the emission of greenhouse gases. While these local problems of congestion,

¹ Includes Bangladesh, Bhutan, Cambodia, People's Republic of China (PRC), India, Indonesia, Lao PDR, Malaysia, Nepal, Pakistan, Philippines, Sri Lanka, Thailand and Vietnam

air pollution and road safety will have priority in the agenda of city managers and policymakers, and addressing these problems will result in a reduction of greenhouse gases by way of co-benefits, the time has come to view reduction of greenhouse gases as a policy imperative to protect our common global environment. Besides, as the transport sector is almost entirely dependent on fossil fuels, increase in transport activity leading to increasing energy demand will have major implications for the energy security of developing countries. The challenge is to make the growth in transport activity in developing countries take a path that is less carbon intensive, more energy efficient and environment friendly without in any way impeding economic development.

As the IPCC has noted the potential for mitigating GHG emissions will vary widely across countries and regions, as will the appropriate policies and measures that can accomplish such reduction (Kahn et al., 2007). What this paper seeks to do is to facilitate policy discussions and choice by looking at the current transport scenario and trends in developing countries, identifying the policy options available to mitigate GHG emissions in the transport sector and indicating the impact that some of these options can have on GHG emissions. The analysis in this paper is based largely on data from the emerging economies of China and India as they are expected to lead the growth in energy consumption and GHG emissions.

Challenges and trends

1. Inter-City freight movement:

Freight transport consumes 35% of world transport energy, of which a major share comes from road based freight vehicles (Kahn et al., 2007). Freight movement in developing countries is largely by road though some countries have well-developed railway networks. With economic reforms and industrialization in the developing world, accompanied by globalisation, freight traffic is increasing with a growing demand for increased speeds and reliability. Consequently, the share of the railways in the total freight traffic has been declining, while the share of roads and air transport has been growing rapidly (Kahn et al., 2007). The share of freight transport through coastal shipping and inland waterways even in countries with extensive coastlines and inland waterways as in India has not shown an appreciable increase. This increase in the share of road transport in the movement of freight at the expense of other modes is best exemplified in India. Figure 1 below depicts the shift in rail-road shares in freight movement in India :

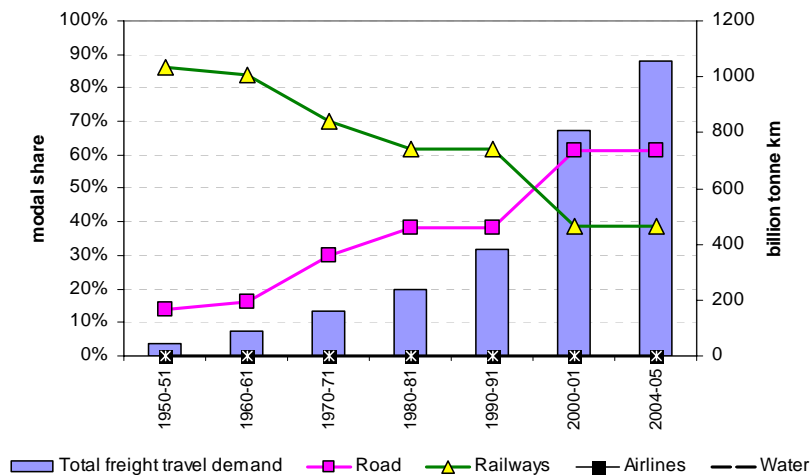


Figure 1 Trends and modal shares of various transportation modes in freight traffic
 Source: Planning Commission, 2007

In China, all modes- road, railways and water contribute significantly to freight transport. However, with the advent of de-centralized production the share of road transport is increasing and becoming a cause for concern. The continuing shift from the more fuel efficient modes to the more energy intensive road transport is leading to an increase in the consumption of fossil fuels and GHG emissions. Freight is also not transported efficiently by road in developing countries as the vehicles used are mostly the less fuel-efficient rigid-axle trucks and not the more efficient multi-axle vehicles.

2. **Population growth and rapid urbanization:**

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 in the developed regions (ADB, 2006). The developing countries are rapidly urbanising. Economic growth in developing nations has been largely propelled by their urban areas, which provide the bulk of employment opportunities. ADB predicts 57% of China’s total population and 38% of India’s total population to live in cities by 2025 (ADB, 2006). In India the number of cities with population above 1 million has grown dramatically from 12 in 1981 to 35 in 2001 (NIPFP, 2007). According to the Planning Commission, India, there will be 60-70 million plus cities by the year 2021. Similarly in China, though only 42% of the people live in urban areas, five cities already have a population of over 5 million and 88 cities have a population between 1-5 million. Population projections in the large cities in emerging Asia show that in 2015 four cities - Bombay, Shanghai, Jakarta and Karachi-would have a population between 20 and 30 million and nine other cities between 10 and 20 million (ADB, 2006).

This rapid urbanisation has had major implications for transport. The growing population in urban areas (especially the work force) has resulted in a huge increase in travel demand. Second, the failure to integrate land-use planning with transport planning in urban areas has led to the development of satellite towns and peri-urban townships. Most cities have become urban sprawls with increasing trip lengths. Third, most developing countries lack a sound and attractive public transport system capable of meeting the high levels of travel demand and this has led to a growing reliance on personal vehicles. Fourth, typical low-density development and longer trips to access jobs and services have caused a decline in environmentally benign means of transport like walking and cycling.

3. Rapid motorization:

Urbanisation coupled with rising incomes will continue to drive the level of motorization in most developing countries. Figure 2 below shows the growth in population, urban population and motor vehicles in India in the period 1980-2003. It will be seen that while the total population and urban population have almost doubled during this period, the number of registered motor vehicles has risen 15 times.

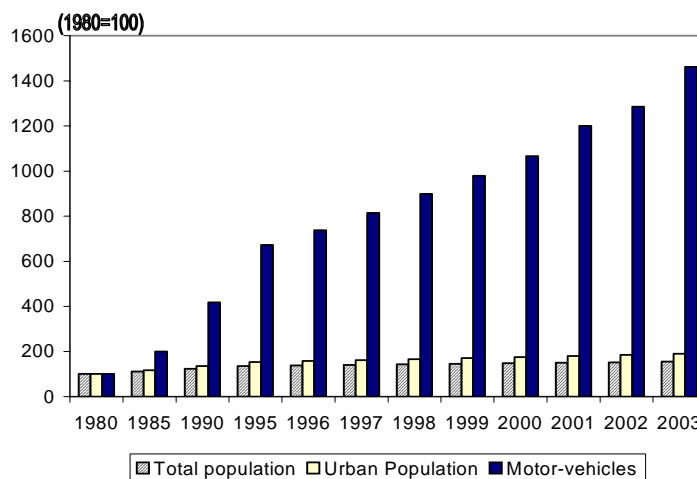


Figure 2 Growth of population, urban population and number of motor vehicles in India, 1980-2003

Source – GoI 2001 & MoRTH 2007

Personal motor vehicles consume more energy and emit more GHG per passenger kilometre than other surface transport modes. Nevertheless, the number of personal vehicles is growing rapidly in many developing countries as a result of rising per capita incomes, growing aspirations of the middle class to own a personal vehicle, the availability of a range of vehicles, easy access to capital, and inadequate public transport. Figure 3 shows the trend in the growth of motor vehicles in India in two decades.

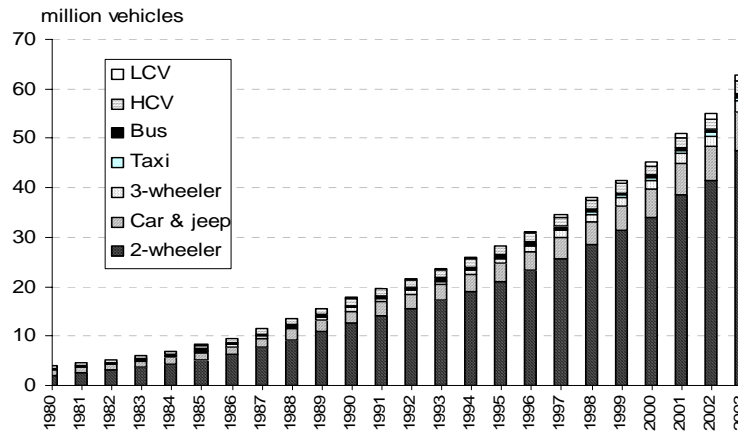


Figure 3 Trends in total number of registered motor vehicles in India
Source: MoRTH 2007

What is interesting to note is the large chunk of motorized two wheelers in the total vehicle fleet, which is a common phenomenon in developing countries. Another trend that is becoming a cause for concern in developing economies is the growth in the number of Sports Utility Vehicles (SUVs) on the roads. Figure 4 depicts the gradual growth in the share of sales of SUVs and mid size car segments in India over the past few years.

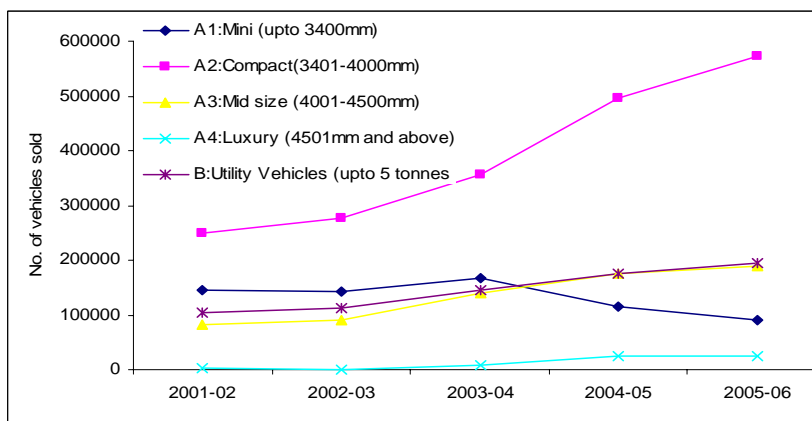


Figure 4 Sales trends of passenger car segments in India
Source: SIAM (2006)

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. As per TERI's estimates, the total number of on-road vehicles in India in 2030 could be close to 540 million under a 6% GDP growth rate scenario and 680 million under an 8% GDP growth rate scenario (TERI, 2006). The vehicle stock in China, excluding more than sixty million two wheelers currently in use, has increased almost seven fold from 5.5 million in 1990 to 37 million in 2006 and is projected to reach 270 million by 2030 (IEA, 2007). The number of LDVs is expected to increase exponentially from 22 million in 2006 to over 200 million by 2030. Figure 5 below depicts the past and expected growth trend for light duty vehicles in China.

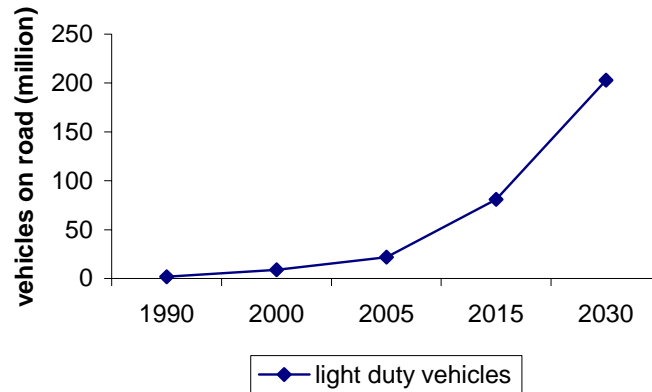


Figure 5 Growth in the light duty vehicle segment in China
Source: IEA, 2007

Motorisation is rapidly increasing in the developing countries of Asia. The implications of this rapid motorisation for road space, urban congestion, road safety, air pollution and energy security could be severe.

4. **Market distortions:**

Current transport planning and markets are distorted in ways that increase motor vehicle use (Litman, 2006). For example, in most developing countries, motorists are rarely charged the full costs of congestion, road space, parking, and air pollution. Public policies have so far tended to favour the automobile and the bulk of public expenditure in most cities has been on expanding infrastructure to cater to the needs of the automobile like highways, roads, flyovers, parking facilities etc. Also, the subsidies on petroleum products in many countries have led to an increase in consumption. While transport demand certainly responds to price signals in the short-term, the demand for vehicles, vehicle travel and fuel use are significantly price inelastic in the long run. As a result, large increases in prices or taxes are required to make major changes in GHG emissions (Kahn et al., 2007).

5. **Declining shares of public transport and Non-Motorized Transport:**

It has been widely accepted and documented that it is the lack of adequate public transport and lack of facilities for non-motorized transport that have contributed to the growing reliance on personal vehicles in urban areas. A good and attractive public transport and Non-Motorized Transport (NMT) system are the most effective options to address GHG emissions and a number of other problems like congestion, road accidents, air pollution, driving stress, etc. Buses, the oldest and most commonly used public transport mode in most cities in developing countries, carry a significant share of total trips (ranging between 40-60% in typical medium-large Indian cities). They are, however, losing their share to personal vehicles for a variety of reasons such as poor quality, inadequate availability and access, issues of personal security. Many cities in the developing world rely on informal para transit vehicles like 3- wheelers and jeeps which are poorly maintained, fuel inefficient,

unsafe and a significant source of emissions. Spaces for walking and cycling in cities are disappearing.

6. Motorization of rural transport:

Large investments are now being made in developing countries to connect villages and rural habitations with the road network and cities. India, for example, has a large programme to connect all the villages and rural habitations through all-weather roads by 2012. Connectivity through good roads will go a long way to provide the rural population with access to schools, hospitals and markets and will enhance their incomes and quality of life. At the same time it will have a major impact on the modes of transportation of both passengers and agricultural produce in rural areas. Non-motorised transport like camel carts and bullock carts will give way to motorised vehicles like tractor-trailers and three wheelers resulting in an increase in the consumption of fossil fuels. While this development is inevitable and even desirable, efforts should be made to introduce public transport in rural areas and to ensure that the motorised vehicles used for transport are energy efficient and environment friendly.

7. Lack of effective emission regulations:

Most developing countries lack a formal fuel quality or emissions roadmap and emission testing facilities and lag behind the developed countries by a wide margin in emission standards. For example in Asia, countries like Pakistan, Bhutan and Cambodia have no formal fuel quality or vehicle emissions road map in place. Some other countries like Vietnam, Indonesia and Philippines do not have a roadmap beyond Euro II. This situation is further aggravated by the large-scale importation of used vehicles into the developing world.

Even in a country like India, which exports automobiles to the developed countries and is capable of meeting emerging European standards, the national roadmap for fuel quality and vehicle emission standards is selective and focuses only on the larger cities neglecting the rapidly motorizing medium and small towns due largely to the non-availability of fuels of the appropriate quality. China will move to EURO IV standards only by 2010. Also by 2010, India will introduce only Euro III equivalent standards nationwide and EURO IV equivalent standards only in 11 major and more polluted cities; no date has yet been set for introducing EURO IV equivalent standards in the rest of India.

Developing countries also lack modern inspection and certification facilities and effective arrangements for monitoring emissions from in - use vehicles.

8. Lack of fuel efficiency standards:

Fuel economy standards have been universally effective, depending on their stringency, in improving vehicle fuel economy and reducing fuel use and carbon emissions. The United States, the European Union and Japan have regulations,

which require the automobile industry to improve fuel efficiency in vehicles over a period of time. However, except China, no other developing country has introduced regulations to effect fuel economy improvements. Nor do they have fuel economy labelling to provide guidance to consumers of the relative fuel efficiency of vehicles in the market.

8. The institutional challenge:

Transport planning and management in urban areas call for a holistic and coordinated approach. In most developing countries, it becomes difficult to bring about such a coordinated approach in the absence of appropriate institutional arrangements and linkages. Responsibility for transport planning and management is often fragmented and divided between and within the state and city governments. They also lack the necessary authority, resources and capacity to address problems of congestion, air pollution and GHG emissions.

Mitigation options

Against this backdrop of growing travel demand, increasing energy consumption and GHG emissions, developing countries need to adopt a multi-pronged approach to contain GHG emissions from the transport sector. A review of both national and international literature on this subject endorses the four broad approaches suggested by ADB to reduce GHG emissions from the transport sector (both national as well as urban transport).

1. Reduce travel demand:

This involves a number of measures like:

a. Integration of land use and transport planning:

Urban planning and transport are interrelated and clearly influence each other. Unfortunately, land use planning and transport are not integrated in most developing countries or even in developed countries although the need for such integration is now being increasingly recognised and practised. Toronto is a good example. Driven by the increasing concerns for climate change, the City of Toronto recognized the importance of transit in its Official Plan called the Toronto Transit City, which said, “No new roads will be built in Toronto. Instead, all growth in travel demand is to be carried on transit². ” The Official Plan recognizes the important relationship between transportation and land use; new population, employment, and development are all to be located at existing rapid transit stations or along existing major transit corridors. Shanghai is another example. It has also come up with a comprehensive transportation plan, which aims to preserve the city’s character and environment largely through the use of regulations, incentives, and fees. There is also increasing focus on the “compact city” concept that aims at planning land use such that travel distances are minimized and a large proportion of the travel demand is catered to by public transport. Integrating

² http://www.transitcity.ca/media/TransitCity_fullreport.pdf

land use planning with transport planning is an important measure that developing countries should adopt as a long term GHG reduction strategy.

b. Substituting/reducing the need to travel through various virtual mobility alternatives using ICT:

Today with the help of sophisticated technologies, a number of trips (for work, education and other purposes) can be reduced or avoided altogether. For example, the Government of Karnataka in India has provided an integrated 'one-stop' facility called 'Bangalore One' for citizens of Bangalore to access information and pay all government and municipal bills. Similarly, some companies have work-from-home programmes which reduce trip numbers. Such measures have the potential to cancel the trip generating activity altogether or reduce trip lengths through neighbourhood Internet stations. However, these initiatives call for a certain sophistication in the economy and availability of ICT which many developing countries lack.

c. Better traffic management and route designs using Intelligent Transportation Systems (ITS):

This also facilitates better-planned trips and smooth vehicle movement thereby reducing fuel consumption. For example, Hong Kong's \$423m ITS project when completed in 2010 will streamline the traffic operations on major highways, road tunnels and urban roads³. In addition Hong Kong is also developing an overall traffic and public transport information system, which will help travellers plan their route and mode of transport before travelling and hence reduce congestion and unnecessary journeys.

2. Improving vehicle and fuel technologies:

These would include:

a. Setting fuel economy standards:

Today several countries, propelled by concerns for energy security and the environment, have set targets for improving fuel efficiency in passenger cars, and are encouraging the vehicle manufacturers to achieve these targets either by providing fiscal incentives or through regulatory mandates. For example, the USA uses Corporate Average Fuel Economy (CAFÉ) standards, which require each manufacturer to meet specified fleet average fuel economy levels for cars and light trucks. Canada's automobile industry has voluntarily agreed to follow the US' CAFÉ standards. In the European Union, the automobile industry has signed a voluntary agreement with the government to reach an overall fleet CO₂ emission level of 140 grams CO₂/km by 2008. In Australia, a similar voluntary agreement has been signed with the government (An & Sauer, 2004).

³ <http://www.roadtraffic-technology.com/projects/hong-kong/>

In Japan, fuel economy standards are based on a weight classification system where vehicles must comply with the standard for their weight class. China introduced fuel efficiency standards in July 2005, which are called Fuel Consumption Limits for Light Duty Passenger Vehicles based on weight class. The first phase of the standards targets a reduction of 5% in per-distance fuel consumption; the second phase, with a goal of 10 percent reduction in fuel consumption for each weight category will come into effect in 2008. With the implementation of these fuel economy standards, it is estimated that 13 million tons of fuel will be saved in 2020 and 31 million tons in 2030 in China (ADB, 2006).

Fuel economy standards have been universally effective in containing the growth of fuel consumption with increasing transport activity. However, most developing nations, with the marked exception of China, have not introduced fuel economy standards. There is clearly a need to introduce fuel economy standards, promote fuel efficiency labelling and provide incentives to promote the sale of fuel-efficient vehicles in developing countries. Increasing fuel efficiency becomes all the more important as countries move from two- wheelers to cars and SUVs.

b. Setting strict fuel quality and emission standards:

Both energy efficiency and emission standards are linked to fuel quality and enhancing them would require policies that prevent fuel adulteration and encourage the use of clean fuel. In India, for example, the subsidy on kerosene encourages the adulteration of diesel with kerosene and the price differential between diesel and gasoline is leading to an increase in diesel cars. Measures should be taken to improve fuel quality to make it possible to introduce advanced vehicle technology that meets increasingly stringent standards for fuel economy and emission reduction.

c. Inspection, certification and maintenance:

Another key measure that is often ignored in developing countries is effective inspection and maintenance of in-use vehicles. Better maintenance of vehicles together with driver training can result in substantial reduction in fuel consumption. According to ADB an effective inspection and certification program together with adequate maintenance can effect a reduction of 2-17% in fuel consumption and GHG emissions (ADB 2006)

3. Initiate modal shifts to obtain lower fuel consumption per passenger or freight kilometre travelled:

This is relevant for both national and urban transport and would include a number of measures such as:

a. Shifting freight from road to more energy efficient modes of transport:

One of the most pressing needs in the transport sector in developing nations is to increase the share of more energy efficient and environment friendly modes of transport like the railways and waterways in the movement of freight. Large investments on alternative modes made in many developing countries have helped in increasing their carrying capacity. But these investments need to be accompanied by efforts to make these modes efficient, attractive and capable of meeting consumer requirements ; policy interventions, including fiscal measures, should also target and effect the desired inter- modal shifts. The Marco Polo model adopted in Europe is a good example of how modal shifts can be achieved in freight transportation. The Marco Polo Program was initiated in 2003 to shift freight off roads to more environmental friendly modes like short sea shipping, rail and inland water transport. The program provided a subsidy at the rate of 1€ per 500 tonne km shifted off the road and targeted to shift the expected aggregate increase in international road freight traffic of 12 billion tonne kms (btkm) per year to cleaner modes during the program period 2003-2010. A mid term review of the program indicated a shift of approx. 45.3 btkm and an estimated at environmental benefit of 1014 million € during the period 2003-06 ⁴. Developing countries should look at adopting similar innovative approaches to target shifts of freight from road transport to other less energy intensive modes and effect the shifts through the provision of fiscal incentives.

b. Increasing the share of public transport:

At the urban level, effecting intermodal shifts from personal to public transport assumes prime importance. Public transport causes lesser environmental damage in terms of air and noise pollution, optimises the use of road space, increases per unit throughput and reduces traffic congestion as compared to personalized vehicles. Any strategy to increase the share of public transport can, however, only be successful if high levels of mobility and accessibility can be provided by alternative means (Kahn et al., 2007). Clean, safe, affordable, reliable and attractive for all traveller groups is the kind of public transport that needs to be developed. This would call for massive investments in bus based public transport in urban areas and the most appropriate mass rapid transport in the larger cities.

Classic examples of cities adopting public transport oriented development are the cities of Curitiba in Brazil and Bogota in Colombia. The Mayors of these cities took bold initiatives to demonstrate that motorisation is not inevitable and that previously congested, polluted and car saturated cities can be converted into cleaner, greener and low cost public transport dominated cities. Dedicated bus lanes with proper stations, low floor buses, trunk and feeder routes, proper fare and passenger information systems, etc. were all put in place to make public transport attractive. The cities did not stop here; innovative ways to restrict the entry of cars into the city centre and car-free days were introduced in Bogota. In Curitiba, emphasis was placed on the integration of mobility with land use and the creation of spaces for education, healthcare, community and parks on bus routes. In Curitiba 75% of people

⁴ Source: http://ec.europa.eu/transport/marcopolo/events/docs/lisbon_cristobal.ppt

use the BRT on the daily commute. In Bangalore in India, the public bus service provider Bangalore Metropolitan Transport Company (BMTTC) has introduced low-floor, air-conditioned buses in order to enhance the image of public buses and persuade some of the affluent two-wheeler and car users to shift to public transport. This initiative has garnered support from some of the companies in Bangalore who are now encouraging their staff to use public transport.

The IPCC recognizes the preservation and augmentation of the market shares of low emitting collective transport modes as a worldwide mitigation option. Ranging from metro, LRT, BRT and para transit, today most developing countries have a menu of public transport technologies available to them. Each city should choose a system that is appropriate and cost effective to meet its current and future needs and make the system widely available, easily accessible and attractive in order to persuade commuters to shift from the use of personal vehicles to public transport. Para-transit should also be regulated and made part of the formal transport system in order to ensure that it supports the public transport system, is fuel-efficient and safe.

c. Maintaining and increasing the share of NMT:

It is unfortunate that cities with a large share of non- motorised transport should now be choked with personal vehicles, making zero emission modes like walking and cycling almost impossible. Developing countries must consciously attempt to reverse this through investments in creating facilities for non-motorised transport and making it safe.

d. Restraining vehicle ownership and usage:

Experience from several countries shows that the penetration of public transport and NMT can be increased only if transport demand management measures like increased fuel taxes, congestion charges, parking charges, toll taxes and road pricing are introduced to discourage the use of personal vehicles. However, these measures by themselves cannot deter the use of personal vehicles unless adequate and attractive public transport is made available as an alternative to facilitate the desired inter modal shift.

Some countries have attempted to restrain the growth in vehicle ownership. Additional up-front private vehicle registration fees coupled with purchase limitations (such as the publicly managed open-bid Vehicle Quota System operating in Singapore) have been used to encourage a market-priced efficient use of public road space (ADB, 2006). Shanghai, China's wealthiest region, has now adopted policies that restrict the number of driving licences and promote public transport (IEA, 2007).

With rising incomes and aspirations it will be difficult to restrain the purchase and ownership of vehicles. However, the use of personal vehicles can be discouraged through a variety of demand management measures. Restraining vehicle use together with increasing the availability and quality of public

transport is the key to effective GHG reduction in developing countries and should be aggressively pursued.

4. Adopt fuels and technologies with lower carbon density:

Though projections show that in the future also petroleum fuels will dominate the transport sector, the use of biofuels to substitute for petroleum products is an option for GHG reduction. Some developing countries are now investing in the production of biofuels and their use in conjunction with petroleum products. However, there are production and supply constraints, concerns of food security, water availability etc. An appropriate policy and regulatory framework to promote and monitor their usage is also not yet in place. It will be some time before alternative fuels substitute conventional fuels to any significant extent in the developing countries.

Battery-operated vehicles, hydrogen-fueled and hybrid vehicles are other options that would also help introducing GHG emissions. However, their share in the total fleet is not significant even in the developed world. Unless technology advances make it possible for these vehicles to become available at affordable prices in developing countries these vehicles are not likely to make any significant contribution to a reduction in fossil fuel consumption or GHG emissions. Developing countries should, however, provide fiscal incentives to facilitate the introduction of battery-operated, hydrogen-fueled and hybrid vehicles in order to create a market that makes their development and production viable.

Impact of mitigation measures

The various measures discussed above will not only help to reduce GHG emissions but also achieve co-benefits in terms of energy security, enhanced road safety, reduction in local pollution, savings in travel time etc. The choice of policy options, no doubt, will vary across regions and will be influenced by the level of economic development, geography, population density, culture etc. However, all these mitigation options have the potential to effect reduction in energy use and GHG emissions and various studies have attempted to measure their potential. In a study 'The National Energy Map for India: Technology Vision 2030'⁵, TERI has calculated the energy savings in the future if one or more policy interventions were to be adopted in India. The options have been summarized in Table 1 below and the comparison of energy consumption across various scenarios is shown in Figure 6.

⁵ Available at: http://psa.gov.in/writereaddata/11913293531_NEMI2030.pdf

Table 1 Description of energy efficiency scenarios for the transport sector for India

Scenario	Description
Enhanced share of public transport (PUB-PVT)	Share of public transport increased to 60% in 2036 as against 51% in the BAU scenario
Increased share of rail in passenger and freight movement vis-à-vis road (RAIL-ROAD)	<ul style="list-style-type: none"> • Railway freight share increased from 37% in 2001 to 50% in 2036 as against 17% in the BAU scenario • Railway passenger share increased from 23% in 2001 to 35% in 2036 as against 23% in the BAU scenario • Share of electric traction increased for rail passenger and freight to 80% by 2036 instead of 60% in the BAU scenario
Fuel efficiency improvements (FUEL EFF)	Fuel efficiency of all existing motorized transport modes increase by 50% from 2001 till 2036
Enhanced use of bio-diesel in transport sector (BIO-DSL)	Penetration of bio-diesel to 65 Mtoe by 2036
Transport sector hybrid (TPT-HYB)	Incorporates all the above mentioned measures in addition to BAU

SOURCE: TERI, 2005

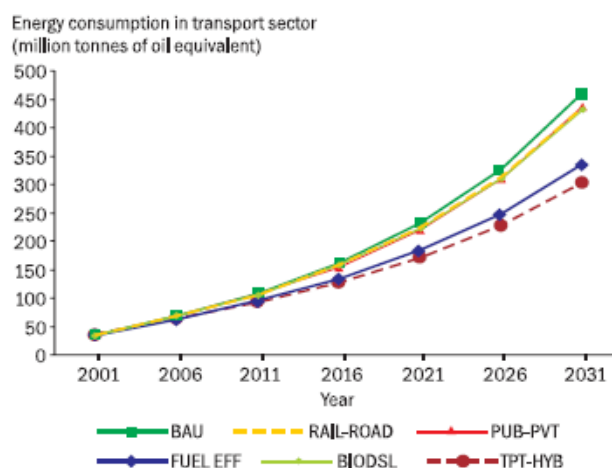


Figure 6 Description of energy efficiency scenarios for the transport sector for India

SOURCE: TERI, 2005

Another study analysed the impact of increasing the share of buses in passenger transport in the three south Asian cities of Bangalore, Dhaka and Colombo. An increase in public transport share in 2020 from what would have been in a baseline scenario showed the following results (Bose R.K., 2007):

- An increase in public bus transport share from 62% to 80% in Bangalore in the year 2020 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 case. The total carbon dioxide (CO₂) mitigation potential over the 15-year period (2005-2020) is 13%
- An increase in public bus transport share from 24% to 60% in Dhaka in the year 2020 leads to a fuel saving of 106,360 tonnes of oil equivalent, which is equivalent to about 15% of the fuel consumed in the baseline case. The total

carbon dioxide (CO₂) mitigation potential over the 15-year period (2005-2020) is 9%

- An increase in public bus transport share from 76% to 80% in Colombo in the year 2020 leads to a fuel saving of 104,720 tonnes of oil equivalent, which is equivalent to about 3% of the fuel consumed in the baseline case. The total carbon dioxide (CO₂) mitigation potential over the 15-year period (2005-2020) is 2%

Wright and Fulton (2005) also estimated that a 5% increase in BRT mode share against a 1% decrease in the share of private automobiles and taxis plus a 2% decrease in the share of mini-buses can reduce CO₂ emissions by 4% at an estimated cost of 66 US\$/tCO₂ in typical Latin American cities. A 5% or 4% increase in walking or cycling in the same scenario can also reduce CO₂ emissions by 7% or 4% at an estimated cost of 17 or 15 US\$/tCO₂, respectively (IPCC, 2007). See Table 2 below.

Table2: CO₂ reduction potential and cost per tCO₂ reduced using public transit policies in typical Latin American cities

Transport measure	GHG reduction potential (%)	Cost per tCO ₂ (US\$)
BRT mode share increases from 0-5%	3.9	66
BRT mode share increases from 0-10%	8.6	59
Walking share increases from 20-25%	6.9	17
Bike share increases from 0-5%	3.9	15
Bike mode share increases from 1-10%	8.4	14
Package (BRT, pedestrian up-grades, cycle ways)	25.1	30

Source: Wright and Fulton (2005), from Kahn et al. 2007

IEA has estimated the following savings in energy use and CO₂ emissions in China under a baseline and alternative scenario. In the alternative scenario a package of policy measures, and which combined the following interventions, was considered,:

1. fuel efficiency standards are prolonged and tightened
2. cars and trucks are scrapped two years earlier on average than in the reference scenario
3. public transport develops more quickly than the reference scenario reducing car usage by 5%
4. increased penetration of alternative fuels to substitute conventional fossil fuels as compared to the reference scenario

The results of the scenario analysis for China are presented below in Table 3:

Table 3: China's Transport Energy Demand and Related CO₂ Emissions in Reference and Alternative Policy Scenario

	2005	2030		Difference from the Reference Scenario in 2030	
		Reference Scenario	Alternative Scenario	Mtoe	%
Road	78	356	283	-73	-20.5
<i>Cars</i>	24	164	121	-43	-26.2
<i>Trucks</i>	31	168	138	-30	-17.9
Other	43	104	84	-20	-18.9
Total energy (Mtoe)	121	460	367	-93	-20.2
CO₂ emissions (Mt)	337	1255	961	-294	-23.4

SOURCE: IEA, 2007

The ADB in its seminal work 'Energy Efficiency and Climate Change Considerations for On-road Transport in Asia' (ADB 2006) has also looked at two scenarios that would, using the policy options suggested to varying extents, achieve a 25% and 50% reduction in fuel consumption from road transport in four Asian countries- PRC, India, Indonesia and Thailand. ADB's analysis shows that the first scenario will see a 29% reduction in CO₂ emissions and the second scenario will bring about a 55% reduction in CO₂ emissions. ADB's analysis also shows that the reduction of trip lengths through the integration of land-use planning with transport planning would have the maximum impact.

As stated earlier, options for mitigating GHG emissions are many and all of them can help to mitigate GHG emissions albeit to varying extents. Each country needs to analyse the available options and make those interventions that are appropriate to its situation, have a significant impact on GHG emissions and maximise the generation of co-benefits by way of reduction in congestion, air pollution, road accidents, energy consumption etc. Many countries have already initiated policies to mitigate the impact of increasing transport activity on fuel consumption and GHG emissions. China through a nationwide memo issued by the Ministry of Construction in 2006 accords top priority to developing urban public transportation. India's National Urban Transport Policy, 2006 calls upon the Indian states to focus on the mobility of people rather than of automobiles and promote public transport in order to reduce fuel consumption and emissions, including emissions of greenhouse gases. While policies and interventions to reduce fuel consumption and emissions will be largely driven by local concerns, countries need to build GHG mitigation into the design of these policies. There is clearly a need for a paradigm shift in the approach to mobility in developing countries that will support and facilitate economic growth, reduce the consumption of fossil fuel and protect the environment, both local and global.

Identifying options, evaluating their impact and implementing those options call for capacities and resources, which are not available in all developing countries. Capacity building in developing countries is a compelling need that calls for international technical cooperation and assistance.

The development of more energy efficient modes like railways and waterways for the transportation of freight and public transport in urban areas call for massive investments. Although these initiatives will bring about a significant reduction in CO₂ emissions they do not qualify for funding under the Clean Development Mechanism (CDM) as it presently stands due to lack of baseline data, difficulties in measuring additionality etc. Given the massive potential for GHG reduction from the transport sector, the CDM arrangements need to be reviewed to fund transport projects that will help to reduce CO₂ emissions, including investments in public transport. Funding through the CDM mechanism alone will not be adequate to meet the cost of implementing measures to contain the growth in GHG emissions from the transport sector in developing countries. Adequate financing and technical advice should be made available to developing countries to enable them to adopt measures that will help reduce the impact of growing transport activity on the climate.

The international community can also make a major contribution to support the efforts of developing countries to contain greenhouse gas emissions through transfer of technology. Improved vehicle technology in the form of cleaner and more fuel-efficient engines, hybrids etc should be made available to the developing countries at affordable costs.

The automobile and oil industries also have a major role to play. They must look beyond cost considerations and assume a global responsibility to support measures to combat climate change. Irrespective of country specific regulations, they must commit through voluntary agreements to making fuel-efficient and low emission engines and clean fuels available to all countries on a global basis. In other words, while some countries may have stringent standards for fuel efficiency and emissions, there must be a common global standard for fuel efficiency, emissions of criteria pollutants and fuel quality that the automobile and oil industry should adhere to even in countries that do not have standards. This would be in their own interests as otherwise the growth of their markets could become restricted. In the absence of an international agency like the ICAO or IMO in the road transport sector it is for consideration whether the ITF could initiate and facilitate a dialogue to evolve this global standard and forge the agreements .

Finally, the International Transport Forum can play a major role in mitigating the impact of transport on climate change by influencing public policy in developing countries and encouraging them to adopt measures to contain the growth in GHG emissions without prejudicing economic growth. The ITF can also play a major role in influencing its developed member countries to provide the necessary technology and finance to enable developing countries to implement GHG mitigation strategies. With the reputation it enjoys, the influence it has at the ministerial level in member countries and the expertise at its disposal the ITF is, perhaps, best equipped to lead international action to mitigate the impact of road transport on climate change.

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