Planning for Public Transport: Integrating Safety, Environment and Economic Issues

Dinesh Mohan
Transportation Research and Injury Prevention Programme
Indian Institute of Technology
New Delhi 110 016, India.

Telephone: 91 11 659 1147
FAX: 91 11 685 8703
Email: dmohan@cbme.iitd.ernet.in

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ABSTRACT

This paper focuses on issues concerning mobility, pollution and safety in megacities of less motorised countries (LMCs) using Delhi (India) as an example. Issues discussed are: Urban transport patterns and environment, choice of fuels and technologies, pedestrian and bicycle environments, and influence of road safety on environmental issues. Accurate and reliable data on traffic patterns, modal shares, injuries and fatalities and emissions are not available in many cities in the LMCs. Innovative ways of arriving at first level estimates have to be developed. Such estimates must be robust enough to help discern trends and provide possibilities for sensitivity analysis of different policy options. The patterns of traffic and management issues in LMCs are very complex and some of their problems have not been faced by the richer countries in the past. In LMC cities non-motorised modes of transport and some form of public transport/para-transit already constitute a significant proportion of all trips. It will be difficult to increase this share unless these modes are made much more convenient and safer. Unless people actually perceive that they are not inconvenienced or exposed to greater risks as bicyclists, pedestrians and bus commuters it will be difficult to reduce private vehicle use. Buses and non-motorised modes of transport will remain the backbone of mobility in LMC mega-cities. To control pollution both bus use and non-motorised forms of transport have to be given importance without increasing the rate of road accidents or bus fares significantly. Public transport fare increases can result in shifts to private modes and this can offset any benefits from cleaner fuels. These issues have to be considered in an overall context where safety and environmental research efforts are not conducted in complete isolation.

INTRODUCTION

Nearly sixty percent of the world's population lives in less motorised countries (LMC) and these countries include 62 of the largest 100 cities in the world. The urban growth rates in Asia, Africa and Latin America are higher than those in Europe and North America (1) and so are the vehicle growth rates. Therefore, we can expect most of the megacities (> 5 million population) of the world to be located in LMCs in the future. Though, the per capita vehicle ownership in LMCs at present is much lower than that in highly motorised countries (HMC) the air pollution levels in LMC cities continue to remain unacceptably high. With increases in populations and vehicles, this situation can get worse unless concrete steps are taken to control the adverse health effects of road transport in these cities.

In this paper we focus on the issues concerning mobility, pollution, use of new technologies and safety in megacities of LMCs using Delhi, India as a an example. According to WHO estimates the situation regarding pollution in LMCs and HMCs can be classified as follows (1):

HMCs*:*
- SO_2, SPM, and smoke : decreasing, often below below WHO guidelines
- NO_x, O_3 : constant or increasing, often above WHO guidelines
- CO_2: increasing

LMCs:
- SO_2, SPM: increasing, often above WHO guidelines
- NO_x, O_3: increasing, below WHO guidelines
- CO_2: increasing

The standard counter measures suggested to control vehicular pollution include the following:

(a) Promote mixed land use
(b) Move toward a greater diversity in modal splits with more importance to non-motorised modes
(c) Lower commuting distances
(d) Reduce number of trips per family
(e) High use of public transport
(f) Increase vehicle sharing
(g) Increase costs of travel and raise fuel prices and introduce road fuel taxation
(h) Improve fuel quality
(i) Improve fuel efficiency and technologies of all vehicles
(j) Phase out old vehicles
(k) Make public transit affordable for the lowest quintile income
(l) Improve quality of pedestrian and bicycle environment
(m) Introduce strict in-use inspection maintenance systems

Of all the measures listed above, (a) to (j) already exist in some form in Delhi and many LMC cities. Delhi has a very mixed land use pattern, a large proportion (~39%) of all trips are walk or bicycle trips (2); of the motorised trips more than 50% are by public transport or shared para-transit modes; compared to HMCs, trips per capita per day in LMCs are lower and more than forty percent trips are less than 5 km in length; and costs of motorised travel are high compared to average incomes.(3) In spite of these structural advantages, the air pollution levels in LIC cities remain high. What these cities do not have are very efficient public bus systems, safe and convenient walkways and bicycle lanes, the best in fuel quality and vehicle technology and efficient vehicle maintenance systems. However, improvements in these will take time, large financial investments and may be difficult to implement for a variety of reasons.

In addition to the problems of pollution, deaths and injuries due to road traffic crashes are also a serious problem in LMCs.(4) According to one estimate the losses due to accidents in LMCs may be comparable to those due to pollution.(5) These problems become difficult to deal with because there are situations in which there are conflicts between safety strategies and those which aim to reduce pollution.(6) For example, large and heavy vehicles can be safer but they are consume more energy and pollute more; congestion reduces probability of serious injury due to crashes but increases pollution; increase in bicycling rates can decrease pollution but may increase crashes if appropriate facilities are not provided.

CITY AND TRAFFIC CHARACTERISTICS OF DELHI

Transport and land use patterns found in Indian cities are different from those existing in most HMC cities. These patterns reflect a new phenomenon and have not been seen in the West since its earlier days of motorization and urbanization. Most Indian cities can be classified as *low cost strategy* cities.(7) In comparison to the cities in the West, these cities consume less transport energy and have high density living. Intense mixed land use, short trip distances, and high share of walking and non-motorised transport characterize these urban centres.(8) Their transport and land use patterns are so confounded by the spectre of poverty and high level of complexity that it becomes difficult to analyse their characteristics using the same indices as used for cities in HMCs.

Urban Transport And Land Use Pattern

Most metropolitan cities in India prepared Master Plans in the 1960s. These were patterned along the following themes :

1. Demographic projections and decisions on the level at which the population shall be contained.
2. Allocation of population to various zones depending on existing density level, infrastructure capacity and future density levels.
3. Land-use zoning to achieve the desired allocation of population and activities in various zones as projected.
4. Large scale acquisition of land with a view to ensuring planned development.

The planning framework as adopted in the preparation of Master Plans has not been found to be commensurate with ground realities. The net effect of the inadequacies of the planning process has been that majority of urban growth has long taken place outside the formal planning process. Informal residential and business premises and developments increasingly dominate urban areas. In Delhi, where half or more of a city's population and many of its economic activities are located in “illegal” or informal settlements, urban planners still rely on traditional master-planning approaches with their role restricted to servicing the minority, high income residents. However, this process along with rising land prices have led to mixed land use patterns and have successfully curbed the number and lengths of primarily non-work related trips by motorized modes. The number of trips per household for different purposes remains constant regardless of whether the person is living in "inner area" which has heavy concentration of employment and commercial activities or the "outer areas" with the planned new developments.(9) The rising cost of transport within the city and long working hours force the workers to live close to their places of work. Unlike the traffic in cities in HMCs, bicycles, pedestrians and other non-motorised modes are present in significant numbers on the arterial roads and intercity highways. Their presence persists despite the fact that engineers designed these highway facilities for fast moving uninterrupted flow of motorised vehicles.

However, air pollution, congestion and traffic fatalities have continued to increase in such cities. Increase in the level of congestion has been a major concern for planners and policy makers in the metropolitan cities. In Delhi average speeds during peak hour range from 10 to 25 km/h in central areas and 25 to 60 km/h on arterial streets.(9) However, Delhi's traffic fatalities in 2000 were more than double that of other mega cities in India. Clearly, criteria for recommending optimal speeds and congestion reduction does not include desired level of safety, pollution and land use patterns.

There is ample evidence to illustrate the mismatch between the careful planning and the growing transportation problems. Unless we understand the basic nature of problems faced by our mega cities, the adverse impact of growing mobility on the environment would continue to multiply in future. The existence of an active informal sector introduces a high degree of heterogeneity in the socio-economic and land use system. This is assumed to add to our problems of congestion and pollution. However, the informal sector is an integral part of the urban landscape providing a variety of services at low costs, at locations with high demand for these services. Many view hawkers, pavement shops, cycle and motor vehicle repair and part shops as unauthorized developments along the road that reduce the capacity of the planned network. However, since the market demands these services, they continue to exist and grow along the arterial roads as well. It is quite clear that long term land use transport plans must address the needs of the informal sector.

Traffic Patterns and Planning Issues

A high share of non motorized vehicles (NMVs) and motorized two wheelers (MTW) characterizes the transport system of Indian cities. In such cities nearly 45%-80% of the registered vehicles are MTWs. Cars account for 5%- 20% of the total vehicle fleet in most LMC large cities. The road network is used by at least seven categories of motorised vehicles and NMVs. Public transport and paratransit is the predominant mode of motorized travel in megacities and carry 20%-65% of the total trips excluding walk trips. Despite a significant share of work trips catered by public transport, presence and interaction of different types of vehicles create complex driving environment. The present design of vehicle technology does not take into consideration this environment where frequent braking and acceleration cannot be avoided.

Preference for using buses for journey to work is high by people whose average income is at least 50% more than the average per capita income of the city as a whole.(10) Whereas increase in fares may or may not reduce the ridership levels, but it will affect the modal preference of large number of lower income people who spend 10-20% of their monthly income on transport with the present level of fares. A survey result shows that nearly 60% of the respondents in low-income areas find the minimum cost of journey to work trips by public transport (less than US cents 10 per trip) unacceptable.(10) Even the minimum cost of public transport trip accounts for 20 to 30% of the family income of nearly 50% of the city population living in unauthorized settlements. This section of the population is very sensitive to the slightest variation in the cost of public transport trips. In outer areas of Delhi NMVs and pedestrians on some of the important intercity highways with comparatively long trip lengths show that a large number of people use these modes not out of choice but rather lack of other options. Even a subsidized public transport system remains cost prohibited for a large segment of the population. Market mechanisms may successfully reduce the level of subsidies, however, they also eliminate certain options for city residents.

Because bicyclists and pedestrians continue to share the road space in the absence of infrastructure specifically designed for NMVs, they are exposed to higher risks of being involved in road traffic accidents by sharing the road space with high-speed modes. Unlike cities in the West, pedestrians, bicyclists and MTWs constitute 75% of the total fatalities in road traffic crashes.(11) Buses and trucks are involved in more than 60% of the fatal crashes. Buses are often very crowded inside and significant proportion of passengers who die are those who fall from footboards of the buses.

In addition, many indigenously designed vehicles (IDVs) such as three-wheeled scooter taxis, vehicles outfitted with single cylinder diesel engines (designed for agricultural use) are present on the roads of Indian cities because of the absence of efficient and comfortable public transport services and their low capital (typically around USD 2,000) and operating costs. The *tuk tuks* in Thailand, *becaks* in Indonesia and *jeepneys* in Philippines serve a similar purpose. These IDVs operate as paratransit modes and provide affordable transport, thus serving a very important and useful role in the context of social sustainability. However, they have unique safety and pollution problems that the West has never experienced. They have high emission levels but cannot be substituted easily by modern vans or buses because of economic and financial compulsions. However, at least the three-wheeled scoter taxis are now coming equipped with four stroke petrol engines or CNG engines which make emissions per passenger from these vehicles less than those of cars. Yet, safety, efficiency and environment friendly technologies for these vehicles have not assumed priority for research in India or any other country.

POLLUTION CONTROL IN DELHI

The main administrative actions taken by the government to reduce the amount of pollution generated by motor vehicles include:

1. Mandatory pollution testing (CO emission at idling) of vehicles every three months.
2. Fitting of catalytic converters on cars and emission norms comparable to Euro-II
3. Strict emission norms for two-wheelers and availability of petrol premixed with lubricating oils at filling stations.
4. Availability of lead free petrol in the city along with reductions in sulphur content in fuels.
5. Phasing out of buses and taxis more than 15 years old.
6. Supreme court directions requiring all buses and three-wheeled taxis to use CNG as fuel.

All the above measures except the sixth one have been implemented with a reasonable degree of success. Various government and non-government organisations have also proposed banning of the three-wheeled scooter rickshaws, taking polluting buses off the road, and strict legal action against vehicles not conforming to emission norms. The Supreme Court's ruling that all buses and three-wheeled taxis convert to CNG fuel by 31 March 2001 created a great deal of controversy and debate.

Because of the non-compliance by bus owners and inadequate supply of CNG the court has had to delay the deadline twice. First to 30 September 2001 and then again to 31 March 2002. However, the effectiveness of such measures are open to question and are discussed in a later section.

Controlling Car Ownership

Car ownership seems to be mainly influenced by the relative price of cars compared to family incomes. Car use for work trips can be influenced by providing comfortable and reliable public transport options. Many policy planners have suggested that a further increase in fuel costs or prices of cars could decrease their use. However, in India, the effect of these measures does not appear to be very strong as a significant number of cars are owned or their use subsidised by the government and private corporations. It is not easy to change this situation as family incomes are likely to rise considerably for the next few decades and car ownership levels are still relatively low by international standards. It may be possible to reduce car use if long term plans are made to introduce car/vehicle sharing systems and technologies and public transportation systems are expanded to such an extent that they are not as crowded and inconvenient as at present.

Improvements in Fuel Quality and Alternate Fuels

In most LMCs, decisions have already been taken to phase out leaded petrol. The next phase, reductions in sulphur and benzene content in fuels will take longer and will be more difficult this requires much higher capital investments. The same will be true for cleaner diesel fuels. Alternate fuels (like CNG) are being introduced in many countries, including India, but widespread use will take time as the infrastructure needed for distribution of fuels like CNG is also time and money consuming. In addition, the real benefit of CNG use comes only if engines and closed loop catalytic converters are specifically designed for such fuels. Such engines are more expensive than the traditional diesel engines and the effectiveness of retrofit technologies in the long run are not known yet. Therefore, CNG may be desirable for a limited number of buses, but its widespread use is not likely in the whole country is the near future.

Electric cars are likely to remain prohibitively expensive for LMC use at least for the next decade or so. However, with careful planning it may be possible for LMC megacities to introduce electric trolley buses in selected areas of cities as they are much less expensive than light rail transportation systems.

Increase in Use of Public Transport

Construction of metro rail systems is considered an important counter measure for reduction in congestion and pollution. Almost all megacities in Asia have plans to construct such systems. However, the cost effectiveness of such projects in low-income countries is very doubtful. Two major studies done to understand the performance of metro rail systems by the World Bank and the Transport Research Laboratory (U.K.) make the following conclusions:

- "It is difficult to establish the impact of metros on traffic congestion, in isolation from other factors. However, there appears to be impact in 10 of the 12 cities for which information exists. In one of the remaining two, Sao Paulo, the impact was short lived, while time will tell whether this is also the case in Manila. The general conclusion is that contrary to expectations metros do not appear to reduce traffic congestion. The passengers are mostly captured from the buses, but the reduction in bus traffic is not proportional and represents only a small part of the total traffic. The relief to traffic congestion is short lived because private traffic rapidly grows to utilise the released road capacity. There has been very little shift from car use… In most cities in most developing countries, it will not be possible to justify metros rationally… In these cities we have sought to direct attention to their priorities and actions to improve the bus and paratransit system which will result in achievable improvements".(12)
- "Several developed countries have industries for metro systems facing lack of demand at home. Part of their foreign policy is to make soft loans to support these industries. At the same time in the developing countries governments are interested because, (1) a large construction project will bring jobs, (2) a metro system seems modern, and (3) because the cost will not be borne until the project has been built; even then the financing may be about 3 percent. A reason not to invest, financial discipline is often not regarded as important. There

> was money to be made, prestige and political power to be won… Short term and long term motivations lay behind the construction of the metro. Firstly, there was the desire to immediately improve political fortunes. In the longer term there was a desire to build a monument to those holding office at that time.”(13)

The experience from Chinese cities supports the conclusions that building metro systems does not necessarily reduce congestion and decrease private transport use. The metro system in Beijing takes only 11% of the public passenger transport volume and a report from Beijing states that "As the advanced track transport system is enormously expensive and requires long construction period, it cannot be taken as immediate solution".(14) Shanghai has built a 22.4 km metro line which carries only 1% of the total number of passengers in the city.(15) The number of public transit vehicle equivalents increased by 91% between 1993 and 1997 but the total number of passengers carried decreased by 53% in the same period.(16) Guangzhou has finished construction of a metro line but details of change in surface traffic are not available. The city has increased availability of public transport standard vehicle equivalents by 97% but total number of passengers carried has increased by 62% only. In light of this experience Wu and Li conclude:(16)

> "Although the central government is actively promoting the Chinese built underground carriages and equipment, the cost of construction and operation for metro is still too high to bear for most cities. Urban rail transport is vital to the megacities like Beijing, Shanghai, Gunagzhou and Tinajin. But for other cities or even the outer areas of the upper mentioned cities, alternatives should be considered including bus-only lanes, improved trams, elevated or ground rails and suburban rails…As a matter of fact, the already built metros in some cities have not become a means of commuter for the middle or low income class…The practice in developed countries showthat the development of public and rail transport itself does not necessarily block the process of motorisation or reduce the number of motor vehicles. Nor does it alleviate traffic congestion. Thus it cannot fundamentally improve traffic contamination."

Construction of a metro rail system and increase in number of buses would also increase the number of access trips by walking and bicycling. High-density metro corridors increase the presence of pedestrians on the surface. This can result in higher accident rates if special measures for traffic calming, speed reduction, and provision of better facilities for bicycles and pedestrians were not put in place in parallel. Therefore, there is no evidence that the construction of a metro rail system on its own would result in the reduction of congestion, pollution or road accidents. It is important that alternative lower cost methods of transportation be explored much more seriously.

The experience of designing and running a high capacity bus system in the city of Curitiba in Brazil gives us a very good example of what is possible in planning public transportation systems at a fraction of the cost (5%-10%) involved for metro lines.(17) Special bus and bus stop designs have been developed in Curitiba to make access to buses easier, safer and faster. This is combined with provision of segregated bus lanes where necessary, traffic light priority for buses and moving buses in platoons. Many bus priority lanes around the world carry 15-20 passengers in one hour in each direction, and experiments show that modern specially designed bus systems up to 25,000 - 30,000 passengers in one hour in each direction.(18, 19) Since such systems can be put in place at a fraction of the cost of metro systems without digging or building elevated sections, they can be introduced on all major corridors of a city. Since the total number of lines so built would be many more than the high cost metro system, the total capacity of this system would also exceed that of a limited metro rail network. An intelligent mix of electric trolley buses and other buses running on diesel and alternate cleaner fuels could take care of pollution issues. The availability of modern computer networks, communication systems and intelligent transport technology hold great promise for making high capacity bus systems even more efficient and user friendly. Even the highly industrialised countries did not have these options available to them in the past decades and so very little serious research and development work has been done to optimise designs for megacities in low-income countries. Any investment in this direction should be highly profitable.

Introduction of Strict In-Use Inspection Maintenance Systems and Phasing Out Old Vehicles

Both these measures are likely to have limited success in LMCs for economic, social and political reasons. Vehicle inspection and maintenance costs are relatively high for LMC income levels and need a capital-intensive equipment and bureaucratic structure. These are not likely to be successful until per-capita incomes rise and costs of such systems are built into the ownership of vehicles. The design and implementation of such systems are likely to take time. Similarly, it will be very difficult to phase out old vehicles, as costs of owning vehicles are very high relative to incomes. However, the average age of private vehicles in Indian is about 6-7 years. This is because high growth rates in vehicle ownership in LMCs have taken place in the last decade or and so. Phasing out old vehicles in India as far as private cars and two-wheelers are concerned may not result in the kind of pollution reduction as projected.

Improvement in Fuel Efficiency and Technologies of All Vehicles

Policies and research in this area are likely to be most beneficial. Research and development work to improve the emission levels from motorcycles and scooters has already been taken up by manufacturers in response to much stricter pollution standards introduced by governments of counties like India, Taiwan and Thailand. These improvements are likely to have a major impact as MTW ownership levels in many LMCs are very high. Continued work and research in this area is very necessary.

One set of vehicles completely neglected for improvements are the country specific indigenously developed vehicles discussed in an earlier section. Many policy makers and city governments are considering the ban of such vehicles. However, such moves may not be in the overall benefit for cities and mobility of the lower income people. Replacing such vehicles with high cost vehicles may result in unforeseen negative consequences both in social effects and mobility practices. It is possible that an increase in fare prices will result in many commuters reverting to use of personal modes. This would be particularly true for those who own scooters and motorcycles, as the running cost for these vehicles is relatively low. Higher use of these vehicles can offset the environmental advantage of using less polluting vehicles.

For example the decision to convert all diesel engines buses to those running on CNG has thrown all of Delhi into turmoil and excited a debate on technologies which no one knows enough about. Part of the problem is that we have specified technologies to be used and not performance norms. All scientifically literate societies no longer specify technology norms because such policies tend to kill innovation, invention and competition. Such norms also encourage inefficiency and laziness in design, promote irresponsibility and at times encourage cartels and monopolies. On the other hand, when performance norms are specified, manufacturers have to compete to give you the most efficient and inexpensive technology that does the same job. Therefore, in our case we should have specified the quality of the exhaust gasses that should come out of an engine and left it to the transporters to select the most effective technology available from anywhere in the world.

However, in our case the problem does not end there. The main obstacle in ensuring cleaner transport in Delhi is the complex economics associated with the issue. A very simple and basic principle of promoting public transport is to keep the fares below the marginal cost of using the cheapest form of private mechanised transport. Any proposed technology that increases the prices of buses would have the unintended result of increasing use of two-wheelers and cars. Today, commuters spend about Rs 450 a month and school children around Rs 300 a month for a seat in a chartered bus. Apparently, these fares are viable only when buses cost about Rs. 0.5 -1 million. If the bus operators have to spend another Rs. 0.3 - 0.4 milion for retrofits or if they have to buy new buses for Rs. 1.8-1.9 million, then fares are bound to increase significantly. Reports suggest that these fares would be in the range of Rs 500-700 a month for schoolchildren around Rs 700-1,000 for chartered buses used by commuters for going to work. (20)

At a marginal cost of using a two-wheeler of about 75 paise a km, the monthly expenditure amounts to about Rs 450 per person assuming 20 km per day for 30 days. Obviously, any public transportation cost higher than this would be resisted by commuters. Since the commuters are already paying this maximum amount, any increase in fares would shift people away from buses. Seven to ten two-wheelers pollute as much as one bus and 4 occupy as much road space as a bus when in motion. Since each bus carries 70-100 persons during rush hour, if only 10 per cent of the bus user population start using two-wheelers it will have the effect of introducing another 10,000 buses on the roads of Delhi in terms of pollution and congestion. If there is more congestion, then all other vehicles will also pollute more. In addition, increase in number of two wheelers could increase the number of road accidents.

Comparison of the Effects of Changing Bus Fuels

We have estimated the effect of fuel change and possible shifts to private vehicles and the details are available in a separate report.(21). Four cases of bus fuels studied are summarized in Figures 1a, b, c and d for total emissions by all vehicles at three locations in Delhi for CO, HC, NOx and PM, respectively:

- All buses on present diesel technology
- All buses on CNG
- All buses on EuroII diesel engines
- 50% buses on CNG and 50% on EuroII

The impact on total CO emissions is negligible (Figure 1a). Similarly, the impact on total HC emissions is also negligible. Total NOx emissions decrease under all changeover possibilities; the largest effect (about 25%) is for changeover to CNG fleet. The second best reduction is in a 50% mix of CNG and Euro II diesel buses and least reduction in entire conversion to Euro II diesel. Reductions in particulate matter emissions are significant under all conversion scenarios. It is interesting to note that total PM emission from any of the conversions is comparable. It is up to 30% less than the existing case. The reason lies in the fact that other transport modes also contribute substantial quantities of PM. Thus, conversion to either CNG, Euro II diesel or 50%-50% mix of CNG-Euro II diesel give similar advantages in terms of reduction of the four pollutants.

Figures 2 a-d and 3 a-d show the estimates total emissions of CO, HC, NOx and PM by all vehicles at the three locations during peak traffic for the following situations:

- Current situation with all buses on diesel
- All buses on CNG with the assumption of 10% and 15% shift of passengers from buses to two-wheelers due to increase in bus fares
- All buses on Euro II diesel engines with no passenger shift
- 50% buses on CNG and 50% on Euro II diesel with no passenger shift

This means that if all the new buses emitted only clean air, even then the pollution load in Delhi would remain the same or even increase. Therefore, no policy which results in the increase in bus fares is likely to have a beneficial effect on air quality in Delhi unless arrangements are made to subsidise public transport through innovative local taxation policies.

As long as we depend mainly on private operators to provide bus transport without subsidy, the question of cleaning up Delhi does not arise. The processes used in arriving at such decisions have to be transparent and put in the public domain. If this were so, we would have been privy to the cost-benefit calculations (if any) done by official committees. Even now, it is not too late to take stock and revise the decision after a public discussion of the options. It would be best if the polluter pay principle is invoked to tax all road users of Delhi annually according to the road space occupied by vehicles and the pollution produced per passenger km by each vehicle. The tax would have to be based on the amount of money needed to run 10,000 modern buses in Delhi while keeping the fare below 75 p per km.

It would be much more useful and beneficial if government-industry partnerships are formed to develop guidelines and standards for use of alternative less polluting engines without increasing the costs substantially.

NEED FOR IMPROVING THE QUALITY OF PEDESTRIAN AND BICYCLE ENVIRONMENT

In light of the discussion above, an exclusive focus on bus and fuel technologies only may not be a sustainable option for cleaner air in cities like Delhi. In all LMC cities NMT modes constitute a high proportion of all traffic. Unless these modes are given importance and roads specifically designed for their needs they make the movement of motorised modes less efficient. In addition to bicycles, non-motorised carts and *rickshas* are used for delivery of goods like furniture, refrigerators, washing machines etc. Semi-skilled workers, carpenters, masons, plumbers, postmen, and courier services use bicycles or walk. Therefore, the demand for bicycles and other NMT nodes exists in large numbers at present and is likely to exist in the future also. This situation is not explicitly recognised in policy documents and very little attention is given to improving the facilities for non-motorised modes.

Technological solutions based on improving fuels, engines and vehicles must be accompanied by improvements in road cross-sections and providing segregated facilities for non-motorised transport.

A large proportion of the decrease in road traffic injuries and deaths in HMCs is the result of the availability of cars which provide much greater safety to the occupants in crashes, and the result of a very significant reduction of the presence of pedestrians and bicylists on HMC streets and highways. Recent estimates from UK suggest that the number of trips per person on foot fell by 20% between 1985/86 and 1997/99 (22). Such trends suggest that reduction in pedestrian, bicycle and MTW fatalities could be largely because of the reduction in exposure of these road users and less because the road environment has been made “safer” for them. Mohan and Tiwari (23) also show that in LMCs buses and trucks are involved in a much greater proportion of the re158e -0.375 2 294.75 0 TD180.1665 Tc684 using two-wheelers or cars. This shift would also increase congestion. Greater use of two-wheelers would also increase injuries due to accidents. Therefore, before we make new laws that might increase the cost of buses, we have to make arrangements for cross-subsidy of public transport. This follows from the polluter and user pays principle based on free market economics. Since car users pollute the most, use the most road space and injure more people per person transported, they must pay for their comfort that harms others. Two wheeler users come next and bus users a low third. A pollution and road tax paid by private vehicle users could help pay for better buses so that we avoid a migration from buses to two-wheelers and cars.

It is quite clear that cleaner air will come at a price, and only if we have well thought out long term policies. The future committees which deal with these issues would be well advised to consider all the complex issues, consider the side effects and perform cost effectiveness studies before issuing edicts. If we don't do this, the air will not be cleaner and a lot of people will be angry.

CONCLUSIONS

Buses and non-motorised modes of transport will remain the backbone of mobility in LMC mega-cities. To control pollution both bus use and non-motorised forms of transport have to be given importance on- wine o14q3jurrs.

road taMe to6tri issues woupforibf p, and ossuing (present technology). Therefore, all future CNG buses should be required to have gas cylinders integrated in the roof of the bus.

Facilities for Non-Motorised Transport and Safety

- Every round trip by public transport involves four non-motorised trips and at least two street crossings. Therefore, greater use of public transport cannot be ensured unless use of roads is made much safer for pedestrians and bicyclists.
- All arterial roads must have segregated lanes for non-motorised transport and safer pedestrian facilities.
- Urban and road design characteristics must ensure the safety of pedestrians and bicyclists by wider use of traffic calming techniques, keeping peak vehicle speeds below 50 km/h on arterial roads and 30 km/h on residential streets and shopping areas and by providing convenient street crossing facilities for pedestrians.

The above recommendations have to be considered in an overall context where safety and environmental research efforts are not conducted in complete isolation. We have to move toward adoption and implementation of schemes that remain at a human scale and improve all aspects of human health. The authors of a report on integration of strategies for safety and environment published by the OECD (6) suggest the following guidelines for policy makers:

- Ask leading questions about safety and environmental goals at the conceptual stage of the project and look beyond the immediate boundaries of the scheme.
- The safety and environmental consequences of changes in transport and land use should be made more explicit in technical and public assessments.
- There should be simultaneous consideration of safety and environmental issues by involving all concerned agencies.

LIST OF FIGURES

FIGURE 3b Comparison of HC emissions under various scenarios of bus fuels with 15% shift to 2-wheelers in case of CNG.

FIGURE 3c Comparison of NOx emissions under various scenarios of bus fuels with 15% shift to 2-wheelers in case of CNG.

FIGURE 3d Comparison of PM emissions under various scenarios of bus fuels with 15% shift to 2-wheelers in case of CNG.

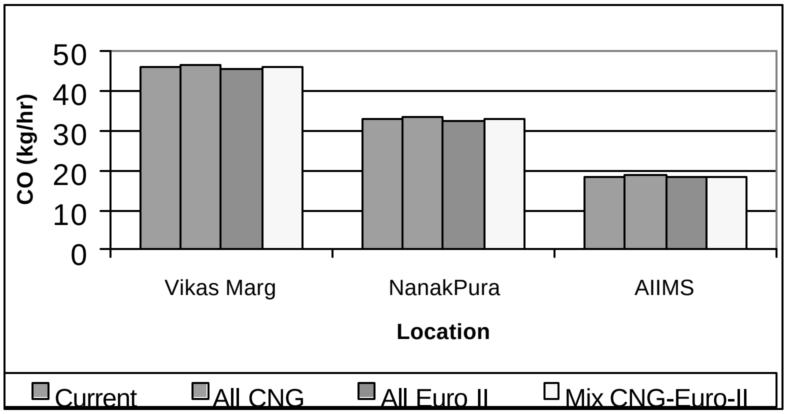


FIGURE 1(a) Comparison of CO emissions under various scenarios of bus fuels without shift to 2-wheelers

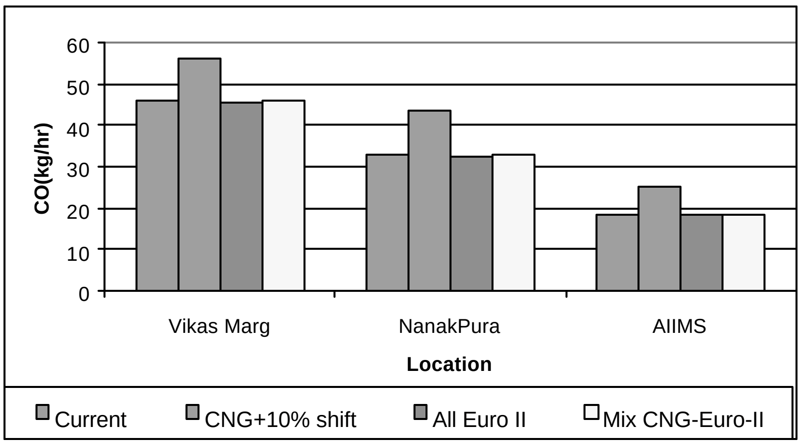


FIGURE 2a Comparison of CO emissions under various scenarios of bus fuels with 10% shift to 2-wheelers in case of CNG.

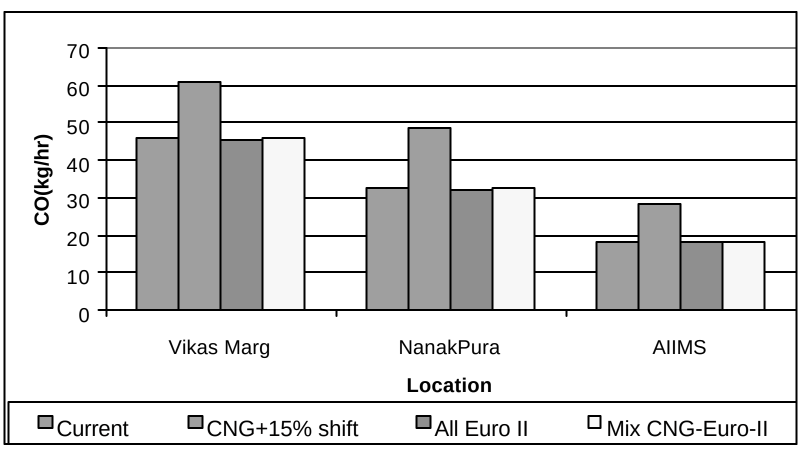


FIGURE 3a Comparison of CO emissions under various scenarios of bus fuels with 15% shift to 2-wheelers in case of CNG.

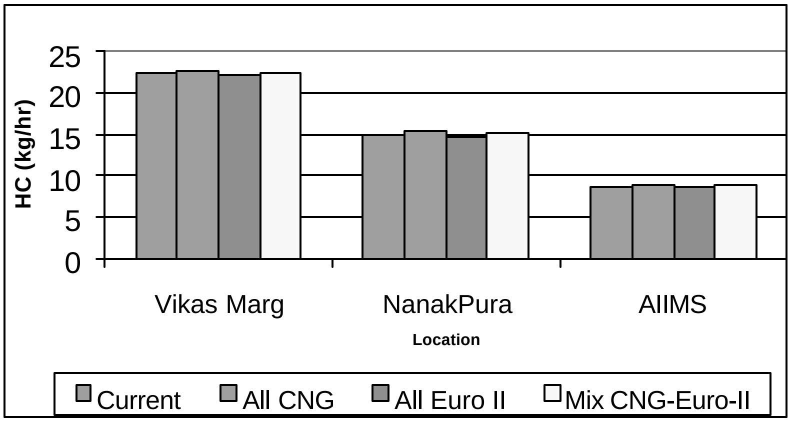
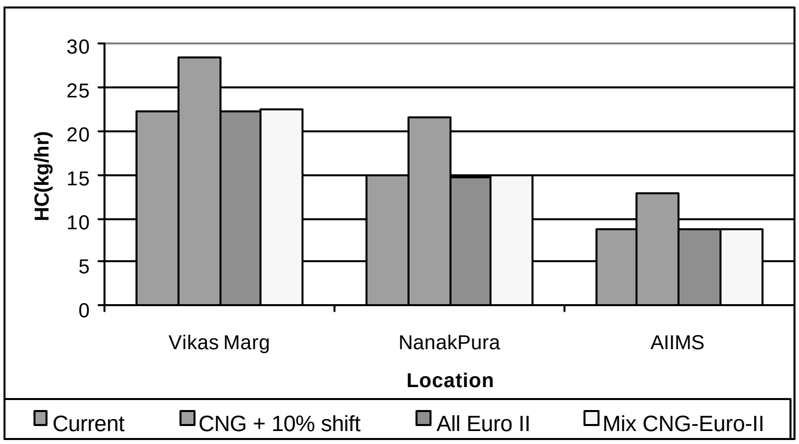


FIGURE 1(b) Comparison of HC emissions under various scenarios of bus fuels without shift to 2-wheelers.

FIGURE 2b Comparison of HC emissions under various scenarios of bus fuels with 10% shift to



2-wheelers in case of CNG.

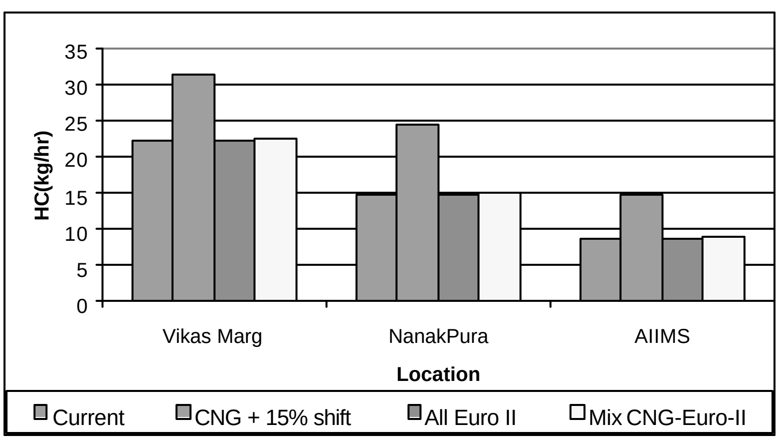


FIGURE 3b Comparison of HC emissions under various scenarios of bus fuels with 15% shift to 2-wheelers in case of CNG.

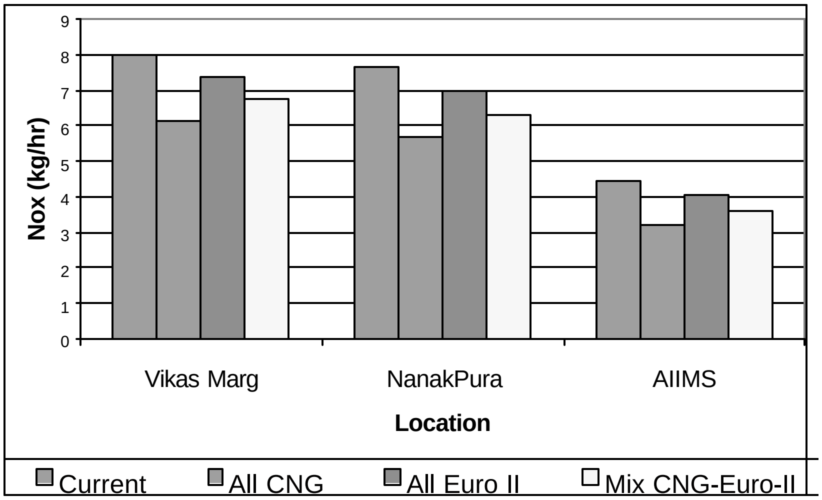


FIGURE 1c Comparison of NOx emissions under various scenarios of bus fuels without shift to 2-wheelers.

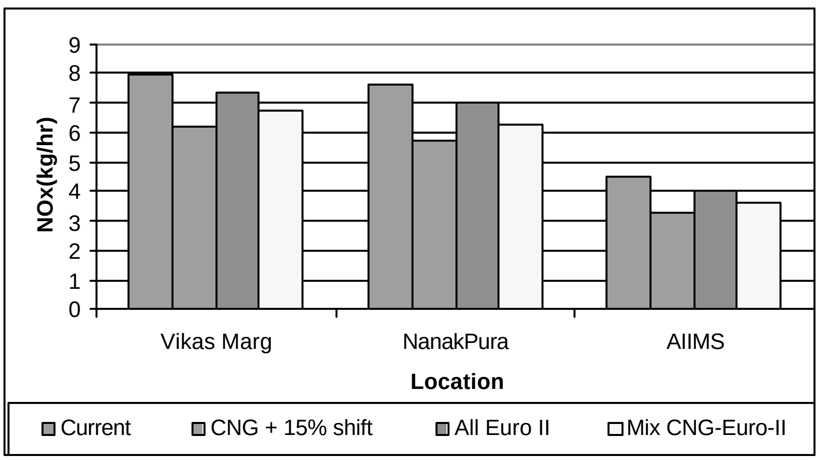


FIGURE 2c Comparison of NOx emissions under various scenarios of bus fuels with 10% shift to 2-wheelers in case of CNG.

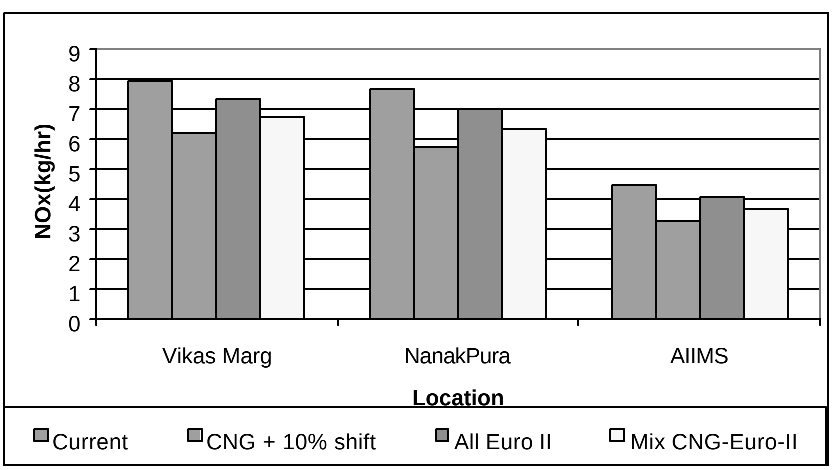


FIGURE 3c Comparison of NOx emissions under various scenarios of bus fuels with 15% shift to 2-wheelers in case of CNG.

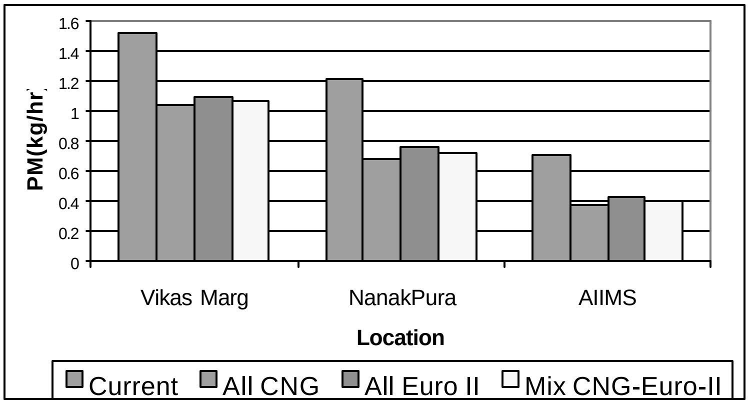


FIGURE 1d Comparison of PM emissions under various scenarios of bus fuels without shift to 2-wheelers.

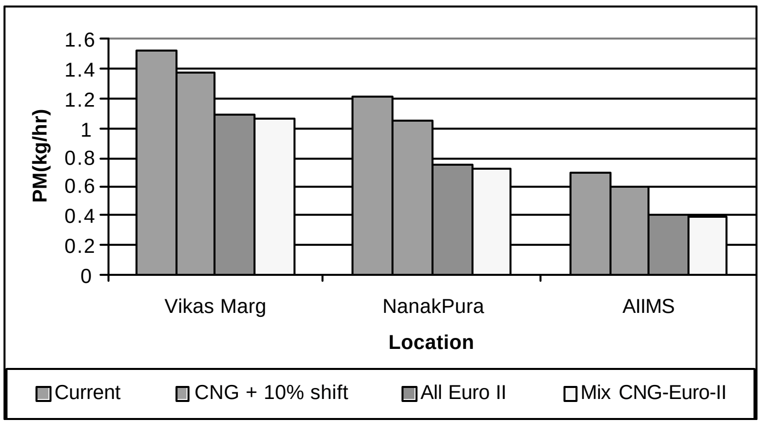


FIGURE 2d Comparison of PM emissions under various scenarios of bus fuels with 10% shift to 2-wheelers in case of CNG.

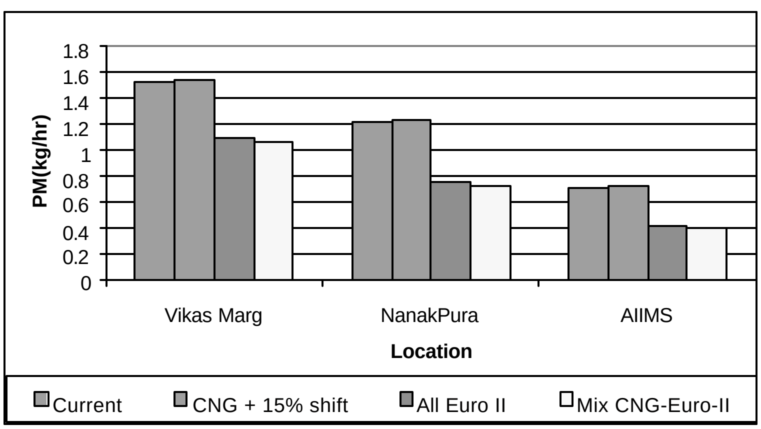


FIGURE 3d Comparison of PM emissions under various scenarios of bus fuels with 15% shift to 2-wheelers in case of CNG.

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