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AIR QUALITY IN ASIAN MEGACITIES: ISSUES AND POLICIES

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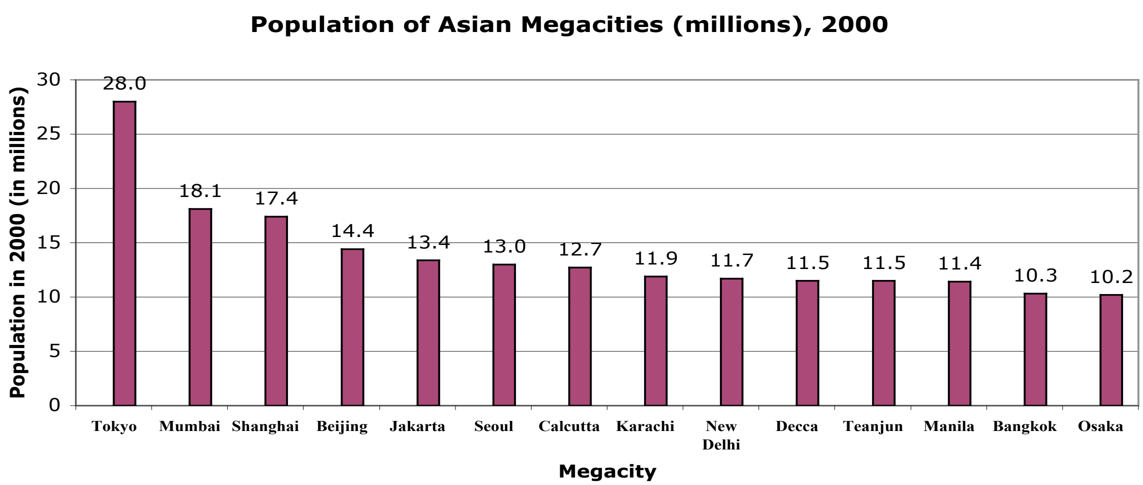
INTRODUCTION

Asia, the most populous continent, has a high proportion of the world's megacities. Of the 14 megacities Asia is home to, the largest and the smallest in population (Tokyo and Osaka) are from high income Japan and Seoul from the medium to high income S. Korea (Figure 1). The other 11 megacities are from low income regions such as China, South and Southeast Asia, where urban population growth represents a combination of rural urban migration and net natural increase, leading to rapid growth in recent times.

Cities are the engines of contemporary national economies in the global system, key to the delivery of vital services which permit continuing increases in gross domestic product (GDP). This is an even more marked feature of Asian megacities, which have become (in the last quarter century) important nodes in a globally organized production system, attracting new technologies and investment capital and exhibiting economic dynamism that strengthens their national economies.

Figure 1.



This global production system is organized by global corporations, which seek to take advantage of economies of scale from large markets and the economies of scope deriving from the corporations' global (knowledge, finance and marketing) networks, and which also take advantage of the lower labor costs in Asia. Given the favorable labor and other input prices in Asia, their abundant labor, and their large consumer market potential, this global production system is likely to continue to grow in size and complexity, thereby continuing to stimulate the economic growth and development of Asian megacities. Briefly stated, the Asian megacities are likely to grow in the near future in population and economic terms.

While large cities are dynamic locales of economic growth, the physical concentration of economic activities and the extensive infrastructure systems of transport and power necessary to facilitate such urban activities create, in turn, external costs in the form of congestion and environmental pollution. Vehicles are the most significant contributor to air pollution in megacities in the newly industrializing Asian countries. This contribution is rising rapidly, with vehicle fleet sizes doubling in seven years, with greater use of highly polluting diesel vehicles and two-stroke motorcycles, and with use of poor quality fuel. The consequence has been worsening air quality in Asian megacities except in Japan (where there have been recent improvements). As indicated in Table 1, all Asian megacities except Tokyo have a serious suspended particulate matter problem. Chinese cities such as Beijing and Shanghai (using poor quality coals and cheap oils) have also a serious SO_2 problem. Karachi has serious lead pollution, while Jakarta and Manila have moderate levels of lead pollution.

Table 1. Air Pollution Levels in Selected Asian Megacities

Megacity	SO_2	SPM	CO	NO_2	Lead	O_3
Bangkok	*	***	*	*	**	*
Beijing	***	***	**ND**	*	*	**
Bombay	*	***	**ND**	*	*	**
Calcutta	*	***	**ND**	*	*	**ND**
New Delhi	*	***	*	*	*	**ND**
Jakarta	*	***	**	*	**	**
Karachi	*	***	**ND**	**ND**	***	**ND**
Manila	*	***	**ND**	**ND**	**	**ND**
Seoul	***	***	*	*	*	*
Shanghai	**	***	**ND**	**ND**	**ND**	**ND**
Tokyo	*	*	*	*	-	***

* Low Pollution WHO guidelines met
** Moderate to heavy – WHO exceeded by a factor of up to 2
*** Serious problem **ND** Inadequate data

Source: Harrington and Krupnik, 1999.

The aim of this paper is to analyze the air quality problems deriving from transport activities in Asian megacities, and identify policy instruments to address the air quality issues and the approaches to strengthen the analytical and institutional capacity to develop strategies which can improve air quality in the megacities of industrializing Asia.

The paper identifies in the next section the underlying socioeconomic attributes and the technical factors that jointly determine the level and nature of air emissions deriving from the use of transport vehicles in Asian megacities. This sets the stage for a more detailed description and assessment of emissions and state of air quality in Asian megacities (Japanese cities, which have only an ozone problem are not discussed further). The paper proceeds to a description of the socioeconomic and institutional *context* of lower income Asian megacities, in which effective policy approaches to air quality improvement can be developed. Appropriate to such a context, the policy instruments for pollution reduction are offered and discussed next. The paper concludes with specific measures which could help build the technical and institutional capacity in the megacities to improve their air quality over time.

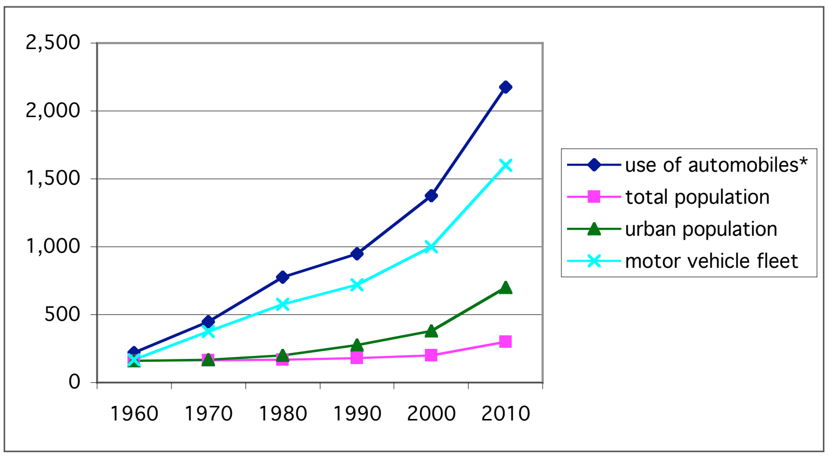
FACTORS UNDERLYING AIR QUALITY IN ASIAN MEGACITIES

The air emissions deriving from transport use in Asian megacities are determined jointly by the level of urban transport demand, the level of fuel use efficiency, and the rate of emissions per unit of fuel use. The levels of transport demand and fuel efficiency in turn derive from a variety of socioeconomic characteristics, while the emissions rate for unit of fuel use depend on technical factors such as engine and fuel attributes and vehicle age and maintenance.

Socioeconomic Context of Urban Transport Demand

The spiraling of demand for urban transport in Asian megacities represents a confluence of several factors. In order to function as centers in the world production system, these cities must have accessibility to global flows of goods and people—implying the need for air, port, rail, and road transport vehicles and facilities. Further, experience in many parts of the world suggests that the rising per capita incomes from economic growth leads to more than proportionate increases not only in vehicle ownership and even more sharply in vehicle miles traveled (Figure 2).

Figure 2. Growth in Ownership and Use Motor Vehicles since 1960



Source: World Bank, 1998.

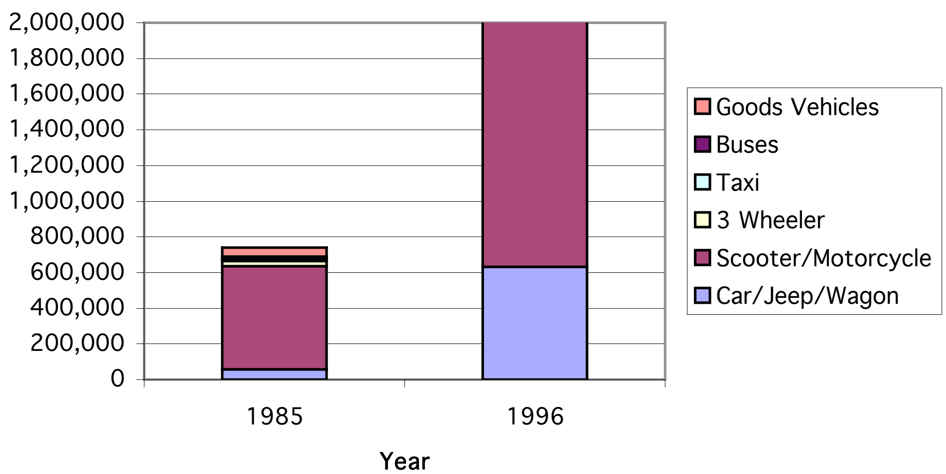
Given the increasing inequalities of incomes in these megacities, the rising demand for vehicles is concentrated among the upper middle and high income segments of the population. The vast majority of the urban population (especially the poorer groups in the peripheral settlements) demand public transport and non-motorized mobility (walking and cycling), and achieve lower levels of mobility and accessibility.

At the same time, the supply of roads and other infrastructure investments and the supply of transit services to meet the rising urban transport demand are handicapped by investment shortfalls deriving from low per capita incomes and savings in these cities. The result is traffic congestion on existing roads and other transport facilities. Congestion in 'stop and go' traffic, in turn, leads to higher levels of vehicular air emissions.

Technical factors underlying air pollution in Asian megacities

Technical factors pertaining to engine characteristics, vehicle age, fuel type used, and maintenance patterns of transport vehicles further increase the level of air emissions for a given level of transport demand. In the industrializing megacities of South and East Asia the greater portion of the motorized vehicles are two-stroke engine motor cycles—reflecting the relatively larger proportion of urbanites who can afford only these cheaper vehicles. In New Delhi, for instance, these two-stroke scooters/motor cycles dominate the motorized vehicle fleet (Figure 3). While the four-cycle internal combustion engines emit HC, CO and NOx, and lows levels of particulates, the overwhelming majority of the two-stroke engines on the road have incomplete combustion and generate particulates disproportionately heavily per vehicle mile traveled (VMT). Trucks and buses using high sulfur diesel also emit (lower levels of CO and HC and high levels of particulate matter. Given the low levels of per capita income, the higher average age of the vehicles, and their poor maintenance patterns further augment these emission levels.

Figure 3. Trend of Vehicular Population Growth in Delhi



Source: Bose and Mesamani, 2001.

Two other factors further increase urban air emissions. First, the motorized vehicles in these low to moderate income megacities do not incorporate advanced fuel efficient technology. The result is greater fuel use, and more urban air emissions for a given level of VMT. Further, fuel components such as lead and sulfur result in harmful emissions of lead and sulfur into the air in these cities. Second, the majority of urban vehicles have embodied in them minimal to low levels of pollution control devices, again increasing the emission load per unit of VMT.

Supply Side Factors Underlying Air Emissions

Large Asian cities such as Kolkata, Mumbai, Bangkok, and Shanghai have dense patterns of settlement largely developed in the pre-auto era, resulting in proportions of urban road space relatively low compared to that in megacities in OECD countries such as Paris and Tokyo (Table 2). Limited investment resources available to expand road supply in the recent decades of explosive motorization have yielded enormous urban congestion in the Asian cities. Because of more limited road space, high levels of congestion are reached in these Asian megacities even at traffic volumes much lower than in Paris and Tokyo. Consequently, Asian megacities register higher emission levels for a given VMT, given the link between congestion and pollution.

Table 2. Road Space as a Percentage of Urbanized Areas

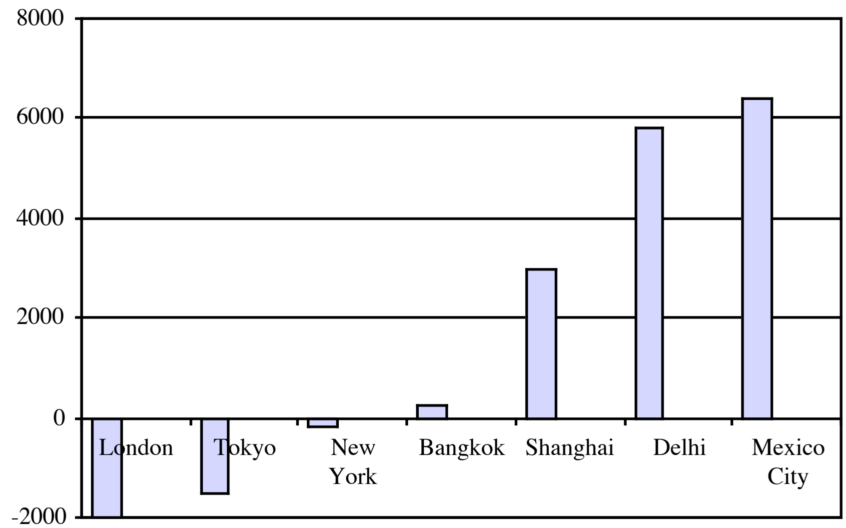
City	Road Space (%)
Developing Countries	
Kolkata (India)	6.4
Shanghai (China)	7.4
Bangkok (Thailand)	11.4
Seoul (S. Korea)	20.0
Delhi (India)	21.0
São Paulo (Brazil)	21.0
Developed Countries	
New York (US)	22.0
London (UK)	23.0
Tokyo (Japan)	24.0
Paris (France)	25.0

THE STATE OF AIR QUALITY IN ASIAN MEGACITIES

As noted in Table 1, the non-Japanese Asian megacities evidence serious suspended particulate problem (exceeding WHO guidelines by more than a factor of three), while the Chinese cities have serious SO_2 problem as well. Emissions of these air pollutants into these densely packed megacities (where a high proportion of urbanites, who walk and cycle, are directly exposed to pollutants) create a variety of adverse effects—inhaleable carcinogenic particles, reduced lung function, destruction of sensitive (human, plant and animal) tissues, all of which lead to many untimely deaths a year.

Indeed, there has been dismal progress in environmental quality over the last decade and rising threats to human health in these Asian megacities. In particular, the damage from the rise in atmospheric concentrations of fine (PM10) particles is rising rapidly. While the damage from PM10 is declining in megacities of industrialized countries such as Tokyo, the trend in premature urban deaths due to atmospheric concentrations of fine PM10 particles is worsening in many Asian megacities (Figure 4).

Figure 4. Change in Number of Premature Deaths Caused by Change in Concentration of PM10 (1980-1990)



Source: Newton and Mannins 2002, p.282.

Viewed from a larger perspective of full health costs imposed by air pollution, Table 3 presents the annual costs of ambient prevailing air pollution levels in excess of WHO guidelines in three Indian megacities—Delhi, Calcutta, and Bombay. The annual costs of premature deaths, hospital and medical attention, and minor sickness for these 3 megacities are in the range of US$ 242-942 million, representing 44% of the national level of national health damages.

Another approach is to estimate the monetary benefits of a policy of reduction of suspended particular matter (SPM) and lead in Bangkok and Jakarta (Table 4). For SPM, medium to upper bound estimates of such a reduction could amount $1 billion in both cities.

Table 3. Annual Costs of Ambient Air Pollution Levels exceeding WHO Guidelines (US million)

Megacity	Costs of Premature Deaths, Hospital and Medical Attention, and Minor Sickness	
Delhi	$US 102 - 398 million	19% of total 36 Indian cities
Calcutta	$US 76 - 302 million	14%
Bombay	$US 64 – 242 million	11%
3 Megacity Total	$US 242 – 942 million	44%

Source: Panwar, Teri India

Table 4. Impacts of a 20% Reduction of Key Pollutants

Megacity	Suspended Particle Matter	Lead
Bangkok	US$ 4 million – $1.6 billion	US$ 300 million - $1.5 billion
Jakarta	US$ 1.2 billion upper limit	-

Source: World Bank, 1992.

STRATEGY OF POLLUTION ABATEMENT IN ASIAN MEGACITIES

In the higher income cities and megacities of North America, Europe and Japan (with a high demand for good air quality), there has been a three decade long experimentation and development of air pollution abatement experience. On the other hand in the lower income megacities of Asia, the demand for pollution abatement is nascent and accompanied by more limited resources. So, the development of pollution abatement strategies must be preceded by a careful analysis of the socioeconomic and institutional context in these cities and what policy challenges and opportunities this context offers.

The Context of Air Pollution Control Policy in Asian Megacites

Challenges

The major challenge for air pollution control policy is the exploding demand for motorized vehicle ownership and VMT in the Asian megacities. The combination of rising VMT, inadequate road space, consequent delays and congestion leads to a vicious cycle of ever worsening pollution. Policies of transportation and pollution control typically developed in this context (presumably formulated by the auto friendly decision making groups) emphasize road expansion (e.g. freeways and flyovers), and parking and other auto friendly initiatives. Predictably, such auto friendly policies induce further traffic growth, congestion, and pollution, defeating such policies in short order.

The widespread auto friendly bias lowers the level of resources available and thus works against the development of strong urban public transit systems which are crucial to the mobility of the majority of the low and moderate income residents in these cities[1]. In some cases, public transportation systems are weakened further by policies instituting such low fares which prevent the recovery of operating and capital costs of transit service. (Which in turn leads to a vicious cycle of deteriorating vehicles, worsening service, dropping transit usage, and further downward spiraling service.

This auto friendly bias lowers the level of resources available and thus works against the development of strong urban public transit systems. The latter public systems are crucial to the mobility of the majority residents in these cities who have low and moderate incomes. Given the per capita income levels and the costs to own and use cars, motorcycles and bicycles in Asian

[1] On the other hand, large Latin American cities such as São Paulo, Critical, Bogotá, etc., however, have more public transit-friendly approaches, with innovative transit policies such as Bus Rapid Transit (BRT) that greatly strengthen urban public transit.

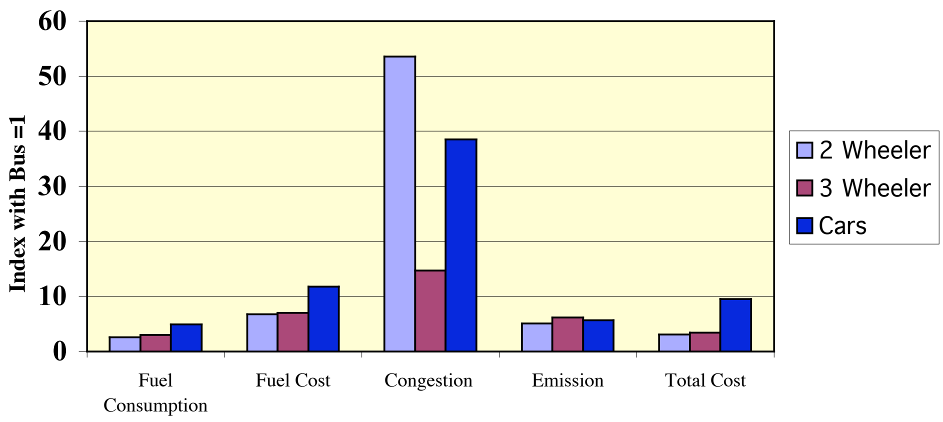
cities (Table 5), clearly cars are within reach of only a minority of residents. Further, a public transport mode such as the bus in Delhi has great advantages over cars and motor cycles in economic, fuel use, congestion and air emissions terms (Figure 5). Thus, for one passenger-kilometer traveled, a 2 wheeler and a car respectively generate (as compared to the bus) 52 times and 15 times more congestion, and 6 and 7 times more air emissions. Clearly, any strategy that promotes and strengthens public transit will be environment-friendly and also serve the mobility needs of the low and moderate income residents. In some cases, public transportation systems are weakened further by policies of such low fares which prevent the recovery of operating and capital costs (which in turn leads to a vicious cycle of deteriorating vehicles, worsening service, dropping transit usage, and further downward spiraling service.)

Table 5. General Costs to Own & Use Vehicles in Asian Cities (US$, 1992 values)

City	Purchase of a New Vehicle (US$)			Annual O & M Expense		
	Bicycle	Motorcycle	Car	Bicycle	Motorcycle	Car
Daka, Bangladesh	61	N/a	n/a	n/a	-	-
Kanpur, India	53	1,200	6,400	15	349	1,000
Shanghai, China	60	2,380	34,000	n/a	-	-
Manila, Philippines	176	1,760	31,300	16	147	1,130

Source: World Bank, 1995

Figure 5. Implications of Alternate Modes Compared with Bus



Another challenge is the poor quality of the transport fuel used, augmenting the SPM and sulfur emissions—requiring the improvement of fuel quality and distribution system.

The final challenge for the industrializing Asian megacities is the limited availability of the scientific and analytical knowledgebase necessary for developing effective anti-pollution policies, and the institutional capacity to implement such policies. In other words, the information and knowledge necessary for pollution policy development pertain to such items as the level of current emissions and air quality, the establishment of emission and air quality standards, and analysis of impacts of pollution control measures. The relevant monitoring and analytical modeling capacity is yet to be developed in full. Once such necessary pollution control knowledgebase is developed over time in the Asian megacities, the capacity to develop and operate institutions and organizations for implementing air pollution policies is also a vital challenge.

Opportunities

If the policy *challenges* noted above are typical of the early stages of development and use of pollution abatement policy in Asian megacities, a number of policy *opportunities* also exist in this situation. First, while auto ownership and use are growing rapidly in these cities, the levels of penetration of car use are still relatively low (as compared with levels in megacities in rich countries). This implies that there are still opportunities in the Asian megacities to prevent the runaway levels of car ownership and use (as in cities like Los Angeles, where there is excessive urban sprawl, congestion, and pollution, and where public transit is greatly disadvantaged). Two such opportunities for pollution control in Asian cities involve:

1) develop a policy of the full cost pricing of private vehicles (where the car user incurs *not only* out of pocket costs of car use *but also* the external costs of auto use such as costs of congestion, pollution, and accidents). Full cost pricing of motor vehicles is a fair policy and has several advantages: lower the growth of urban car use, relative advantaging of public transport systems and,

2) provide time for the development of complementary land use and transport polices which will strengthen markets for public transport systems. Such land use policies which can promote denser urbanization , when accompanied by complementary transport policies can reduce urban sprawl, which in large cities of industrialized countries such as US has led to excessive VMT, energy use, congestion, and pollution.

A combination of policies that ‘get the right prices’ for vehicles and, complementary land use and transport policies can help Asian megacities to develop effective pollution abatement strategies.

Table 6. Potential Policy Instruments for Reducing Vehicular Emissions in Asian Megacities

Reduction Strategy	Technological Approach	Economic Incentives	Management Approach
Lowering VMT (Demand restraint, increasing role of public transport, private vehicle occupancy increases)	Promote bus rapid systems and complementary public transport systems	Road pricing parking pricing, fuel tax; improved bus productivity. Move towards full cost pricing or surrogate taxes. Congestion pricing (area licensing, time of day and electronic pricing). Tax incentives	Parking policies, vehicle use limitation, financing innovations to promote shift to public transport modes; bus priority & HOV lanes
Increasing fuel efficiency	Lower vehicle size and improve engine efficiency, ITS.	Incentives for fuel efficiency.	Promulgate fuel efficiency standards.
Reducing Emissions Rate/Unit of Fuel Use	Improve two stroke technologies and operating systems, promote extra low sulfur diesel; electronic fuel injection; promote CNG.	Higher tax on traditional diesel; differential fuel and vehicle taxation.	I/M programs, vehicle scrappage programs; tighter standards on lubricants and SPM; mandate use of gas, better traffic management.

Potential Policy Instruments for Reducing Vehicular Emissions in Asian Megacities

Table 6 lays out the set of potential policy instruments for vehicle emissions reduction, which respond to the challenges and opportunities outlined above.

The three ways open for reducing vehicular emissions in Asian megacities are:

**lowering vehicle miles traveled (VMT),* through restraining transport demand, through increasing the role of urban public transit and increasing the occupancy of private vehicles,
**increasing fuel efficiency*, so that less fuel is used (with lower pollution) for a given level of VMT,
**reducing the rate of emissions per unit of fuel used.*

To follow each of these approaches, different types of policy instruments are available depending upon one of the following approaches one adopts: a) technological, b) economic incentives, or c) a management approach. It is important to note that urban transport users respond to economic and financial incentives and constraints -- modifying for example their travel demand behavior in the light of such policies as higher prices for parking, fuels, road usage, subsidies to public transport subsidies etc. Typically, megacity environmental quality is likely to improve faster if one pursues policy instruments which work *with, instead of against* existing or proposed economic incentives.

Technological Approach

An example of an application of new technologies to reduce overall urban transport demand and VMT is provided by the recent innovations like the Bus Rapid Transit (BRT) systems in Latin American cities such as Curitiba, São Paulo and Belo Horizante. BRT systems with dedicated lanes and supportive feeder transit systems and land use policies offer high quality transit mobility that increases transit travel and lowers auto VMT—with beneficial effects on air quality. Vehicle fuel efficiency can be increased by improving engine efficiency, lowering vehicle weight and Intelligent Transportation Systems. Technologies that lower the emissions rate per unit of fuel use include improvements of two-stroke motor cycle engines, use of extra low sulfur diesel, use of CNG and electronic injection.

Economic Incentives

Policy instruments which offer incentives for transport user behavior modification appear in the form of changes in prices and taxes that ensure that private vehicle users pay the 'full' costs (including 'external' costs such as congestion, pollution and road damage) incurred. Such policy instruments are aimed at persuading urbanites towards lower automobility, higher public transit use, more convenient non-motorized transport, more fuel efficiency and reduced emissions for unit of fuel used.

Management Approach

Bus priority lanes, High occupancy Vehicle lanes, transport regulatory reform, tight standards for fuels, emissions, vehicle age and vehicle use limitations are examples of management type instruments, which can complement the other two types of instruments noted above.

DELHI: A CASE STUDY OF MEGACITY POLLUTION CONTROL STRATEGY

In Delhi, which in the last three decades has tripled in population and increased fifteen fold in its vehicle fleet has pollution levels exceeding vastly WHO standards (Table 1). With its population expected to exceed 22 million by year 2020, and its vehicle fleet likely to grow faster, the prospects for air quality in this megacity are not promising.

In the late 1990s, the pollution levels in Delhi were multiples of ambient standards set by the Central Pollution Control Board; SPM and CO standards were exceeded 85% of the time (Bose et al., 2001). The legislative and executive branches of government did not respond to the deteriorating air quality situation. The judicial branch (the Supreme Court) heard several environmental lawsuits in this matter – made possible by a constitutional provision that assures a certain quality of life to Indian residents. In response to the Supreme Court Directive, the central government created a Environmental Pollution authority in 1998, with a mission to reduce pollution for the National Capital Region (Bose and Nesamani, 2000).

The strategies recommended by this authority and endorsed by the Supreme Court are:

*Reduce vehicle emissions by setting tighter standards for fuels and auto emissions,
*Establish Inspection and maintenance of in-use vehicles,
*Use clean alternative fuels and,
*Increase public transport service.

These court-sanctioned strategies which guide pollution abatement in Delhi have two characteristics: one, not deriving from the 'give and take' of legislative and executive sector processes, these are 'command and control' directives. Second, the policy instruments in Delhi represent largely a technological approach to pollution abatement—a situation reminiscent of US pollution control experience of depending on technical solutions rather than on changing transport user behavior.

The adoption of increasingly stringent emission standards—close to those in OECD countries—requires use of advanced technologies in a context where enforcement is weak. Table 7 lists the new fuel use standards required of buses, taxis, autos, and motorcycles. Compliance with these directives in a low income country is not only expensive, but may have perverse effects. Buses built locally (at $22.000, or 10% of the prices prevalent in EU or US) turn over faster (Bose et. al, 2001). The capital cost of a CNG bus, however, is 60% higher, even though fuel is less expensive—the initial cost outweighing the fuel savings. Accelerated scrappage of diesel buses and introduction of CNG buses impose additional costs on and weakening the public transit system. This militates against the important anti-pollution directive of strengthening the public transport and drawing users away from autos. Further, the distribution of very low sulfur diesel fuel in a country where price differences encourage fuel dilution poses a problem. However, the Supreme Court directives are being followed in Delhi with some delays and significant reductions in air pollution—with some perverse side effects.

While the technology driven pollution strategy in Delhi offers some pollution relief, the power of market or economic incentives must be harnessed in the future. With appropriate pricing of elements of vehicle use (road, parking, time of day, etc.) future use of public transit and nom-motorized traffic can be increased and personal vehicles travel discouraged, fuel efficiency improved and emissions rate reduced.

Table 7. Technological Approach to Air Quality Control in Delhi (Supreme Court Imposed)

A Technology Approach

Supreme Court Order	Status of Implementation as on July 1, 2001
The number of buses must increase to 10,000 by April 1, 2001 and must operate on CNG	About half of the required 10,000 buses are in service, with over 95% operating on diesel.
All pre-1990 taxis and auto rickshaws must be replaced with new vehicles running on clean fuels by March 31, 2000.	All pre-1990 taxis & auto rickshaws have been removed by the deadline
Local governments must provide financial incentives to replace all post-1990 autos and taxis with new vehicles that operate on CNG or clean fuels by March 21, 2000.	Financial incentives are being offered for new vehicles operating on CNG. 42% of the auto rickshaws and 12% taxis are on CNG.
All buses older than 8 years must be scrapped by April 1, 2000 unless they operate on CNG or other clean fuels. The entire city bus fleet (public & private) must be steadily converted to CNG.	1200 CNG buses are in operation (1171 dedicated CNG buses and 29 retrofitted with CNG kit).
The Gas Authority of India must create a network of 80 CNG refueling stations by March 31, 2000.	73 CNG refueling stations are open (9 mother, 17 online, 39 daughter and 8 daughter booster

CAPACITY BUILDING FOR ASSESSMENT OF POLLUTION CONTROL POLICIES

Delhi and the other megacities of Industrializing Asia, while experiencing rapidly rising pollution levels, are in the early stages of development of pollution abatement policies. The key requirement at this stage for these cities is building capacity for formulation, assessment, selection and implementation of pollution control policies as quickly as possible.

Capacity building for policy assessment and implementation comprises of two parts:

*Acquisition and maintenance of the requisite knowledgebase and,
*Development of the requisite institutions for policy implementation

Knowledgebase Requirements

Policy development requires several types of information and capability to analyze the information to ascertain the scope and seriousness of the pollution problem, formulate alternative policy instruments to address the problems and analytical ability to select the instruments most consistent with the megacity objectives and standards.

The policy development group must establish the current status of urban air emissions and quality: What type and how much of different pollutants are emitted? Are they increasing or decreasing and to what degree? What factors underlie these changes? What health and other costs do they impose on residents?[2] What is the level of emission and ambient air quality standards that need to be established to avoid such damages? What policy instruments can be identified that can meet the regional standards? What analytical models can be developed and used for evaluating and choosing from among these policy instruments?

Specifically, the knowledgebase requirements are:

*Development and operation of Air Quality Monitoring Networks,
*Emission Inventories.
*Establishment of Ambient Air Quality and Emission Standards,
*Establishment of Pollution Control Measures,
*Establishment and use of Stakeholder groups,
*Models of air quality, incorporating congestion, pollution and other costs,
*Measurement of Health Impacts and,
*Policy Simulation Models

To some degree, the various Asian megacities have developed many of these components of the knowledgebase as a one-shot exercise for some base year to support specific plans. However, the essence of policy formulation is as a dynamic and on-going continuous process of monitoring, analyzing and reviewing policies. Thus, not all cities establish quality assurance and control programs after establishing air quality monitoring networks (Han, et. al). Emission Inventories once established must be periodically updated and checked for completeness. Similarly, quality and emission standards must be periodically revised in the light of information and analysis.

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[2] For instance, in Jakarta, Bangkok, and Manila, where the motor vehicle is a major cause of pollution, the social costs from exposure to airborne dust and lead accounted for nearly 10% of average urban incomes in the early 1990s (Han, et. al).

Institutional Capacity Requirements

The success of pollution control policies depends critically on the institutional context in which the policies are implemented. Currently, there is too much fragmentation and overlapping of authority among transport and environmental agencies. In Delhi, there are 12 Federal, state, and local agencies responsible for provision of transport service. When a similar situation prevailed in US transport system in 1960s, there was institutional reform and the creation of integrated land use and transportation agencies—with further integration of transport and environmental agencies in the 1980s. Similar institutional reform is necessary in the Asian megacities as well. Another avenue of change is increasing public participation in the form of instituting stakeholder participation in policy assessment and implementation.

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