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Vehicular Air Pollution: Setting Priorities

South Asia Urban Air Quality Management Briefing Note No. 1

Air pollution is viewed as a serious problem in many cities in South Asia. Many city governments hold transport largely responsible and have adopted, or are considering, technological measures to reduce vehicle emission. This note outlines a framework for the appraisal and selection of appropriate measures in the sector.

A Framework for Policy Appraisal

The first step is to answer a sequence of questions to identify what needs to be targeted.

- Is outdoor air pollution important?
- If so, what are the most serious pollutants?
- Does transport contribute significantly?
- What transport activities do most damage?

Is air pollution important?

The impact of outdoor air pollution on public health and lost productivity should be compared with other threats—including inadequate provision of safe drinking water, inadequate primary health care, and extensive use of dirty cooking fuels in homes. On the basis of comparative assessment of exposure risk and attenuation cost, the cost-effectiveness of policies for outdoor air pollution in saving lives and reducing illnesses should be compared to policies in other areas.

What are the most serious pollutants?

Different pollutants should be ranked according to their toxicity and ambient concentrations. Available data indicate that the pollutants with the most damaging health impacts are fine particulate matter (causing serious respiratory illnesses and premature deaths) throughout South Asia, and airborne lead (which retards intellectual development of children) in Pakistan or Sri Lanka where leaded gasoline is still used.

Does transport contribute significantly?

If outdoor air pollution is found to be serious, the next question is the relative contribution of road traffic to pollution. If it is actually small compared to other sources—such as refuse burning, emissions from informal sector cottage industries, large industrial emission sources—then aggressively targeting vehicle exhaust may not improve air quality much. In this case, the primary focus should be to consider what environmental benefits can be achieved through marginal adjustments to transport policy rather than comprehensive and costly solutions.

A common error is to conclude that transport is the major polluter on the basis of estimates of total pollutants emitted in tons per year. Such calculations reflect the fact that, in terms of weight, carbon monoxide, mostly from gasoline vehicles, dominates in nearly all cities, but ignores the varying toxicity of different pollutants. From a health impact perspective, examining contributions of different emission sources to fine particulate matter (PM) would be more appropriate in South Asia. Emissions inventories typically show that transport is an important but a minority contributor to PM pollution. Emissions inventories must be used with care, however, as some in-depth studies have confounded the conventional wisdom. Identifying sources of pollution is a complex process with major implications for policy decisions. Approaches suitable for South Asian cities will be covered in a separate briefing note.

What transport activities do most damage?

Two sources of particles are especially visible in South Asian cities: heavy-duty diesel vehicles and two stroke engine two- and three-wheelers. In both cases, but particularly in the case of commercial vehicles, age and poor maintenance may concentrate the pollution impact even further.

Common perceptions about mobile sources of particles can be misleading. For example, a recent study in Colorado, USA, showed that gasoline, and not diesel (as suggested by the emissions inventory) vehicles were the primary contributors to particles in the vehicle exhaust category [1]. While detailed analysis of particles conducted in this study is time-consuming and resource-intensive, even rudimentary carbon and other chemical analyses of particles can go a long way to

supplementing an emissions inventory and enhancing our understanding of contributions from different sources. Figure 1 shows the process for such policymaking.

Selecting Policy Instruments

If transport is a significant contributor to urban air pollution, the next step is to evaluate alternative instruments to reduce the impact. Briefly, the issue can be disaggregated in turn into three objectives –

- Fewer vehicle kilometers traveled in total
- Less fuel use per vehicle kilometer traveled
- Less pollution per unit of fuel used.

Table 1 shows some of the key policy options in each category. Three important observations can be made. First, each has both *technical and behavioral components*. Second, most transport users are subject to–and respond to– *strong economic and financial constraints and incentives*. Third, environmental improvement is likely to be more easily achieved by *working with, rather than against, the economic incentives*.

Reducing vehicle movements

In the long run, efforts at reducing emissions must be coupled with decreasing demand for motorized transport. Three main thrusts may be effective.

1. *Increase private vehicle occupancy* by such measures as giving priority to high occupancy vehicles (HOVs) both on the roads and in parking, and developing incentives for ride sharing. Particularly where there are discrete and significant bottlenecks, this approach can have substantial effects on individual travel decisions, and hence on environmental impacts of urban transport.
2. *Increase public transport share*, particularly for the journey to work. This not only reduces total vehicle kilometers, but also enables remaining vehicles to flow more freely, thus reducing emissions per vehicle kilometer. Some technological measures can be helpful–segregated busways, as in Bogota, have been demonstrated to reduce emissions substantially. Priority bus lanes have some, but lesser, impact. Other policies are predominantly administrative. For example, institutional and regulatory reform to create orderly competition for franchises has improved performance and maintained public transport share in many countries.
3. *Restrain use of private vehicles*. Use of private vehicles can be limited administratively (as by the "Day-without-a-car" programs in Mexico City and Bogota). But this may have the adverse side effect of causing people to retain or obtain a second car (often old and polluting) to escape the restraint. It is thus increasingly recognized that such schemes need to be supported by economic measures. An important step is to try to ensure that private

Figure 1. Flow Chart for Evaluating Transport-Related Policy Options

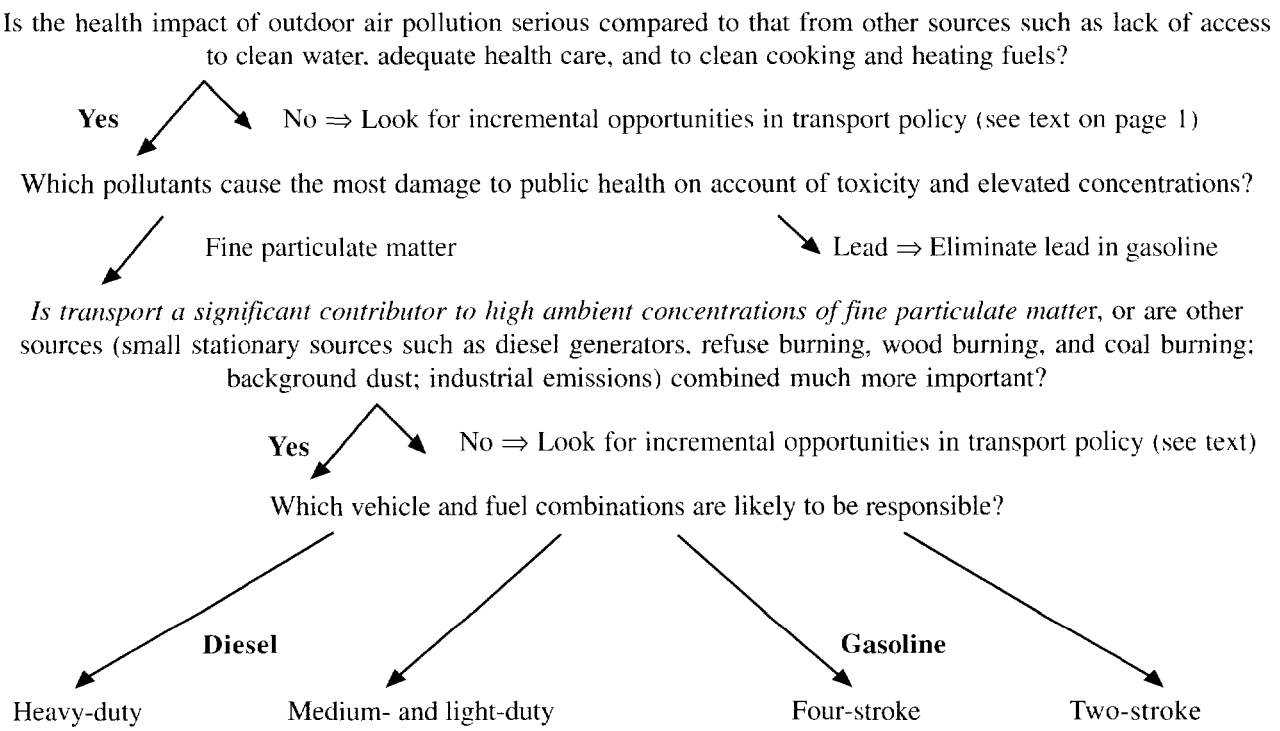

Table 1. A Framework for Selecting Instruments

	Technological	*Administrative*	*Economic*
REDUCING VEHICLE KILOMETERS			
Increase private vehicle occupancy		High occupancy vehicle lanes Parking priority to HOVs Encouraged car sharing	Congestion pricing Tax incentives
Restrain demand		Vehicle use limitation; parking policies	Road pricing, fuel tax, parking pricing; taxing vehicles by distance run
Increase public transport share	Dedicated busways	Bus priorities Public transport regulatory reform	Subsidy to public transport
REDUCING FUEL USED PER VEHICLE KILOMETER			
Improve fuel economy	Increase engine efficiency Reduce vehicle size	Fuel economy standards	Fuel taxation
Encourage NMT	Investment in NMT infrastructure	Protection of NMT in road use	
Improve traffic management	Intelligent traffic system technology		
REDUCING EMISSIONS PER UNIT OF FUEL USED			
Improve fuel quality		Tighter diesel fuel standards Bans on leaded gasoline	Differential taxation
Improve vehicle maintenance		Age restriction on vehicles I/M programs	Differential vehicle taxation and fines
Improve conventional diesel technology	Four stroke; electronic fuel injection; oxidation catalyst (with diesel containing 0.05% sulfur or less)	Tighter emission standards for in-use vehicles Diesel sulfur reduction to enable catalyst adoption	
Improve two- and three-wheeler technology	Higher quality lubricant for two-stroke engine Four-stroke engine Pre-mix fuels for two-strokes	Tighter 2T lubricant standards Ban new two stroke-engines Tighter two/three-wheeler emission standards	Differential taxation
Use alternative fuels	Investment in CNG distribution	Much tighter PM standards Mandate use of gas	Differential fuel and vehicle taxation
Switch to "clean diesel" technology	Ultra-low sulfur fuel (0.005% or less) and particulate trap	Much tighter PM standards	Higher tax on conventional diesel

vehicle users pay fully for all the costs incurred, including pollution, congestion and damage to roads. Although correctly charging for these "external" costs is complicated by their location- and time-specific nature, such charges are already being implemented in cities such as Singapore and Seoul, as well as in some developed countries. South Asian countries could benefit from setting charges for use that reflect costs.

Using less fuel per vehicle kilometer

Fuel taxation is the strongest instrument here. While it may not induce those who have private cars to use public transit[1],

in some developed countries it has discouraged less essential trips, reduced trip lengths and encouraged purchase of higher fuel economy vehicles. Vehicle taxes and annual license fees that are based on pollution characteristics could further be used to prevent over-use of polluting vehicles.

Eliminating impediments to nonmotorized transport (NMT) by providing adequate sidewalks and bicycle lanes, and assuring the safety of pedestrians and cyclists can also deter the use of cars, particularly for the short trips which are on average the most polluting (because of high pollution at start up and at very low speeds).

Generating less pollution per unit of fuel

Many governments see the solution to transport generated air pollution primarily as one of technological clean-up. In some respects this is right. For example, *elimination of lead in gasoline* is an important and effective step that governments can take, both because of the relative ease and low cost with which lead removal can be implemented, and because of the heavy environmental impact of leaded fuel. Bangladesh, India and Nepal are lead-free today.

In South Asia, emphasis tends to be put, rightly, on the reduction of particulate emissions. The policy debate has sometimes focused narrowly on the question of replacing diesel by cleaner alternatives, most notably compressed natural gas (CNG). If a cheap source of natural gas exists (as in northern Bolivia) and a distribution infrastructure for gas exists (as in Argentina) this may indeed be the appropriate policy to pursue. Even so, replacing diesel with natural gas has run into difficulties worldwide because of unfavorable inter-fuel taxation: diesel is not taxed sufficiently, so that CNG cannot compete with diesel in the long run on economic grounds. This presents a serious challenge to the promotion of CNG as a diesel replacement in South Asia. If, in addition, alternative fuels are expensive, the economic cost of conversion can be very high and it may be more cost-effective to concentrate on other dimensions of policy.

The Policy Implications

Three important caveats should be noted about a technology-focused policy, namely:

- *Fuel quality and vehicle technology should be treated together as a system.* Strengthening of fuel specifications and vehicular emission standards should be technically consistent. For example, it does not make sense to mandate oxidation catalysts in diesel vehicles if the level of sulfur in diesel is above 0.05 percent, as sulfate-based particu-late emissions will increase initially and catalysts will be poisoned gradually by sulfur.
- *Adoption of the best available technology is seldom cost-effective* in developing country cities with a large number of poorly maintained vehicles. Upgrading maintenance practices and replacing the worst engines should be considered first before moving on to better technology.
- *Mandating a specific technology or fuel choice* is a move that should not be taken lightly. Cost-effectiveness, and technical, economic and social sustainability should be carefully considered. For example, mandating catalytic converters when gasoline is known to be routinely adulterated with kerosene may lead to short catalyst life.

Institutional and regulatory reform to create orderly competition for franchises has improved performance and maintained public transport share in many countries.

In considering policies, governments should thus look not only at administrative enforcement of technological alternatives but at fuller policy packages. To assist that consideration, this briefing note will be supplemented by further notes on international experience with CNG vehicles; public transport policies to reduce air pollution; taxation instruments; and traffic management to reduce pollution.

Note

[1]The cross elasticity of demand is typically 0.1 or less.

Reference

[1] Watson, J.S., E. Fujita, J.C. Chow, B. Zielinska, L. W. Richards, N. William and D. Dietrich. 1998. *Northern Front Range Air Quality Study Final Report*. June 30, prepared for the Office of the Vice President for Research and Information Technology, Colorado.

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