Synopsis: Constructing an Effective Package of Measures

Adopting a Positive Policy Stance

The transport sector has contributed to the deterioration of air quality in many large cities worldwide. But in a number of industrial country cities, declining air quality has been halted or reversed. Initially that improvement was associated with the elimination of major pollution from stationary sources, phasing out the use of coal in a number of coal-consuming cities, and more recently by addressing air pollution from the transport sector where the introduction of cleaner vehicle and fuel technology has resulted in dramatically lower emissions. Traffic demand management measures, bus priority measures, and the promotion of cycling have also played a role in reducing air pollution in a growing number of cities in both developed and developing countries. In some richer developing country cities the situation is not far removed from the situation of the industrial countries, where the value to society of improving air quality has increased faster than the marginal cost of advanced technologies. In those cities—for example, Santiago—investment in state-of-the-art fuel and vehicle technologies can be a logical and cost-effective step in air quality improvement.

Cost-effectiveness is a key consideration for developing countries as they devise their air quality policies. It should be remembered that only after adopting lower-cost options have industrial countries considered more costly mitigation measures requiring the use of emerging technology. In fact, the significant improvements in reduction in pollution from mobile sources that have allowed most industrial countries to meet the air quality guidelines recommended by the World Health Organization have come through well-established technological and operational strategies that are discussed in this report. The most advanced state-of-the-art technologies are still waiting to be introduced on a large scale even in the high-income industrial countries. Developing countries moving directly to more costly measures for controlling air pollution may simply divert resources from investments that offer greater reduction in environmental pollution or incur significantly more expenses to achieve smaller additional reductions in absolute terms.

The most aggressive and bold actions to control transport-related emissions should be undertaken in those cities with the most serious air quality problems and where the transport sector is a major contributor. However, even where transport’s contribution is not currently high—such as in major coal-consuming countries or in low-income cities with a high percentage of solid fuel use—there is no excuse for taking a resigned attitude to air pollution from mobile sources. It is wise to anticipate the increase in transport emissions that has accompanied economic growth in every municipality worldwide.

Because of the great variety of national situations there is no universally applicable strategy for optimal reduction of transport sector emissions. Rather, it is necessary for decisionmakers to consider policies within their own technical, economic, political, and institutional circumstances.

The policy tools at their disposal can be broadly classified into two types:

- Direct policy tools that specifically target air quality improvement
- Indirect policy tools with objectives other than air quality improvement, but where there are collateral benefits in environmental improve-
ment, economic growth, and long-term poverty reduction.

Direct Policy Tools

Direct policy tools have air quality improvement as their primary objective. Some have very low cost-to-benefit ratios (“low-hanging fruit”), and hence substantial robustness to differences in national situations.

Targeting the greatest dangers to health

The initial targets for action in developing countries should be those pollutants that are known to cause the greatest damage to health:

- **Lead** is strictly a matter of gasoline specification, and the move to ban lead in gasoline is effective. Stopping the addition of lead to gasoline, which can be done at a relatively low cost, instantly stops lead emissions from all gasoline-fueled vehicles, regardless of their age or state of repair.

- **Fine particulate matter** originating especially from diesel-powered vehicles and two-stroke engine two- and three-wheelers, is a serious problem in developing countries.

- **Ozone** precursor control is a high priority in a limited but growing number of cities, often with specific climatic conditions.

Gross polluters

Worldwide, much of the emphasis has been on the emission characteristics of new vehicles. Even in the United States, however, a study found that poorly maintained vehicles, representing 20 percent of all vehicles on the road, contributed about 80 percent of total vehicular emissions (Auto/Oil Air Quality Improvement Research Program 1997). The problem of old and poorly maintained vehicles is even more transparently obvious in most developing countries. Dealing with these requires:

- Efficient identification of target groups (usually old, high mileage trucks and buses)
- Development of instruments for their testing and repair
- In some circumstances, assistance with premature scrapping.

Fuels and fuel standards

The appropriate standards for fuel will depend on country circumstances, including the level of air pollution and the costs of upgrading. But some general guidelines can be stated. The first three steps are expected to have high benefit-to-cost ratios:

- The first priority should be to move to unleaded gasoline while ensuring that benzene and total aromatics do not rise to unacceptable levels.
- Sulfur in gasoline should be lowered to a maximum of 500 wt ppm and preferably lower as soon as possible to enable efficient operation of catalytic converters (following lead removal).
- Where sulfur content in diesel is very high, a strategy to lower it to 500 wt ppm or lower should be identified and implemented. When combined with modern engine technology and good maintenance practice, sulfur reduction to 500 wt ppm would enable significant reductions in particulate emissions. Where moving to 500 wt ppm is very difficult in the near term but lowering sulfur to 2,000–3,000 wt ppm is relatively inexpensive, efforts should be made to move to this level immediately.
- Where the resource and infrastructure conditions for natural gas are favorable and those for clean diesel technology are much less so, consideration may be given to shifting high mileage public transport fleets from diesel to CNG.
- In countries with current or potentially high levels of air pollution from mobile sources, especially those that have already taken steps toward 500 wt ppm, or where new oil refining capacity is being added or major renovations being undertaken, the cost-effectiveness of moving to ultralow sulfur standards should be examined, taking into account maintenance capability and the concomitant investments in the necessary emission control technologies to exploit lower sulfur fuels.
**Vehicles and vehicle standards**

The setting of appropriate standards for vehicles is an essential complement to the determination of fuel standards. General guidelines for setting these standards are listed below. The third and fourth recommendations for motorcycles and catalytic converters are likely to have high benefit-to-cost ratios.

- Emission standards for in-use vehicles should be set at levels that are achievable by a majority of vehicles with good maintenance, and should be tightened over time.
- Vehicle emission standards for new vehicles should be progressively tightened to levels consistent with improving fuel quality.
- All new two-stroke engine motorcycles should be required to meet the same emission standards as four-stroke motorcycles.
- The installation and continued maintenance of catalytic converters should be required for all new gasoline-powered vehicles in countries where lead in gasoline has been eliminated.
- The introduction of particulate filters and other devices to reduce end-of-pipe emissions from diesel vehicles should be considered where ultralow sulfur diesel is available. As filter and other device technology develops and prices fall, and as low-sulfur fuels become more widely available, this strategy will become more robust.

**Inspection and maintenance**

A targeted and effective vehicle inspection program is necessary to make vehicle standards effective. International experience suggests the following advice on establishment of an I/M system:

- Centralized, test-only private sector centers with modern instrumentation, maximum automation, and “blind test” procedures, and subject to independent monitoring are most effective.
- In some circumstances, targeted incentive schemes for scrappage or replacement of high mileage gross polluters may be considered for complementing I/M.
- Education campaigns and clinics should be undertaken to improve two-stroke engine maintenance and lubrication.

**Urban design**

Much suspended particulate matter in developing country cities comes from re-suspension of road dust. This can often be addressed by simple urban designs and landscaping that can be implemented at a small incremental cost in many road projects, bringing significant environmental benefits. Whenever possible, road projects should include provision for paving all sections of the road including sidewalks, and where paving is not practical, landscaping with trees that require no watering.

**Institutional development**

Ensuring that transport and environmental policies are consistent and well integrated requires an appropriate institutional basis. A basis specifically targeting air quality improvement requires:

- An effective air quality monitoring regime be established in large cities, with institutional responsibility clearly assigned and with adequate resources allocated.
- Institutions for administering and enforcing vehicle emission standards be established with a primary task of identifying and removing from the road gross-polluting vehicles.

**Legal sanctions**

Where regulatory measures and fines are insufficient to curb the worst offenders of local air quality, legal sanctions should be developed and implemented to:

- Prevent fuel adulteration and the smuggling of low-quality fuels from neighboring countries. Consideration may be given to hold fuel marketers legally responsible for quality of fuels sold.
- Prevent the import of grossly polluting vehicles.
- Ensure that testing stations are following correct procedures.
Indirect Policy Tools

Some policy measures are indirect policy tools with primary objectives other than air quality improvement, but which can give sizeable collateral air quality benefits. They tend to have long “gestation” periods, but can derail air quality management in the long run if poorly handled.

Sector reform

Many of the measures needed to reduce transport-related air pollution will be suboptimal or ineffective over the longer term without the reform of the transport or fuel sector. The oversupply of bus or taxi fleets, the misallocation of clean fuels such as natural gas, or simply poor quality gasoline and diesel fuel can all be symptoms of market distortions or regulated inefficiencies. Therefore, prior to or in parallel with instituting regulatory and administrative measures for reducing transport-related emissions, cities and countries should ensure that transport and fuel sectors are efficiently (and equivalently) organized. A few examples of where sector reform can produce improvements in air quality are described below:

- Rationalize public and private transport fleets, reduce predatory behavior by paratransit, and ensure that private road users are not disproportionately favored over public transportation. To the extent that traffic congestion is a result of the organization of the transport sector, a city can make major improvements in air quality by improving the efficiency of the sector.
- Reduce direct and indirect subsidies and protection of domestic petroleum refineries and require that they meet increasingly stringent fuel quality standards. Rather than investing large sums of capital in inefficient and unprofitable refineries, the sector should be opened to new entry with the long-term objective of creating an open and competitive market. Allowing imported fuels to compete with domestic refineries is a particularly effective way of forcing efficiency improvement in the sector.
- Establish and enforce transparent and clearly defined regulations. Lack of enforcement is another way of protecting inefficient operators. Rigorous enforcement will also reduce the incentives for smuggling of fuels and fuel adulteration which are a major obstacle to maintaining fuel quality and reducing vehicle emissions in developing countries.

Where prices are controlled by the government, unsustainable subsidies that discourage uptake of cleaner fuels should be phased out. While sector reforms cannot be the sole solution for reducing emissions from mobile sources, the efficiency of the transport and energy sectors must be a concern for environmental policymaking. Some of these reforms, such as import liberalization for clean fuels, will be national in scope, whereas others, such as urban transport sector reform, will be local. In both cases, they are likely to have significant economic and social benefits aside from their environmental benefits, and in this sense should be seen as “no regret” measures.

Appropriate fiscal policies

Fuel taxes should be used to reduce private vehicle use, encourage fuel-efficient vehicles and the use of cleaner fuels, and compensate for road wear and tear and environmental damages. The main implications of this are as follows:

- In many countries this will mean raising taxes on diesel fuel for transport use.
- In addition to fuel taxes, separate vehicle charges should be considered based on vehicle weight, axel-loadings, and annual mileage.
- Direct charges for the use of urban road space should be introduced, including congestion charges.
- Taxes, import duties, and vehicle licensing disincentives should be introduced for polluting vehicles and engines.
- Serious consideration should be given to eliminating subsidies to public off-street parking as well as not permitting free on-street parking, especially where they increase congestion by generating private transport trips to congested locations, or where on-street parking increases congestion by reducing available road space.
Integration in transport planning and management policies

All of the technological improvements need to be set within a favorable transport planning and management policy framework. That framework requires the following:

- Transit-oriented development strategies should be developed to reduce trip lengths and concentrate movements on efficient public transport axial routes.
- Air quality audits of all new major transport infrastructure projects should be undertaken as part of environmental impact assessment procedures to determine if projects will lead to or worsen exceedances of ambient air quality standards.
- Priority should be given to buses in the use of road infrastructure, and particularly the creation of segregated busway systems, in order to improve and sustain environmental standards for buses.
- The efficiency of bus operation should be improved through the design of more efficient route networks, better cost control, and by the creation of incentives for improvement through commercialization and competition.
- Adequate pedestrian and bicycle facilities should be established in order to promote nonmotorized options for short distance trips.
- Protocols for traffic signal system settings should be established and implemented which result in reduced air quality emissions without compromising pedestrian and bicyclist safety.
- Fiscal and/or administrative devices should be implemented for restraining private-car traffic in congested areas, particularly at peak times.
- Competitive bidding for transport franchises should be promoted based on performance-based criteria, including emission characteristics of vehicles.
- Urban traffic management centers should be established, involving police in traffic management system design and training.

A municipal department or agency with comprehensive responsibility for integrated land use and transport planning, including environmental protection issues, should be created.

Political and Technical Consistency

Experience suggests that strategies for reduction of urban air pollution are most likely to be successful where they are internally consistent in a technical sense, and as far as possible consistent with other sector strategies.

Technical consistency

Regardless of what vehicle emission and fuel quality standards are set, they should be technically consistent. The following are a few real world examples where technical consistency has not been followed:

- Mandating catalytic converters for gasoline vehicles in the absence of a reliable supply of unleaded gasoline.
- Mandating oxidation catalysts in buses when diesel available on the market contains relatively high levels of sulfur (significantly exceeding 500 wt ppm), which not only leads to rapid catalyst deactivation but also increases particulate emissions markedly by facilitating the oxidation of sulfur to sulfate while the catalyst is still effective.
- Mandating particulate filters in all diesel vehicles when the sulfur content of diesel sold on the market is in the thousands of wt ppm, incapable of enabling effective operation of the filter.
- Setting the same emission standards for vehicles irrespective of their weight, so that heavy trucks are required to meet the same particulate emission standards in g/km as small passenger cars.
- Failing to establish sufficient refueling capacity before or at the same time as mandating a large-scale conversion to CNG.

An audit on the technical consistency of a strategy, including consideration of upstream (fuel and other infrastructure) and downstream (transport sec-
tor service conditions) interactions is an essential requirement of an urban air quality strategy.

**Avoiding conflict with transport economy**

Ultimately, policies for air quality have to be politically feasible. This means that they have to be seen as not inimical to the interests of those capable of building a political consensus against them. A very common conflict is that with economy of transport. For example, a major source of particulate pollution is likely to be heavy diesel engine trucks and buses. In those circumstances simply forcing higher-cost vehicles on to the formal public transport sector (whether gas or modern diesel) may have the perverse effect of causing that sector to be replaced, legally or illegally, by a fragmented, smaller-vehicle informal sector that may be no less polluting but much more difficult to control. To avoid this, a multi-strand policy is likely to be required. Modernization of fleets through assisted scrappage programs, served by effective inspection programs to identify the appropriate vehicles for replacement, may be effective. International experience has demonstrated that attempts to improve the quality of the public transport fleet are most likely to be effective if undertaken in the context of a thorough reform of regulation of the sector.

**Social acceptability**

An even more difficult conflict arises where existing high levels of personal mobility are constrained in order to reduce air pollution. For example, if pollution arises from privately owned two-stroke engine motorcycles (typical of many Asian cities), the most effective short-term instruments are likely to be programs to improve lubrication behavior. For the medium term, the most effective response would be to tighten emission standards, leading to significant replacement of two-stroke engines by four-stroke engines (as well as introduction of new direct injection two-stroke engine technology). In the very long term, however, this is not likely to be a sustainable solution, because the motorcycles are replaced by motor cars as income rises, and congestion increases. Hence, even in cities such as Hanoi or Ho Chi Minh City in Vietnam, which have high levels of four-stroke engine motorcycle ownership and very high levels of personal mobility, further long-term action will be needed to manage and restrain car use. Such long-term action may call for a broad policy, including traffic management and restraint through parking and other policies, together with public transport development. That would include bus priorities and segregation, or possibly even rail system development in the largest cities. Those types of investment, while environmentally beneficial, will probably also be justified by transport-efficiency considerations.

**“Horses for Courses”**

The policy stance adopted in this report is that strategies need to be adapted to local problems and possibilities. Mostly that impinges on the pace at which state-of-the-art technology can be adopted as incomes increase. But some other characteristics of cities also influence the selection of strategies.

**Cities in fuel-producing countries**

Curiously, cities in fuel-producing countries may face particular difficulties with fuel quality. This is because they may perceive a need to protect the local manufacturers and be tempted to do this by a liberal approach to fuel quality. This is a particular problem in countries with government-owned refineries, where finance ministries may be resistant to the very large investments necessary to improve fuel quality (particularly to bring down sulfur content). They may also resist competition from cleaner imported fuels for balance-of-payments reasons. It is not uncommon to find a politically powerful and connected monopoly state oil company resolutely opposing tightening of fuel standards, even something as straightforward as gasoline lead elimination.

The solution is to set what are considered to be economically and environmentally supportable fuel standards and to open the market to imported as well as domestically refined fuels. But there is no easy path to this solution. What is worth doing, however, is to undertake a study of achieving different levels of standards and to compare costs of imports with those
of domestically refined fuels. If the cost of the former is markedly lower, it is important to understand why and inform the public openly so that benefits and costs of protecting the domestic oil industry can be fully appreciated.

If the country is fortunate enough to have an indigenous supply of natural gas and an existing distribution network, a program of assisted fuel switching to CNG in heavy vehicles may be a consideration. Usually, however, CNG is not markedly cheaper than diesel as a transport fuel, so that the cost-effectiveness of the use of CNG is a major problem. The structure and levels of fuel taxation may also need to be adjusted to give the appropriate incentives to operate gas vehicles without seriously depleting tax revenues or simply generating a replacement of gasoline, rather than diesel, vehicles by natural gas. Even for a country with gas resources and city distribution, such as Colombia, the distribution costs from gas field to market may leave the full distributed cost of gas uncompetitive with that of liquid fuel, so that supporting tax discrimination will still be necessary for large-scale switching from diesel to CNG. The apparent balance-of-payments benefit of using a domestic resource needs to be carefully weighed against the sector efficiency and macroeconomic costs of subsidy to domestic fuel producers.

Cities in vehicle-manufacturing countries

Vehicle-manufacturing capacity is unlikely to cause a country any problem if it is privately owned, subject to competition from imports, and at least in part dependent on exports for its livelihood. In those circumstances vehicle quality is unlikely to be a big problem as companies will need to meet standards that would be acceptable in industrial-country markets. That has been the case in emerging manufacturing countries such as the Republic of Korea. However, it is not unusual in these cases for the auto industry to be pitted against an oil industry that does not want to bear the costs of manufacturing fuels to the higher standard. Government needs to mediate and arrive at a compromise position.

The presence of vehicle-manufacturing capacity may also make vehicle I/M easier to the extent that there is likely to be greater local technical capacity to handle I/M. In non-manufacturing countries all vehicles are imported. The appropriate stance then would seem to be to adopt standards related to those of the source country that can be achieved by properly maintained vehicles. That would to some extent be hampered because local technical expertise in vehicle I/M would likely be lower, making enforcement of standards more difficult.

The greatest danger in developing countries that manufacture vehicles is likely to arise from protective trading policies. There will be a temptation to prescribe, or severely tax, the import of new vehicles competing with those manufactured domestically. At the same time, because of a perceived need for cheaper, secondhand vehicles, in some countries restrictions on the import of used vehicles are likely to be nonexistent or much less stringent. This is likely to have the perverse effect of encouraging the import of older, lower-standard vehicles.

The role of economic philosophy: the command economies

Some of the most severe problems of transport-generated air pollution arise in the command economies and the transition economies. In such economies, formal sector public transport provision, fuel pricing, and vehicle imports tend to be tightly controlled by the government. But the disappearance of the former sources of support for public transport in the transition economies and the increasing difficulty of maintaining it in some of the remaining controlled economies (for example, the central Asian republics of the former Soviet Union) have led to a collapse of the traditional large vehicle public transport services on which the population was primarily dependent to meet its movement needs. Public transport vehicles are not being adequately maintained or replaced, with the effect that those still on the road are highly inefficient and polluting by industrial country standards. The disappearing traditional service tends to be supplemented or replaced by informal sector services operating under inefficient, quasilegal regulatory arrangements, often with inappropriate vehicles. For example, public transport in the secondary cities
of Uzbekistan is increasingly dependent on the seven-seater Daewoo Damas minivan.

Sector reform is crucial in those countries. Indeed, significant progress in urban air quality management is unlikely unless sector reforms are carried out in parallel with imposition and enforcement of emission standards. The agenda for such countries thus appears to be that of leveraging private capital, promoting market-based solutions, and undertaking public education to create market conditions favorable to emissions reductions.

Some special cases?

Some cities will inevitably not be adequately comprehended in this limited taxonomy. For example, many historic cities do not have enough space to carry the traffic volumes generated or to provide segregated public transport systems. For those cities, the experience of some of the European cities such as Zurich may offer the most appropriate model. In that and many other cases, some locations have been closed completely to motorized traffic; in others entry is limited to public transport. The success of some of the European cities in maintaining public transport access in constricted space can be replicated in developing countries if the political will exists to give adequate priority to public transport in the allocation of space.

At the other extreme are cities that have been developed at artificially low densities, such as the cities of apartheid South Africa. On the one hand, these cities present enormous social problems; on the other, they offer the possibility for innovative planning solutions in the process of restructuring land use. Land use planning and the allocation of adequate space for segregated public transport is particularly important to air quality in those cities.

Conclusion

While the specific actions for reducing transport emissions will vary from city to city, there are several underlying principles that this report seeks to emphasize for building an effective policy package:

- Raise awareness among policymakers and the general public about urban air pollution levels and damages and specify and promote the role that transport plays.
- Press for sector reform that increases sector efficiency, benefits society at large by providing goods and services at lower cost, and at the same time reduces emissions.
- Raise awareness in business as well with consumers about business “best practice” that is also likely to bring about environmental benefits to society.
- Work with, not against, the economic incentives of various transport actors.