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Making Urban Transit Systems Sustainable Around the World

Many Birds with One Bus?

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Urban transport in most cities around the world is developing in an unsustainable fashion, as reflected by rapid growth in traffic congestion and air pollution driven by individual motorization. Strengthened bus systems, built on rapid bus corridors, and improved bus technologies could play an important role in putting cities on a more sustainable path. Results and some of the main messages are presented from a recent study at the International Energy Agency, Paris, which has assessed the situation in a number of the largest cities in the developing world, while also drawing on experience from several cities in the developed world. A principal finding is that buses tend to carry a large share of travelers but contribute only a small part of total traffic and pollution. Also, although bus ridership is declining in many cities, new types of bus systems are emerging that offer the potential to reverse these trends and have done so in several cities (e.g., Curitiba, Brazil, and Bogota, Columbia). Advanced bus propulsion systems, that is, fuel cell and hybrid buses running on a variety of fuels, could eventually provide substantial relief from bus-related pollution problems. However, in developing countries, spending scarce funds for cleaning up the emissions from present technologies, along with developing improved bus systems that enhance traffic flow, would provide far more relief in the near-term than spending on a few advanced technology buses. Both paths must be followed, but the latter must not obscure the former. Conditions necessary for bus systems to prosper are discussed and, in conclusion, recent promising developments are highlighted.

Transportation is a backbone of growth in developing economies. But transportation has become a major source of environmental problems as well, as its share of pollutant emissions, energy consumption, and greenhouse gas emissions has grown. Problems are exacerbated by vehicle travel levels that are rapidly outstripping the capabilities of existing infrastructure systems, leading to traffic congestion and even more fuel use and air pollution than would otherwise occur. The problems are particularly acute in the largest cities of the developing world. Swollen populations and high traffic densities with vehicles of all types mean major congestion, slow travel speeds, human exposure to very polluted air, and high rates of morbidity and mortality from traffic accidents (*1*). At the same time, growing incomes lead to mode shifts toward vehicles that add to these problems. Traditional nonmotorized forms of transportation, such as walking and bicycling, give way to motorized transport: first buses, but as incomes grow, increasingly cars and, especially in Asia, motorized two-wheelers. Ironically, then, transportation, which "brings people to people" in cities, also threatens to strangle cities (*2*). The potential role exists for improved transit systems, and especially advanced bus systems, in achieving transport sustainability.

In many developing cities, a large share of all urban passenger transportation activity is already borne by buses. Indeed, in most Organization for Economic Cooperation and Development (OECD) countries in Europe, buses carried as much as half of all traffic in urban areas until the 1950s and 1960s, when they were displaced in part by rail systems such as underground metros, but increasingly by private cars as well (*3*). In many cities at or above middle-income status (e.g., Mexico City, Bangkok), buses and other forms of collective transport are losing shares of trips and travel to individual modes. This evolution is spreading rapidly to even poorer developing cities, with buses in cities like Delhi losing share mainly to motorized two- and three-wheelers. The rate of this evolution, and whether it can be reversed, will depend on several factors, including income growth, the price of automobiles, the pace of population growth, the way cities develop their transport infrastructure (and their land-use development patterns), and, perhaps most importantly, the extent to which bus systems are improved and further developed.

Given the inherently economical (and space-efficient) nature of bus travel, strong efforts to keep bus travel viable and increase its share of trips are warranted and beginning to occur. City authorities around the world have started to ask for efficient, clean, and affordable urban bus transit systems that will maintain or even increase their share of mobility even as incomes grow and cities expand. And this appears to be feasible, if bus systems are reformed and modernized. In fact, a growing number of cities have managed in recent years to significantly increase the share of travel carried by buses. In perhaps the best-known example of Curitiba, Brazil, a large-scale bus system that grew over three decades with the city continues to carry a large share of all traffic, as citizens of that relatively wealthy city simply use their cars less than do other Brazilians of similar income and situation. Several other cities, particularly in South America (such as Bogota, Colombia, and Quito, Equador) are following Curitiba's example and developing strong "bus rapid transit" (BRT) systems.

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tem works so well. In Sao Paulo, busways play a less prominent role overall, but have been developed for several key routes and are integrated with the rail metro, other bus lines, and paratransit (minivan) routes (*8*). Good examples can be found even in North America. In

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Ottawa, Canada, the highly successful BRT consists of three main routes operating on dedicated busways and is linked to an expanding rail network. It is also linked to park-and-ride stations at the fringes of the city (*9*). What makes these systems attractive to riders is their speed and reliability. In Los Angeles, a city that is almost starting from scratch with regard to revitalizing mass transit systems, a recent initiative is based not on dedicated busways, but on a more modest plan to improve bus speeds on existing routes using a signal synchronization system. This system gives buses priority treatment at intersections. These "Rapidbus" routes are also providing new stations with real-time schedules using electronic displays to indicate the timing of the next bus. Although there are no dedicated lanes, this approach has succeeded in raising average speed 15%, attracting more passengers, and even lowering fuel use per kilometer slightly, relative to other buses in the same region of Los Angeles (*10*). Relative to major investments in expanding roadway infrastructure, or developing new rail lines, these measures were undertaken at very low cost. And they were not undertaken in a vacuum; all were part of wider, long-term urban transit and land-use strategies.

Compared with underground metros or surface light rail transit, advance bus systems have the disadvantages of taking road space and contributing to local air pollution. But they have the advantages of flexibility and very low cost (in dollars per unit of capacity or passengers carried per year) and can in some instances provide superior service to rail (in part because they can be accessed by users more quickly and easily than rail systems, especially overhead and underground systems) (*3*, *11*). Bus systems can be built and improved quickly and modified if necessary at relatively low cost. Further, although a well-designed rail system can carry a larger number of passengers along a corridor quickly and remove travelers from the roadway network, this often takes many passengers off of existing bus systems, and mainly frees road space for . . . more cars. Certainly there is room in most transport systems for contributions from more than one transit mode, but buses appear to be an appropriate "backbone" for the transit systems in most cities, especially poorer cities in the developing world.

The potential for revitalizing bus systems is hampered by a number of factors. At the top of the list is the manner in which bus systems are managed and the way individual bus routes and buses themselves are regulated. Serious problems in these areas prevent buses in many cities from providing efficient service as well as from producing significant revenues; this in turn represents a major hurdle in the viability of improving the technology and operation of buses themselves. Although the manner in which bus services are organized, managed, and licensed varies considerably from city to city, a number of problems are commonplace, as discussed below. A second major issue is that buses are too often stuck in traffic. The sustainability of bus systems is dependent on bus speeds both from the point of view of providing a service that encourages ridership and from the point of view of raising revenues—slow bus speeds reduce the total kilometers, and therefore passenger loadings, that a bus can achieve each day.

As a result of the lack of revenues available to pay for better buses, many cities are dominated by older, poorly maintained buses with little or no pollution control; they are typically outmoded vehicles often converted from truck frames or bought used from developed countries. Budgets available for upgrading these buses or replacing them, or even replacing worn parts, are often tiny. Poor fuel quality—usually very high sulfur diesel fuel—combined with poor engines means most buses in the developing world are major sources of particular matter and oxides of nitrogen emissions, and therefore of ozone (smog) as well (although they are often not such gross polluters per passenger kilometer traveled as are cars).

As a result, buses are often seen as a major part of the problem, not part of the solution. In part this may be because looking at buses without considering the number of people that they move, but in any case it is clear that to be seen as part of the solution, buses must be made cleaner and faster, that is, they must become a more attractive choice for riders.

To meet this challenge, the International Energy Agency (IEA) recently undertook a 1-year study to examine technological and system-oriented options to provide clean and efficient public transit in large developing cities around the world. The project involved working directly with leading authorities in cities in Asia and Latin America and focused both on bus transit and the environment in which buses operate. A number of areas of potential improvement were assessed: adoption of advanced technology and alternative fuel buses, improved bus transit operations and regulation, and physical improvements to systems, such as dedicated bus lanes. The advanced bus technologies that were considered included fuel cell and hybrid-electric propulsion systems, compressed natural gas (CNG) and other alternative fuels for buses, and clean diesel technologies. Some of the key findings of the project are reviewed; a full-length IEA report on the project is also available (*12*). Although the project focused nominally on bus systems, we were drawn to the broader issues of transport activity and emissions in each region, as reviewed next.

ASIF EQUATION: THE BASIC TOOL FOR ANALYSIS

To develop sensible, sustainable plans and policies in transport, it is first necessary to understand where one stands and where one is heading. This issue—keeping score on transportation and environment—is not simply one of counting accurately (bottom-up statistics). It also rests on untangling the components of changes in underlying transport activity, fuel mix, and overall emissions over time and across the population and the vehicles they use (top-down decomposition). This approach is similar to those used for estimating the contribution of traffic and transport to pollution (*13*). Such a decomposition is vital for measuring progress in taming the major problems related to traffic volume and emissions, particularly in cities in which the overall growth in vehicle numbers and use swamps other effects. The same approach is useful both for allocating political credit for success and for fixing blame and fixing the problem when a policy or technology does not yield the intended benefits.

For these reasons, the IEA developed the ASIF equation (Activity, Structure, Intensity, Fuel mix) to cover transport effects in a more general (and thus complete) way (*14*, *15*).

$$G = A * S_i * I_i * F_{i,j} \tag{1}$$

where

G = emission of any pollutant summed over sources (modes) i;
A = total travel activity, in passenger kilometers (or ton-km for freight), across all modes;
S = conversion from total passenger (or freight) travel to vehicle travel by mode;
I = energy intensity of each mode (in fuel/passenger or tonne-km) and is related to the inverse of the actual efficiency of the vehicle, but it also depends on vehicle weight, power, and of course driver behavior and traffic; and

F = pollutant emissions intensity of fuel type j in mode i (which could be measured per unit fuel consumption, as appropriate for carbon, or per kilometer, which is more appropriate for regulated emissions). Figure 1 schematically illustrates this relationship and introduces other factors that affect the basic ASIF parameters.

What matters for transport and environment is that each of these components be included in measures aimed at improving sustainability. Increasing bus travel share (and load factors in buses) reduces fuel use per passenger kilometer and (if at least some passengers switch from motorized vehicles), induces an overall modal shift toward less fuel-intensive modes. Of course, not all components respond the same to a given stimulus, say a fuel tax increase or a kilometer road-use fee. And not all actors, that is, vehicle operators, travelers, or shippers, will respond to the same stimuli in the same way, either. Each component (and not simply those related to fuel) affects emissions, too. For example, congestion increases emissions, as do short trips in motor vehicles taken with cold engines. If some car trips are replaced by less energy-intensive modes or nonmotorized transport, the savings are more than proportional to the kilometer not taken by car.

Modes are linked as well: provision of bike lanes and safe cycle storage encourages cycling to collective transit nodes (bike and ride); measures to give buses or cycles priority lanes often take road or parking space from cars, which discourages car use, and so forth. ASIF helps remind analysts of some of these linkages. In the end, ASIF is only an identity, but it has a powerful ability to identify underlying factors and rates of change.

TALE OF TWO CITIES: BANGALORE AND MEXICO CITY

The examples that follow (Figures 2 and 3) are taken from Mexico City and Bangalore, India. They show the contribution of different motorized modes to traffic, travel, and several kinds of air pollution. By putting these into an ASIF matrix, however, unlikely combinations of estimates are easily identified if they give unrealistically high distances per year (say 200 000 km/car/year), far too much fuel

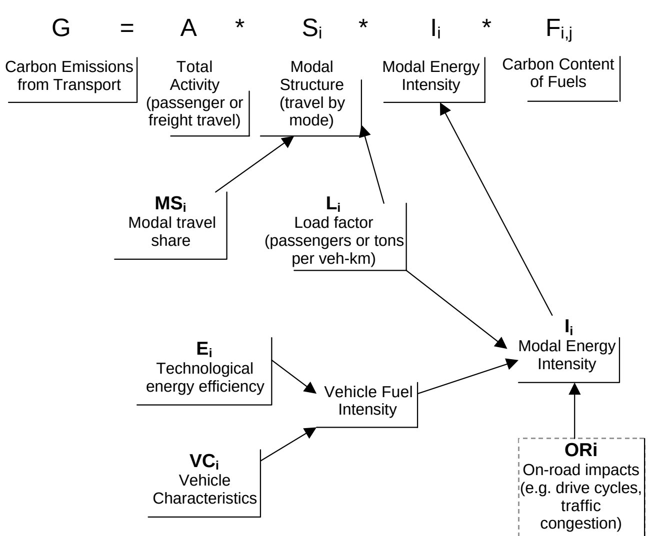

FIGURE 1 The ASIF equation in two dimensions (carbon dioxide case).

consumed, or very high or low specific emissions coefficients when vehicle activity is compared with estimates of total emissions. Certainly there are many uncertainties, particularly the distances each vehicle moves in a year and even local fuel sales. But as a first-order estimate of key parameters of traffic, transport, and pollution, the figures and the estimates behind them are very useful. Data for other cities are provided in the full IEA Sustainable Urban Transport Project report (*12*) as well as in other sources (*3*, *6*).

Although there are some differences, there are also interesting similarities between these two cities. "Paratransit" exists in both Mexico City and Bangalore, in the form of small buses and vans independently owned and operated, often by very small businesses. These account for a large and growing share of travel in Mexico City, which is lower in Bangalore. Since they are less space efficient than large buses, they produce more pollution and congestion than buses. But air pollution and overall traffic are still dominated by private vehicles, automobiles in Mexico City and two- and three-wheelers in Bangalore. If buses and *colectivos* are counted together, their share of 40% of traffic in Mexico is much less than the corresponding share in Bangalore of 60%. Private vehicle ownership is much higher in Mexico than in Bangalore, and this is what accounts for most of the difference. Average income is much higher in Mexico than in Bangalore. Given the clear link between income and car use and ownership (*15*), it is not surprising that Mexico City has a higher share of car travel. Normalizing by approximate populations (6.0 million for Bangalore, 13 million for Mexico City) gives approximately 6700 pass-km/year traveled in Bangalore and about 10 000 in Mexico City; the figures for cars and two-wheelers are 700 and 2300 pass-km/year, respectively. This increase of more than a factor of four illustrates how automobile ownership and use increases sharply with incomes, again, at the expense of the collective share of travel. But the high level of bus travel in Bangalore is surprising, and may reflect long work trips into the city of those actually residing outside of Bangalore.

Other cities in Latin America (Rio de Janeiro, Sao Paulo, and Buenos Aires) face the domination of the automobile illustrated by Mexico City, whereas those of lower-income Asia (Delhi and Dhaka) resemble Bangalore, with the domination of two-wheelers. Higher-income cities in Asia (Bangkok and Jakarta) have begun to show an increased influence on cars (*16*). In every case, large buses account for only a modest share of the vehicle population but carry a much larger share of passenger travel and are very low polluting per passenger kilometer. Thus, although cleaning up buses is important for reducing air pollution, getting riders out of cars or two-wheelers and on to buses (or preventing shifts in the other direction) could have a far greater affect on both air pollution and congestion.

This rough comparison is meant neither to absolve nor implicate buses in any part of the pollution picture. Rather, it illustrates the importance of using ASIF to see the context in all four dimensions—total mobility, mode (or vehicle type), vehicle technology, and fuel. Tracking all of the "data" shown in these tables as well as the specific emissions coefficients (g/km, etc.) is important for moving resources to technologies and policies that will bring the greatest reductions in congestion and pollution from a baseline.

KEY AREAS OF ATTENTION FOR IMPROVING BUS SYSTEMS

The recent successes of Bogota's Transmileneo system, as well as steady progress in a number of cities in developing and developed countries, suggest buses can play a key role in providing clean

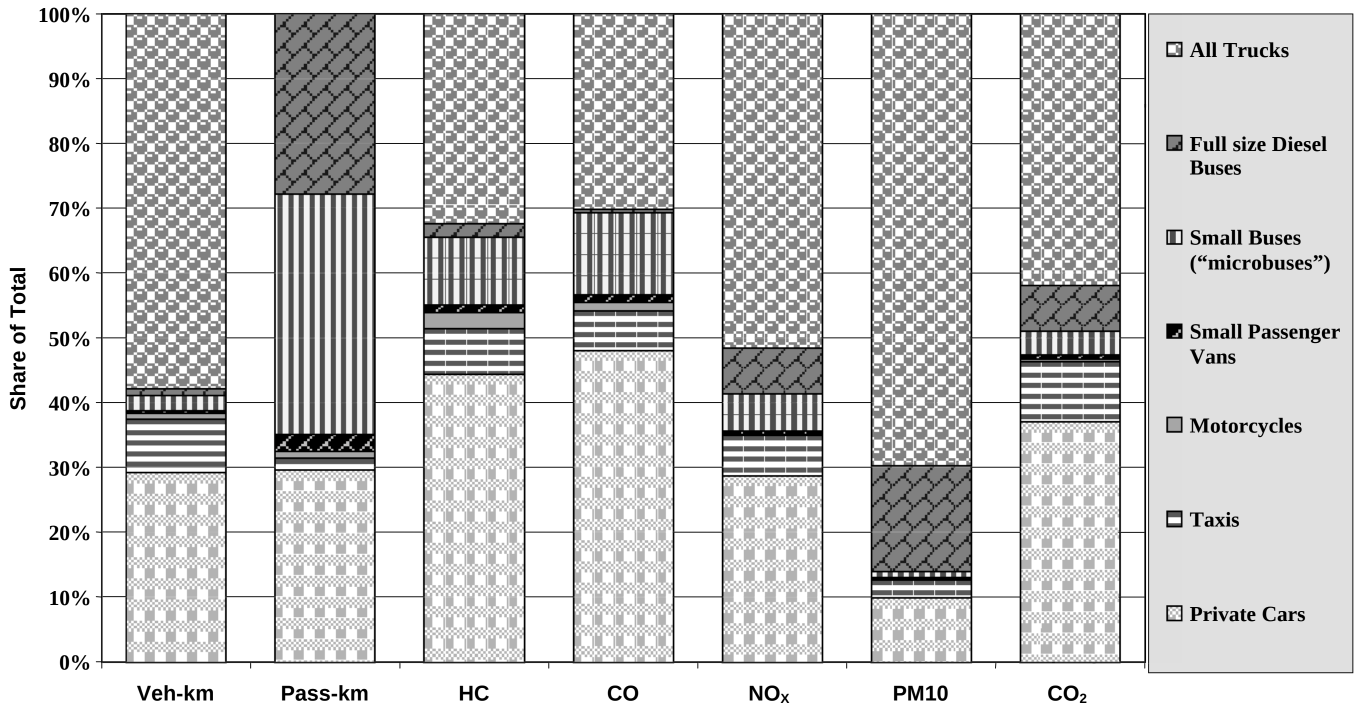

FIGURE 2 Traffic, travel, and emissions shares for Mexico City in 1998 (source: Mexico City Ministry of Environment; Global Emission Model for Integrated Systems) (PM10 = particle size ~ 10 microns).

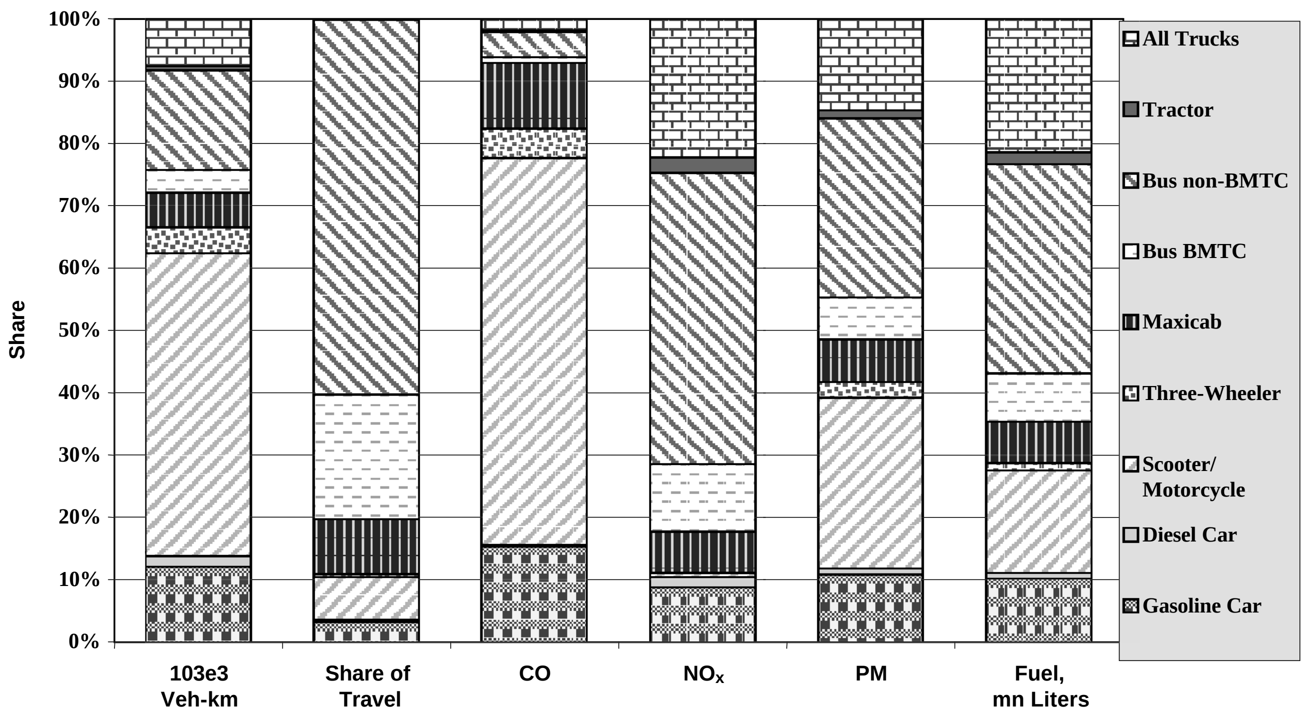

FIGURE 3 Traffic, travel, and emissions shares for Bangalore, India, in 2000 (source: Swedish International Development Agency, Report on Bangalore, Dec. 2000) (PM = particulate matter, mn = million, BMTC = Bangalore Municipal Transport Corporation).

access in cities while improving transportation and air quality overall (*17*, *18*). The findings of the IEA project in this regard include the following key areas of attention:

- Cities must take a long-range, systematic approach, including strengthening transit system governance. Any urban transit bus development plan must be part of a systematic or comprehensive plan in order to succeed. The plan must include a long-range vision of where both the region and its transportation system are headed, and how the direction might be changed. Issues of governance and transport system management (including regulation and licensing of bus companies) are as important as technical issues. The various policies affecting transport must be harmonized so that they work together, for example, to encourage use of mass transit, make access to transit easy for pedestrians and cyclists, and discourage single-occupant car travel. Improving integration of transport and land-use planning is also very important. Improvements in single or isolated elements of a transit system or transport plan rarely have strong effects, whereas the systematic approach allows synergies to strengthen the system and improve transportation.
- Each additional bus can provide large benefits. Regardless of whether a bus is "clean" or "dirty," if it is reasonably full it is displacing anywhere from 10 to 40 other motorized vehicles (including two-wheelers as well as cars; in some cities the primary displacement is of two-wheelers). The fuel savings, carbon dioxide reductions, and pollutant reductions of such displacements are relatively large; our scenario analysis suggests that, especially in developing cities, they can be much larger than the potential benefits of making a fuel or technology upgrade to the bus itself (*12*). Thus, getting more buses on the road, speeding them up, and getting more riders onto buses (mainly by offering a service that riders want) is the best strategy for providing efficient, sustainable transportation systems.
- Transit system improvements go hand in hand with bus technology improvements. For bus companies to justify the expense of moving to advanced technology, or even be EURO-2 compliant, these buses must earn considerably higher revenues than do the current buses. Revenues can be increased three ways: fuller buses (carrying more passengers per kilometer), faster buses (more kilometers and passenger boardings per day), and higher fares. The first of these requires system improvements and policies that promote transit (like fuel pricing). The second can benefit from both system improvements (such as dedicated bus lanes) and from better buses (newer technologies with better engines can help improve acceleration and average speeds). The third of these methods to increase revenue, higher fares, may be possible once actions taken on both the system side and bus side sufficiently improve the quality of the bus experience for riders. This includes faster travel, safer and more comfortable rides, and greater reliability and predictability. Thus improvements to the "system" side of the equation help lead the way to better buses.
- Bus system regulation and licensing need reform. In many developing cities, most buses are run by independent bus companies. In some cities private companies have grown up to fill vacuums created by the inability of public bus systems to provide adequate service. There are often many independent bus providers, often quite small, surviving on a day-to-day basis. These companies are not able to make major investments in buses or bus systems. Companies often compete to provide service on the same routes, resulting in low bus-load factors, poor service for customers, and general chaos on the streets. The major overhauls in the approach to bus licensing taken in cities like Bogota, as part of their BRT system development, have proved critical in the shift to the provision of high-quality bus services.
- Increasing bus speeds is a high priority. The opportunity to increase bus travel speeds and thus move more people farther each day is probably the most important improvement that can be made to many bus systems, since it increases both revenues and the overall efficiency of the system. It can contribute to raising revenues two ways—first, by simply allowing the bus to run the length of the route more often per day, and second, by improving the level of service and attracting more riders to the system. Increasing fares, in contrast, may have the opposite effect on the level of ridership. However, there is strong evidence that wealthier individuals are willing to pay considerably extra for "premium" levels of bus service, such as the guarantee of a seat, air conditioning, and reliable service. Even the poorest of cities (e.g., Dhaka) has a large population of middle-class residents capable of affording premium service. In fact, Dhaka has a premium service (featuring air conditioning and guaranteeing a seat) on two routes with fares several times that of regular buses.

With regard to the effect of bus speeds on revenue, Table 1 provides some indicative parameters on different bus speeds and ridership levels and the effect on the revenue generated by a typical bus in South Asia, reflecting typical bus speeds and fare prices in a city like Delhi. A comparison is also shown with a "typical" bus in an OECD country (real values, of course, vary considerably and data on the actual averages are quite poor). This table shows that the revenue generated by a bus in South Asia is likely to be much lower than in the OECD,

TABLE 1 Indicative Bus Operating Characteristics and Revenues, South Asia Versus OECD

	South Asia Current	South Asia Improved	OECD Current
Fare ($ / boarding)	10¢	10¢	$1.00
Average number of riders	40	60	25
Average boardings / km	10	15	5
Average speed km / hr	8	16	16
Distance km / day	150	300	300
Daily revenues per bus	$150	$450	$1,500
Annual revenues per bus	$54,000	$162,000	$540,000

NOTE: Sources for data vary, but the assumptions for fare, average ridership and speed are indicative assumptions used to demonstrate the point; distance per day, daily revenues, and annual revenues are calculated based on these assumptions.

mainly because fares are much lower—perhaps only one-tenth as high. It also shows that this revenue could be tripled by increasing bus speeds substantially and increasing the average number of passengers carried on each bus.

To increase bus speeds and improve bus systems in general, the role of developing BRT systems is central.

- Development of demonstration BRT corridors appears to be an important step. In many developing cities the task of modernizing bus systems and increasing ridership is daunting. Part of the problem is knowing where to begin and what to do. Pilot or demonstration projects that focus on a single bus corridor help deal with both of these issues. They allow testing and fine-tuning of a different approach to delivering bus services and create the "seed" that can later grow into a fully established system of BRT routes. Demonstration projects typically include dedicated bus lanes, improved infrastructure such as bus stops and terminals, and (often very importantly) a new system of regulating and licensing bus services on the route. They can also offer a showcase for advanced technology (or just new and modern) buses.
- Fully developing one or two BRT systems on each continent should be a goal. The concept of bus travel that begins to look and feel like rail travel, and that provides comparable or even superior service to rail (not to mention compared with other modes) is catching on fast in cities around Latin America but is still virtually unknown in other parts of the world. By developing at least one successful system in each region, other cities (and mayors) in that region are likely to also want this type of system. Once BRT systems are seen as an urban, and political, asset, they are likely to spread rapidly around each region.

On the technology side there are also important steps:

- Advanced bus system technologies appear cost-effective. A key to developing successful bus systems is to make bus travel attractive. Although obvious, this has been achieved in very few places. However, there are a number of recent innovations that may allow systems all over the world to quickly improve. Dedicated bus lanes give buses important speed advantages over other traffic modes. But other technologies, such as global positioning systems to track bus position and relay this information to travelers in real time, and advanced signal systems that give buses an "early green" or "long green" at intersections, are nearly commercial and hold the promise for major near-term benefits in cities all over the world. This may be a case where technology "leapfrogging" makes good sense.
- Buses can be cleaned up significantly with some simple steps. Although many advanced technologies are being developed, the simplest and probably most cost-effective measures can be taken with existing buses. These include proper vehicle maintenance (engine tuning and optimization for low fuel consumption and low emissions), periodic engine overhauls, use of low-sulfur fuels with basic emissions control equipment (diesel fuel in many countries currently has in excess of 1,000 parts per million of sulfur—bringing this level down even to 500 would make a big difference in particulate matter emissions and allow the use of oxidation catalysts). Ensuring that bus operators take these steps is the challenge and requires a strong commitment on the part of governments with regard to setting, and enforcing, rules.
- Advanced propulsion and fuel technologies are becoming available but are expensive. The most advanced propulsion technologies (fuel cell buses, even hybrids) are too expensive today for most developing countries, but cities can begin to move up the "technology ladder" toward these technologies. A variety of lower-cost strategies to clean up buses includes switching to very low-sulfur diesel fuel, adding (improved, or in some cases any) exhaust gas after-treatment systems, and better maintenance. These could reduce emissions significantly over the next few years, as the prices of the more advanced technologies fall. Buses produced in less developed countries that meet EURO-2 or even EURO-4 emissions standards together with cleaner fuels and in some cases retrofitted pollution controls (or diesel emulsions) are probably within the financial reach of major cities in Asia and Latin America. Whether cities choose to clean up diesels or switch to an alternative fuel such as CNG, the costs are not zero—but the benefits are great when these first steps are taken.
- Decisions with regard to clean and alternative fuels [such as ultra-low sulfur diesel (ULSD), CNG, liquid petroleum gas (LPG), or dimethyl-ester (DME)] should take into account emissions effects—but also energy supply, cost, and infrastructure considerations. For good reasons, decisions with regard to alternative fuels often get made on the basis of energy, rather than strictly environmental, considerations. Important aspects in any city are the national availability and supply of different fuels, local fuel distribution infrastructure, and relative fuel prices. Even in pursuing a path toward cleaner diesel buses, a major question is the availability and cost of ULSD fuel from domestic refineries or imported. In undertaking any clean or alternative fuels initiative, cities must be sensitive to these considerations. It will also be important for cities to determine whether they want to embark now down a particular path toward "next generation" buses, such as fuel cells (see next paragraph of bulleted information) which may require CNG or other alternative fuel or feedstock, such as LPG or DME.
- Field tests of options, and data collection, are imperative. Perhaps the greatest need today is field testing of buses and fuels. Using antiquated emissions models from one city (with one kind of fuel specification) to simulate emissions in another is unsatisfactory. Ignoring local fuel and road conditions, driver training and behavior, real passenger loads, and so forth leads to results that have little resemblance to real emissions or measures of durability. Given the wide uncertainty in system costs noted above, it is important to pin down the system benefits. This is particularly true when the challengers are either very ULSD or CNG—requiring major irreversible investments in infrastructure to fully develop.

CONCLUSIONS: A PROMISING OUTLOOK

The development of a strong bus system in Curitiba during the 1980s and 1990s led the way for similar projects around Latin America. Mayors, such as Enrique Peñelosa of Bogota, saw how such a system could be implemented in their own (typically much poorer) cities, and BRT projects are now underway in cities like Quito, Porto Allegre, and even Cuenca, Colombia's "second city" (*17*). Even Mexico City, one of the largest and dirtiest cities in the world, recently began developing its own advanced bus system. These recent developments have made it clear that much-improved transit systems can be implemented around the world, and at least slow the growth in the shift toward private vehicles, if not actually reverse this trend. Developing cities have the advantage of possessing still relatively undeveloped roadway infrastructure, making a shift in direction much easier than it would be in most developed cities. But so far the spread of systems has pretty much been restricted to Latin America; it is imperative that success stories are achieved on each continent in the near future, to raise awareness of the possibilities and, hopefully, spur the spread of such systems, much as Curitiba did for Latin America.

In a more general sense, developing cities have begun to take significant actions to draw the line on emissions and traffic congestion.

Both through well-publicized collaboratives among national and local stakeholders (such as the World Bank's Clean Air Initiative) and in less publicized efforts to adopt clean fuels and engines, city leaders have begun to implement promising programs to fight the difficult transportation problems. A wide recognition has arisen that the problems are multifaceted and need coordinated solutions, including technical aspects (engines, fuels, and vehicle designs), system aspects (improvements in transit owner–operator and financial structures, licensing reform, route system development, scheduling, route infrastructure, and urban planning), and political (coordination of government agency efforts, overcoming resistance to change from entrenched stakeholders such as bus operators, vehicle producers, fuel providers, etc.). All these trends bode well for major transport system reforms around the world in coming years.

With regard to moving toward cleaner vehicle technologies, there are also some promising developments, particularly in three areas. First, demands for cleaner fuels in Japan, North America, and Europe have provoked oil companies into making cleaner diesel fuel, an effort that can be replicated in developing countries. Second, bus manufacturers have been developing new bus designs that are both much cleaner and more efficient than even 10 years ago. Even relatively low-tech diesel buses can now be outfitted with catalytic particulate traps that may be affordable in cities around the world. Finally, demonstration versions of inherently cleaner and more efficient propulsion systems, such as diesel/electric hybrids and fuel cell systems, are now being tested in IEA countries and in a few developing countries, such as Brazil. Thus overall the outlook is bright—but strong supporting actions are needed to help these cities move ahead over the next few years, if a transition to more sustainable transport systems is to become a global reality.

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