

International Union of Air Pollution Prevention and Environmental Protection Association
Integrated Program on Urban, Regional and Global Air Pollution
JOINT SEMINAR

SUMMARY REPORT

REDUCING THE IMPACT OF VEHICLES ON AIR AND ENVIRONMENTAL QUALITY IN CITIES

**Hotel Royal Pedregal, Mexico City
January 22 – 23, 2004**

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Richard Mills and Luisa T. Molina

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Session 1: Introduction

1.1. Welcome

Menachem Luria (Hebrew University of Jerusalem)

The International Union of Air Pollution Prevention and Environmental Protection Associations, founded in 1964, represents environmental protection specialists across the private, public and voluntary sectors in over 35 countries throughout the world. We realize that many of the major environmental issues, such as ozone depletion and climate change, are too big for IUAPPA, and are handled by larger and more powerful international organizations. Therefore, IUAPPA has decided to focus on issues often neglected by these other organizations, issues such as urban air pollution, transport, and other problems in megacities. In Lima, Sao Paulo, and other cities, local organizations are addressing these issues and have generated public enthusiasm and awareness through educational programs.

We are working in places where the air pollution problems are most severe but not necessarily where there is the most information, e.g., Cairo, Mexico City and Istanbul. . We are grateful to groups like the one led by Mario and Luisa Molina, whose work addresses these difficult problems in these cities. We are also grateful to Luisa and Mario Molina for organizing this workshop and we hope to continue working with them in the future. We would also like to thank all of the international participants, and the General Director of IUAPPA, Richard Mills, who helped bring this all together. We will be meeting in London in August at the 13th World Clean Air Congress, and we hope to see you there.

1.2. Introduction

Richard Mills (IUAPPA)

This meeting fits well into the upcoming World Clean Air Congress, where one of the main sub-themes is megacities. At this week's meeting, we need to see if we can discern and identify the key issues and themes that should be highlighted in the World Congress in August, which provides a forum for environmental protection specialists in both industrialized and newly industrializing countries to exchange information, and to learn from each other.

If there is one thing that is common to megacities, it is the issue of transportation. We chose to focus on transportation at this meeting because of its strong link to air quality and because it remains a major and growing issues in many megacities. By comparing and contrasting

experiences we want to draw out broad lessons and future priorities so that this World conference can be a positive way to push forward the policy debate. Nevertheless, we must remain very sensitive to the fact that every locality will be different and requires its own unique mix of policies. But we also know that there are some important similarities. We need to find the common ground to see which of those key elements can be transferred internationally.

1.3. The Mexico City Air Quality Case Study ***Mario Molina (Massachusetts Institute of Technology)***

Air quality is a global problem as important as other global issues such as climate change and ozone depletion, particularly in the developing world. Air quality is critical in megacities because of the health effects, but there is also a tight link between air quality and global climate change, as can be appreciated, for example, when we consider the impact of atmospheric particles. We have to consider all of these problems together, not losing sight that there are very strong connections, not only in the science, but in the policy realm as well.

For several years MIT has headed a research team studying air quality in the Mexico City Metropolitan Area (MCMA). The topography and meteorology of the MCMA contribute substantially to the problem of air pollution. Mexico City is at 2.2 km above sea level, surrounded by mountains, with a metropolitan population that estimated to be between 18 and 20 million people. In recent decades, population has increased dramatically, and so has the population of vehicles. The mountains, together with frequent thermal inversions, trap pollutants within the MCMA basin. The high elevation and intense sunlight also contribute to photochemical processes that drive the formation of ozone and other pollutants. Satellite pictures clearly show not only the smog in the Mexico City basin, but also the outflow to the north. In the early 1990s, Mexico City was labeled as the world's most polluted city; its situation was similar to that experienced in Los Angeles in the 1960s.

However, significant progress has been achieved. In the 1990s, there were successful reductions in the concentrations of some pollutants such as lead, carbon monoxide and sulfur dioxide. Comprehensive air quality management programs were developed and implemented. The monitoring and evaluation of air pollution were improved. The government strengthened and began to enforce a vehicle inspection and maintenance program. Lead was removed from gasoline in the early 1990s; sulfur concentrations were also reduced substantially. Natural gas in industry and the power sector replaced fuel oil. Reductions in carbon monoxide were achieved by the difficult and relatively expensive step of improving emissions control technology, specifically catalytic converters. These first improvements, although difficult to achieve, lead to major reductions in concentrations of these primary pollutants. However, serious air pollution problems still persist. Some measures have not fully been put into practice due to lack of financial resources, lack of information and inadequate follow up. Secondary pollutants such as ozone and particulate matter (PM) have been much more difficult to control, and there has been less improvement. Standards are still violated too often, so we have a long way to go to improve the situation further. As we heard from the Seventh Workshop, while concentration reductions were due in part to control measures, changes in the weather also contributed.

Turning to the program we started at MIT, we had several important characteristics in mind. First, we needed to know what is being emitted and how it is being converted in the atmosphere. Technologically speaking, we know how to solve the problems. Cleaner technologies exist, but we need to understand the social, economic and political factors in having a successful program of control measures implemented in Mexico City. This requires

coupling the science with the policy. To the extent that we can, we have included stakeholders from various sectors ranging from the automobile industry to government officials. They have participated in our program from the start, formulating strategic measures taking into account what needs to be done in practice to reduce emissions. In the sense that we bring together various sectors, we call the program “integrated.” This is not traditional for the Mexico context, where many of the decisions are made by experts behind closed doors. Even if they are experts, and very well intentioned, the problem is that they might not always make the best decisions, due to the fact that they did not engage and interact with all the other relevant stakeholders in their decision-making process.

This integrated approach is a new process, and we hope to apply this method not only to other cities in Mexico, but also worldwide. It is a *process* to learn to communicate with colleagues in other disciplines. This interdisciplinary process is pushed forward significantly by our students, since they have to communicate through their research with students in disciplines other than their own. Not only do we need participants from different disciplines, but also from different sectors and organizations.

One key area of our research activities is the interrelationship between air quality and personal and freight transportation. Why is this linkage of particular importance? First, transportation emissions are a dominant source of air pollution. In the MCMA, about three-quarters of the emissions come from vehicles, and half of the cars do not have catalytic converters. Second, economic growth is closely linked to transportation and good mobility, so draconian cutbacks in the transportation sector, while perhaps improving air quality, would not serve the economic growth agenda. So we have been wrestling with this dilemma: how to improve air quality while ensuring personal and freight mobility.

In the book *Air Quality in the Mexico Megacity: An Integrated Assessment*, we published the results of the first phase of the program. Here we will give one or two examples of what was learned from this first phase. For example, we saw that for NO_x, diesel trucks were important emitters, and that this was also the case for PM₁₀ emissions. So, it was clear that diesel trucks were not receiving enough policy attention. Recently there has been more pressure on government to deal with trucks, e.g., retrofitting of trucks will be implemented this summer.

The driving factor that justifies taking these measures is the health effects of air pollution. We have worked closely on this matter with our colleagues at Harvard School of Public Health in the US and the National Institute of Public Health and other institutions in Mexico. We can estimate the approximate change in mortality for reductions of 10% in pollutants such as PM₁₀ and ozone. However, in addition to the risk reduction in terms of deaths per year, we can also add information on the monetary estimates for these health impacts, although for communication purposes and because of the controversy related to the monetary value of a statistical life, we like to present the figures in terms of lives saved and illness reduced, instead of their monetary equivalents.

The focus of the second phase of the Mexico City program is to address not only air quality on its own, but also in conjunction with other problems facing megacities. For example, transportation has many other consequences such as congestion and urban sprawl, not just health impacts. We also want to be more quantitative. We have made significant advances in understanding the air pollution science for Mexico City; however, we still need to improve the emissions inventories, which supply crucial information about pollution sources that supports the formulation of effective control strategies to improve air quality. For example, results from our air quality modeling indicated that hydrocarbons (HC) emissions are underestimated by a factor

of 2 or 3. The problem of underestimating HC emissions is not unique to the MCMA, it is also a problem in cities like Houston, where their emissions inventory was off by a factor of 10 due to intermittent high hydrocarbon emission events from the refineries and petrochemical plants, which was discovered during a field study. This example illustrates the critical role that field measurements play in the development and performance evaluation of emission inventories.

Meteorology is another important part of the problem. We need to know with how much air chemical species emitted by various activities are mixed with, and how the atmosphere in the Mexico City basin gets rid of the pollutants. In Mexico City, generally we start fresh every day, but it is important to know if there is any “carry over” of pollutants from day to day.

One of the important reasons to improve air pollution science is to have a reliable tool to evaluate the impacts of a variety of emission control policies. This is a nontrivial process. It is necessary to understand how the emissions are transformed in the atmosphere to pollutants, and this is done with atmospheric photochemical models. What we have learned over the years is that these models can easily reproduce diurnal, multi-day ozone concentrations. However, there are many variables that can be changed, and it is possible to adjust them in different ways until the ozone levels are accurately reproduced. The key question is, however, how can one establish that the models are providing the “right” results for the “right” reasons?

To improve the predictive power of atmospheric modeling, a major field campaign was conducted in Mexico City in April 2003 by a multinational team of atmospheric scientists led by Dr. Luisa Molina. The campaign involved advanced instrumentation deployed aboard both a mobile laboratory and at a major fixed site to quantify a wide range of gaseous and fine aerosol chemical species, much of it in real-time with high temporal (1-10 s) resolution. In addition, extensive meteorological data as well as a wide range of fixed site chemical data were collected by our collaborating Mexican research groups.

One of the novel instruments used during the campaign is an aerosol mass spectrometer, which measures the chemical composition of particles in an unconventional way. The conventional method is to capture the particles in filters for several hours, and then to analyze the filters in the laboratory. However, with the aerosol mass spectrometer one can obtain the chemical composition as a function of particle size in real time. These measurements found that a large fraction of the particulate matter in Mexico City consists of organic compounds.

With the mobile lab it is also possible to characterize plumes of pollutants emitted by individual vehicles across the city (with the so called “chase experiments”), and in this way sort out primary emissions from secondary pollutants (that is, those formed by subsequent atmospheric transformations). For example, an interesting aspect was the high level of formaldehyde in Mexico City, which was compared to the much lower levels measured in Boston. Formaldehyde (HCHO) is easily transformed photochemically to radicals that speed up ozone formation, and can explain, in part, the rapid ozone formation rate in Mexico City. We can thus estimate the percentage of HCHO that was emitted directly to the atmosphere and the portion resulting from photochemical oxidation of hydrocarbons.

Yet another task is to consider the policy implications of the science. For example, we find that new cars emit more ammonia (because of inefficiencies in the catalytic converters), but we don't know if this is a major concern. It might be better to have one type of emissions reduction than another, but we want to have better information available to answer these sorts of questions.

Another important component of the program is education and outreach: it involves, for example, a vigorous exchange of students, capacity building for scientists and engineers in Mexico City, and the creation of a new Masters Program for mid-career professionals from Mexico. Many doctoral students from around the world have worked with us on this program.

Another activity is the MIT scenario analysis. Rather than attempting to make predictions, we conduct a standard exercise working with different scenarios or “future stories” to examine the implications of various policies on the environment. From these scenarios we can conclude that the future growth in the vehicle fleet will often overtake early environmental gains from technological changes. Many of the control strategies tested were affected strongly by urban growth patterns. This will happen in many of the scenarios, unless very strong measures are taken. We also wanted to assess the technical, economic and political feasibility of the various control measures. Part of the process to understand the political feasibility is the use of conflict assessment, which was discussed by Professor Larry Susskind at our Seventh Workshop.

With the scenario analysis, we hope to learn how the emission levels will develop in the future, say 20 years from now, and use atmospheric modeling to estimate the pollutant concentrations that will result from such emissions levels. It is essential to take into account the growth in the motorization index in the MCMA, which has increased rapidly over the past few decades, now at about 170-180 vehicles per thousand inhabitants. This is a major policy issue. Something has to be done, and we will hopefully have the chance to continue the discussion and the summary that was put forward at our Seventh Workshop. For improvement of air quality and mobility, there is no single answer; it requires many coordinated policies and actions; strategies must be integrated for synergistic effect. We must recognize the interaction of transportation, environment, land-use and human health in formulating policy options and undertake consensus building to deal with governmental and stakeholder conflict.

Recently, we initiated collaboration among professionals and institutions in Mexico City, Bogotá, Sao Paulo and Santiago de Chile to deal with similar and very serious air quality and mobility problems. The direct objectives of this collaboration are to share experiences with various approaches to transport and air quality problems in order to reach conclusions about effective practice in the four cities and to help each other to improve these practices. We are very excited about this collaboration with colleagues in Latin America and elsewhere. Every city has had successes, but has also made mistakes. We hope to avoid repeating past mistakes, and learn from the successes of others.

We have prepared a background paper on the progress in reducing emissions from transportation in Mexico City and several of our collaborators will talk more about the Mexico City public transit system, the inspection and maintenance program and the fuel quality issues.

(The background paper by the Integrated Program on Urban Regional and Global Air Pollution on “Progress in Reducing Emissions from Transportation in Mexico City” is attached as Appendix 2. See Appendix 3 for the Power Point presentation of Mario and Luisa Molina.)

1.4. Issues and Achievements in Transportation in Santiago, Chile ***Oscar Figueroa (Univ. Católica de Chile, Santiago)***

In Santiago, the use of the private automobile is growing rapidly. Between 1991 and 2001 the number of cars per household grew from 0.36 to 0.56, resulting in a large increase in private vehicle use. Santiago has a one-day-a-week restriction on vehicle circulation, but with the

introduction of cars with catalytic converters in 1993 (which are not subject to the vehicle restrictions) the number of vehicles circulating daily has continued to grow.

Therefore, Santiago is in the process of developing a transportation plan that gives priority to public transportation, mass transit, rail, and bus rapid transit, while rationalizing the use of the private car and enhancing non-motorized transportation. The Metro currently consists of 3 lines, with 40 km in its network, and is planned to expand to 4 lines and 80 km by 2005. Santiago is also developing the Transantiago Project, which should be launched in 2005. Transantiago consists of a network of trunk routes and feeder services, organized into 10 zones.

As part of this general plan, a combination of exclusive bus avenues and reversible streets for cars has been implemented. Cars were removed from the principal public transport routes in the city, resulting in an average timesaving of 14% on all buses. Reversible streets for cars allow vehicles to travel towards the city in the morning and away from it in the afternoon, leading to an average time saving of 43% for drivers. The important lesson of this project is that one can create dedicated lanes for buses while avoiding the negative impacts on cars, thus saving time for both public and private transport.

An important component of traffic demand management is an analysis of educational trips, comprising 30-40% of all trips. Schools are being built in zones where they are currently lacking in order to improve school access and reduce travel distances. Another part of the traffic demand management effort is the creation of urban sub-centers, which increase the supply of trades and services. The current distribution of these centers in the city is uneven. The new sub-centers will hopefully change journey patterns in the long run. There is a strong tendency toward the development of suburban zones, but attempts are being made to change this behavior. Finally, there are some experiments to promote non-motorized transport (NMT), specifically bicycles.

The land use planning policy of Santiago is different from growth control because it consists of the internalization of the costs of the impacts of expansion, requiring developers and private agents to pay these costs, rather than simply limiting growth. The idea is to reduce the negative impact of new construction and rearrange land use.

Another focus of the transportation plan is intermodal passenger travel. An intermodal fare card that would allow transfers between the metro and buses on one ticket, regardless of the number of bus transfers, is under consideration. One ticket would serve for one origin-destination trip, reducing the cost of linked trips.

Santiago has an Intelligent Transportation Systems (ITS) operation control center, similar to the one in Bogotá, which monitors bus system operation and provides travel information to users.

Finally, Santiago plans to adopt new vehicle technology requirements and emissions standards for buses based on EPA-98, and EURO-III, as well as to phase in unleaded gasoline for cars and require sulfur content of 300 and even 50 ppm in diesel in the future.

Discussion

Dr. Rodrigo Garrido commented on the fare card, Multivia. According to Dr. Garrido, this is a very interesting technological advance. Earlier mechanical devices used on buses to count change increased waiting time dramatically and was a total failure. The plan was at risk of losing credibility, and a contactless card, which allows passengers to board and get off more

rapidly and conveniently was essential. Transantiago will use this card for the entire system, and hopefully reduce travel and waiting time.

During air quality contingency, according to Dr. Pedro Oyola, the flow of cars is reduced, even diesel-powered vehicles and those with catalytic converters. There were four contingencies in 2003. New freeways currently under construction will make it easier to cross from south to north and east to west at speeds closer to free-flow.

Regarding the dedicated avenues for buses, Mr. John Rogers expressed surprise at seeing only a 14% increase in bus speeds. He asked why there was such a small increase, and if it was perhaps because there was not much congestion before. According to Dr. Figueroa, before the dedicated bus avenues were built, buses already had a lot of space, and, therefore, the increase was not that great. Also, passenger boarding and alighting still takes a long time. Sir Christopher Foster added that, in London, the major benefit was not as much the *reduction* in travel time, but the increase in its *reliability*, translating into improved conditions for drivers.

1.5. Transportation and Air Quality in São Paulo ***Eduardo Vasconcellos (National Association of Public Transport, São Paulo)***

It is not easy to generalize, but in developing countries, we often have new and fragile democracies with poor citizenship. People do not exactly know their rights and duties, and laws are not always enforced. We have large economic and social differences between groups, which translate into large political differences. Different classes have different ways of accessing power and of influencing policies. In the developing countries, there is a “myth” of roads as being democratic investments, *per se*, that can be shared by everyone. But we have found that this is not the case, and that roads are used in a very inequitable manner. This is an example of the privatization of public space.

Mobility is greatly influenced by income. Low-income families make 50% fewer trips, that is, they are making work or school-related trips only. Most of these trips are very close by. They also have poor accessibility to public transport, due to both monetary and physical barriers. The very low-income family uses only 26 km-m² per day, while a wealthy family uses 232 km-m² each day, or 9 times as much road space.

Congestion has increased and traffic speeds are falling on the main arterial systems in São Paulo. Bus speeds are only 12 km per hour. What is the difference cost, both in time and money, between using a car and using a bus? For buses, the average time traveled is 43 minutes, including trip time, waiting time, and walking time. By comparison, the average trip in a car is 20 minutes and 16 minutes by motorcycles. The direct costs are 1.2 R\$ for buses, 1.8 R\$ for cars, and 0.6 R\$ for motorcycles, a figure that helps explain the increased use of motorcycles. Unfortunately, motorcycles pollute a lot. Simulations for various mode share shifts show that if we shift 20% of bus trips to autos, we will use 32% more gasoline and emit 17% more pollutants. With a shift of 20% to motorcycles, we will increase local pollutants by 54%. However, if we can shift 20% back to buses, we will save gasoline, pollution, energy, transport costs, and road space.

Returning to policy issues, democracy and transparency are key factors. Roads are public assets, and need to go back to the people that most need it. Public transportation is a public service that needs to be tightly regulated by the government. This notion is central. There are several competing issues that need to be addressed. Even if we are looking for strategies to decrease pollution, there are other externalities, such as traffic accidents, which in some cases

may be more important than pollution. Poverty and equity issues also need to be addressed. The poor need access to jobs, schools, and services. We should emphasize social *equity*, while still considering minimum levels of *efficiency*. We have to balance both, but with an emphasis on equity. Equity means that all people should have access to education and work, but this does not mean free transportation for all.

There are three sides to sustainability: environmental, economic and social. The difficult question is how to balance all three. Pollution is moving from being a “problem” (a situation without a solution) to an “issue” (seen as solvable and requiring government action). But we are still transitioning. There is still no widespread consensus that pollution is a real issue, and not just a problem. On the other hand, traffic accidents are still seen as a problem.

There are several proposals for São Paulo. One is a structural and long-term proposal to enhance democracy, promote discussion, and reduce educational and income disparities. This also includes controlling and changing urban growth, ensuring institutional and policy coordination, and recapturing roads as public assets. Technical and operational proposals include analyzing potential political support and conflicts, how social groups and classes see proposals, the public and private costs, and the time frame for implementation.

For technical and operational improvements, it is clear that good traffic management is a viable, low-cost, short-term, and highly effective measure with strong support. To reduce emissions, mandatory inspections and on-street emissions controls are needed (especially for trucks). However, there are social aspects to this problem, which limit the amount of money individual vehicle owners can spend. Many trucks are owned by individuals with low incomes. Restrictions for motorcycles (there are 500,000 in Sao Paulo) will be difficult because they are a critical source of employment for many people. Any attempt to enforce truck or motorcycle regulations will result in a political struggle. Improvements to the bus fleet will be less difficult, but who will pay the cost to buy new vehicles? With inspections, a key question is who will pay, and how to avoid the type of corruption that has happened elsewhere.

A new NMT system and a new public transportation system are needed. Informal transportation has found niches where regular public transport has been unable to provide good service. There are 80 km of real bus corridors, and 200 km of poorly enforced near-curb bus lanes.

When we discuss issues such as congestion pricing, we need to think not about getting people out of their cars, but about ensuring high quality public transportation system for mobility of the majority of the people. New types of fuels for buses are also needed, such as CNG, hybrids or hydrogen. Priority must also be given to bus lanes.

To reduce automobile use, we need to recapture roads for the use of public transportation. There are 10 million people and 5.5 million vehicles in Sao Paulo. Automobile owners do not pay anything because there is no enforcement of existing regulations. Options need to be considered to remedy the situation, including increasing property taxes and parking costs and reducing parking availability. A vehicle restriction scheme based on license plates is in place, but its effectiveness is limited by the growth of vehicles. When area restrictions (such as a restriction in 1974 on vehicles entering the city center) were made, a decline of the economic activity resulted, and such schemes are politically unviable. Road charging has been discussed for a long time, and the London experience has been encouraging. However, transport engineers in Brazil remain divided on this. There are equity and control problems that need to be considered. However, as pointed already in other cities, there is no single solution, and we expect that a mix of policy measures will be needed to reduce congestion.

1.6 Colombia Transportation Measures for Abating Air Pollution in Megacities *Dario Hidalgo (Transport Consultant, Bogotá)*

Dr. Dario Hidalgo was the former deputy director of the Bogotá TransMilenio. In this presentation, he is going to focus on the successes of the past 6 years, which are important because we have shifted the way we perceive the city, and how we view the problems of transportation and air quality.

Eight years ago, Bogotá was overwhelmed with its transportation problems. People in Bogotá felt that there was little to be done, and that it was time to just throw in the towel. Whatever funds available were given to road expansion and the construction of overpasses in a few critical intersections. Road maintenance was generally neglected. Metro expansion and elevated highways were also considered, but there was no way to finance these projects. Bogotá needed to find a new solution.

Today, Bogotá is a world example of sustainable development with social justice. Travel time has been reduced by 12%, traffic deaths by 21%, and the city consumes less energy, is less polluted, and is less segregated, both socially and in its use of public space and transit. In spite of anticipated changes in political authority, these priorities for mobility are still in place.

How did this happen? In large part, it was due to the leadership of Mayor Enrique Peñalosa (1998-2000) who redirected transportation policy away from road construction towards mobility. Rather than focusing in vehicle technology and road construction, the city adopted measures to increase the share of walking, biking and public transportation, while reducing the use of private automobile. This entailed the recovery of pedestrian and bicycle infrastructure, an imposition of driving limitations on 40% of automobiles during peak traffic periods, and the rapid expansion of bus rapid transit (BRT) in the city. Although there were major debates about these policies, they were not rejected, since only 16% of the population uses private automobiles. As a result, the strategy was continued under the administration of Mayor Antanas Mockus (2001-2003). Since the mayor is not re-elected, each administration must deliver results in just 3 years.

In Bogotá, the focus was on generating institutional capacity biased towards implementation. Detailed planning studies drawn up were more than just nice looking reports – they were meant to make things happen. Money was allocated and long-term grants were assured. Furthermore, to make the strategy feasible, traditional service providers were included. Without this provision, informal service providers would have blocked the change. Cultural changes were also promoted, including transit use, respect for public space, and the use of bicycles -- 200 km of bicycle lanes were provided. These strategies were implemented at very low cost.

The city recovered pedestrian space, constructed 200+ km network of bikeways, and implemented a full-scale BRT system. Public transit use went up from 72% to 73% between 1998 and 2002. More importantly, some polls have shown a downward trend in the modal share of private vehicle trips, from 16% in 1998 to 11% in 2002, and an increase in the share of non-motorized vehicles, from 9% to 13%. Average travel time has decreased from 48 to 42 minutes. The rate of public approval of these policies has also increased substantially.

The Transmilenio BRT system is a very important part of the overall mobility strategy, but it is not isolated from the whole vision. It is a fully scaled BRT, with stations, exclusive busways in the median on arterial roads, large articulated buses, level boarding, prepayment, ITS and

branding. Transmilenio was based upon successful experiences in Brazilian cities and Quito, Ecuador. With the advantage of hindsight, however, Transmilenio was able to improve on these earlier examples. The design and implementation principles were based on service, not on specific technologies. These service principles are respect for life, respect for diversity, and respect for travel time, quality and consistency. The system also had to be affordable for the government, the user, and the private operator.

State-of-the-art fare collection systems are operated through a private concessionaire. A new public authority for planning, promoting and controlling the systems was put into place. Its focus was more on management, integration and service than on the infrastructure itself.

Phase I (1998-2002) put into place 41 km exclusive busways, 309 km of feeder lines, 61 stations, 470 articulated buses, and 241 feeder buses, as well as state of the art fare collection and real time bus control systems. The heaviest used lines serve about 35,000 passengers per hour per direction, comparable to a Metro line. The 39 feeder routes and the 12 trunk services were used by 51% of users at no additional payment. Implementation time for Phase I was 54 months, with a public capital investment of 240 million US dollars, and private investment of 100 million dollars. Phase I has a calculated socio-economic internal rate of return of 61%, with travel timesavings of 32%, and a 93% reduction in traffic fatalities on the trunk corridors.

Phase II will expand the system by 40 km of exclusive bus ways and 200+ km of feeder services. This expansion includes 52 stations, 335 articulated buses, and 150+ feeder buses to accommodate 600,000 additional passengers per workday. 11 km of Phase II were built in 2003, with an additional 30 km planned for 2004-2005. The long-term goal for the total system is to have 85% of the area of the city within 500 meters of the trunk system by 2020, with the rest of the city covered by short distance feeder systems.

One of the most important aspects of the program is the innovative institutional scheme of public and private involvement based on binding performance contracts. The private sector is responsible for bus acquisition, operation and maintenance, and implementation and operation of the fare collection system. It is important that these contracts are based on open bidding, and that they include ways to fire the contractor if they fail to perform. Competition for the individual passenger is being replaced by competition for the market.

This system has improved quality of life in many ways. Although air quality was not at the top of the agenda for the system, it has been positively impacted by the program. Emissions reductions are due both to the replacement of an obsolete transit fleet with a cleaner and more efficient one as well as a modal shift away from the automobile. One of the requirements of the system is that new buses not be purchased until several older buses are destroyed (the exchange used to be ~3:1, and is now ~7:1). Rough estimates are available of the relative emission impacts of an upgrading of the bus fleet and of the modal shift. For CO, these were 4% from TransMilenio and 7% from modal shift, for NO_x they were 8% and 1%, and for VOC they were 9% and 1%. The modal shift has been more important in reducing CO, while TransMilenio's cleaner and more efficient bus fleet has had greater impacts on NO_x and VOCs. Ozone concentrations have fallen between 1998 and 2002 by about 6%. However, there have been increases in PM₁₀ and sulfur concentrations, of 12% and 15%, respectively. Environmental standards, 170 µg/m³ for the max 24-hour PM₁₀ standard, and 65ppb for the max 8-hour ozone standard, are still regularly exceeded. Yet, the hope is that this mobility strategy both has and will continue to bring about air quality improvements.

Sustainable transportation measures show important impacts in improving quality of life, including air quality. Nevertheless, there is still a long way to go. The Bogotá experience is transferable to other cities. One needs a strong political will in order both to generate a continuous process, with clear ideas and vision from the beginning, and to allocate the required financial and technical resources for project preparation and execution. To finance the project, the gasoline tax was raised 20% and the national government provided a 16-year loan. It is also necessary to think in the long term, but with specific, practical actions that are able to show short-term results and assure financial sustainability. Measures employed must reinforce these principles, even if they are not popular (like taxes and traffic demand management).

Discussion

In respond to a question about the fuel type of the TransMilenio vehicles. Dr. Hidalgo pointed out that this was a big discussion in Bogotá, in part because of the various lobbies. In the bidding process, they excluded fuel use as a factor in the decision process. They discussed using natural gas, but there was conflict with the gas and diesel interests. Diesel buses are currently used. CNG technology is not competitive now for use in Bogotá.

Dr. Anderson noted that the goal for having 85% of the city within 500 meters is impressive, but wondered about the road network capacity for such expansion. Dr. Hidalgo replied that as the system grows, it would need incrementally less infrastructure for fewer passengers on the routes; the additional infrastructure requirements should not be too excessive.

It seems clear that Transmilenio is a success, according to a participant, but in Latin America as a whole, a decrease in air pollution will require significant regulation. Other countries cannot afford a large, deregulated system. What is the need for regulation in Bogotá? Dr. Hidalgo agreed that this is a challenge facing Bogotá. Currently, they have formal companies, and owners are affiliated with them. The system was not strongly regulated initially, and there are ongoing efforts to control informal operators, which is difficult since there are some areas where the regular system does not provide service. Regulated services are much better, providing higher quality service for the same cost. But the problem is assuring the growth of the formal transit systems, to provide high quality services at a moderate cost.

Dr. Gakenheimer commented that due to the success of the program, it is now being copied all over Latin America and around the world. But there is a danger that in the excitement and rush to take advantage of BRT in other cities, some of the complementary aspects, in particular, the land use implications, may be left out. BRT could exacerbate the decentralization of already explosively decentralizing cities. We need to look at this issue in order to guarantee long-term accessibility. BRT can also provide an opportunity to implement other complementary measures, such as congestion pricing or parking restrictions, since it is a good compensatory measure.

Mr. Samaniego asked what led to the policy choice to pursue BRT instead of expansion of the Metro. How was this decision made? Also, was emphasis put on intermodality? According to Dr. Hidalgo, Metro was not expanded due to lack of money. Intermodality was not done correctly in the first phase, but they are working on this. Initially, they did not have facilities for parking safely in the stations. They are now integrating bikes slowly into the intermodal system. This integration is relatively low cost for the user and for the government.

Dr. Slott raised a question about driving restrictions, and whether there were second car purchases. In response, Dr. Hidalgo pointed out that since people are only restricted from

automobile use during the peak period, it is not a full restriction, which diminishes the incentive to buy a second car. Those that are able to change their schedule do it, arriving earlier or later to work, and they have found good cooperation from companies. As a result, few people bought a second car, in part because of the greater flexibility of this type of restriction, and in part due to the economic situation, which made it difficult for people to afford a second car.

1.7. Relevance of Transportation Measures to Abate Air Pollution in Cairo
Alan Gertler (Desert Research Institute, USA)

An important question is what can be done in the developing world to avoid repeating the mistakes of already developed countries. In the case of Cairo, where 2/3 of the population lives below the average developing world poverty level, this is a difficult question. For example, there is no opportunity here to put in a 40-m wide bus lane, because the entire road is less than 40-m wide. According to Dr. Gertler, as discussed at the Seventh Workshop, all of greater Cairo suffers from high levels of air pollution. Although transportation is important, other key sources, such as smelters, need to be addressed first.

In Cairo, levels of PM10 and PM2.5 are very high. PM10 source apportionment done in winter and fall of 1999 at six sites found an average of 200 micrograms per cubic meter. Lead smelters and non-transportation sources are very important. Motor vehicles in some areas create highly elevated PM10 emissions. These emissions are very high even if re-suspension of dust particles is excluded. There is a lot of PM10 from burning and from geological material. Levels of PM2.5 are clearly impacted by motor vehicles. For PM10, probably 25% or less comes from motor vehicles, but the absolute amounts are high. For PM2.5, motor vehicles account for 50% or less of the sources at most of the monitoring areas.

There are many other sources to go after first. These “low hanging fruits,” include open trash burning (in Alexandria, trash is picked up instead of burned), industrial emissions controls, shutdown and removal of smelters, switching from heavy oils to other fuels such as natural gas (which Egypt has in abundance), the institution of an air quality monitoring system, and reduction of secondary PM precursors – NO_x, SO_x, NH₃, and chlorine. But it remains to be seen how Egypt can jump 50 years ahead without having to go through each painful step of air quality improvement experienced in the United States.

These other sources need to be addressed, but transportation is still important, given the absolute magnitude of the problem. Implementing transportation control measures is critical to obtaining healthy air quality levels. Cairo can learn from the experience of other megacities. It is important to verify the effectiveness of their current I/M program, expand and maintain the fleet of CNG buses, regulate emissions from diesel vans commonly used for passenger transportation, encourage newer technology for light-duty and heavy-duty vehicles, use better quality fuels (fuel composition is generally not measured), develop market mechanisms to reduce congestion, expand the road system, especially across the Nile, and address problems of re-suspended road dust. They also need to address the lack of enforcement of current regulations, and convince the government that there is a problem. There is frequent turnover of upper levels administrators in government, which makes it difficult to develop and implement measures.

The mobile source inventory needs to be verified, drawing from US experience which showed that mobile sources emission factor models often underestimate emissions. Tunnel studies have shown that CO and HC can be underestimated by a factor of 2 to 4, while still correctly predicting NO_x. If the model predicts the observations, it is probably getting the “right” answer,

but for the “wrong” reasons. They need to challenge the inventory to get good inventory numbers needed to make good policy decisions.

In summary, the Cairo case differs significantly from the Mexico City situation. It is much worse.

Discussion

Dr. Robert Slott agreed that checking emissions inventory is an important factor, and added that public information and public availability of data relating to air quality and health effects is also important. Dr. Michael Walsh noted that this presentation raises the issues that, in reality, many countries do not have the means to develop emissions inventory and often lack emissions testing labs. He asked how the speaker proposed to carry out these emissions inventories in Cairo. Dr. Gertler responded that emission inventories are indeed difficult to carry out and maintain, but his team will try to use simpler techniques that work more consistently. When developed countries donate analytical equipment to developing countries, it often remains unused. Short field studies can supply a lot of information, especially VOC and NOx measurements.

Responding to a question about how these recommendations can be implemented given the economic situation of Cairo, Dr. Gertler noted that government will is often not there. This is clearly a major challenge, and it is unclear whether and how these recommendations will be implemented. Dr. Mario Molina suggested that the first step would probably be to determine the current attitude of senior government officials and move forward from there. While government officials would probably react first by saying that they cannot afford to address air pollution, it is possible to demonstrate to them that if they do not address it, the health costs and their impacts on the economy and productivity will be huge compared to the costs of addressing the issue. Dr. Gertler responded that when he talked to the Egyptian Minister of the Environment, it was the first time anyone from the USAID project had talked to him. The official was very interested in the project, but unfortunately, with the high turnover of political offices, he is no longer in the government.

Another question was raised about how the population perceives the air pollution problem. In other countries, the problem of air pollution has been addressed when the public opinion became strong enough. According to Dr. Gertler, the population in Cairo is struggling to survive, and pollution is the least of the concerns of most people. For example, 200,000 to 800,000 people live in what is called the City of the Dead, a graveyard without any infrastructure. Therefore, successful programs must start with the wealthy population. Unfortunately, the rest of the population is more likely to die from other causes before air pollution affects them. A participant added that it is probably better if a local group tries to convince government that there is a problem, rather than a group from outside. For this reason, in the long-run, capacity building is probably more effective than short-term technical help.

Dr. James Longhurst added that in the case of the UK, mobilizing the wealthy residents was important for addressing air pollution, but it took a long time. According to his Egyptian colleagues in the UK, it seems that the wealthier people are aware of the magnitude of the issue, but they are also concerned that the infrastructure cannot handle this problem. However, it seems that there is local capacity in Alexandria, and that their experience can perhaps be mobilized. What is it that makes Alexandria different? According to Dr. Gertler, the difference in Alexandria was that the Mayor believed that pollution needed to be cleaned up. Cairo is chaotic, while Alexandria is a smaller and more manageable city. Political will was probably a

key factor. Another reason that the garbage is being cleaned up is that people are making money from it; garbage collection is a private enterprise.

Dr. Miriam Lev-on added that there will be a UN-sponsored meeting on clean fuels in March 2004 in Beirut, where they will focus on opportunities for improving fuel quality, particularly among middle eastern countries.

1.8. Clean Air Issues, The Philippine Experience ***Nereus Acosta (Congressman, House of Representatives, Philippines)***

The Philippine Clean Air Act (PCAA) was filed in 1988, but was not signed into law until 1999 by President Estrada. There was a 12-year gestation of the law, but there was little public awareness or government support. But by 1999, support and pressure had grown. Circumstances, conditions, and political pressures were right for the Clean Air Act to come to fruition. It is one of the most stringent clean air laws in Asia, although there are problems with implementation. It included Euro/EPA standards, complete phase-out of leaded gasoline, de-sulfurization of diesel, and a ban on direct incineration. However, the Clean Air Act is one of the 450 mandates that are underfunded, or even unfunded. There is some assistance from the Asian Development Bank, but there is nothing in the general appropriations for implementation of the Clean Air Act, and the Environment Management Bureau has no real capacity to implement the law.

Metro Manila has 14 million people, with 3.4 million registered vehicles (maybe 1 million more unregistered), which are the source of 75% of air pollution. It is one of the five most polluted megacities in the world. There are 200,000 or more two-stroke tricycles/motorcycles in secondary roads, which pollute more than cars. In terms of the cultural and political landscape, there is a chaotic political environment, and widespread poverty and inequality. There are also many institutional weaknesses that hamper implementation.

The five “i’s” – information, infrastructure, institutional arrangements, instruments, ideology – need to be brought together in an integrated approach. The situation is “half-full” or “half-empty,” depending on whether you see problems or promises.

Information is necessary. The organization equivalent to the EPA in the Philippines is extremely understaffed, with only 18 full-time employees. Environmental impact assessments and cost-benefit analyses are difficult, and monitoring is lacking. We need more information that includes scientific and technical data for standards and benchmarking, baseline and case studies, social and economic analysis on demographic trends and health impacts, determination of environmental impacts and their economic assessment (cost-benefit analysis), and more monitoring, modeling, simulation and verification.

In terms of *infrastructure*, policymakers often support roadway construction because they believe that this is the solution to the problem. As a result, there is a focus on diversions, circumferential roads around the metropolis, flyovers and overpass complexes. In the long term, these contribute to greater congestion. There is no focus on transit-oriented development, BRT, or ITS, and a minimal focus on new technologies. Decongestion plans are not in the works; and while they are being discussed, nothing is happening. There is emission testing in place, but political infighting interferes with implementation. The Metro Manila Development Authority, which would like to operate more like the CAM in Mexico City, finds their efforts

hobbled by politics and a lack of funding. The 13 mayors in Metro Manila strongly dislike the Manila Development Authority because it interferes with their authority.

With respect to the *institutional frameworks*, while there has been some improvement, the situation is still largely pessimistic. There is no land use legislation to complement the Clean Air Act. Environmental policies are disconnected, which could probably be said of other countries in the region. Coordination of agencies should be possible and workable, but it is a source of friction. There are some success stories with public and private partnerships, one of which is the “bantay usok” (literally translated to “watch against smoke-belching vehicles”). This is run by NGO-media groups. Civil society has acted first, government has only reacted. Mandates are unfunded, but even where they are funded, there are problems of corruption and waste of funds. Congress has oversight authority over implementation of the Clean Air Act, but the committee has only met three times.

The Philippine Clean Air Act has market-based *instruments* in its framework – including pricing, taxation, and incentives – but they are not currently being implemented, and their good intentions are not generating good, workable programs. There is also a standing court order banning the ban on the importation of second-hand vehicles and buses from countries such as Japan and Korea. Up to 50% of vehicles and buses have been imported, and the average vehicle is very old. Since nothing in the Philippines is ever wasted, vehicles are constantly being refurbished. Equity issues are very important. For example, how do we make the tradeoffs between the livelihood of the tricycle owners and public health? There were mass protests against the proposed phase-out of two-stroke engines in tricycles.

In terms of *ideology*, there is a very short-term vision, and lack of continuity from administration to administration. Government corruption is also an issue. The Philippines, ranked the 11th most corrupt country in the world, is a classic “weak state” according to political theory, where those implementing the rules are not trusted by society at large. There is some environmental education and public and media outreach currently being done, and there is a strong civic society organization. But public involvement can be a “double-edged” sword, and may be motivated by a political agenda rather than a desire to clean the air. Court systems and judicial involvement in environmental decisions are important, but can be abused or politicized.

Finally, the country needs more *integrated* approaches. We cannot move without sound analysis of the context, constraints and challenges of our problem, and we must understand the relative impacts in different cultural, demographic, economic and political circumstances. What does “sustainability” mean in fuller environmental economic and social terms? We need competent leadership, and effective implementation, innovation and adaptation.

Discussion

Dr. William Anderson noted that it was interesting that the pressure from the World Bank was partially responsible for the passage of the Philippine Clean Air Act, and asked if they could have a role in furthering its implementation. Dr. Acosta replied that, unfortunately, while the World Bank and other international organizations are effective in putting pressure on countries for certain actions, especially when that pressure is tied to loans, they just don’t “get it” in terms of the broader social context, including implementation issues. They are learning, but the problem is that these are large organizations, which have ossified over time and history. The World Bank realizes this, and is moving from technocratic to more integrated solutions. There are also some good things happening, such as the non-motorized transportation program in Maraquina, and pedestrianization at the Manila Bay area. They may not be wide-scale, but they

show the way forward locally. These are the things that work in the short term in this political framework.

Dr. Pablo Montero asked if there are moves forward in the use of market-based instruments on any specific pollution problems. Dr. Acosta responded that it will probably take a few more years, because industries don't know what the problem is, and are suspicious of the government's ability to carry out these instruments.

In response to a question about cleaner fuels, Dr. Acosta noted that they recently acquired new CNG buses, and while it is only a small number, it is a good start. There are linkages with New Delhi's clean fuels program, and the Philippine Department of Energy and Department of Transportation are looking into this. These projects are in the pipeline, but funding and politics will remain a problem.

A participant asked if Dr. Acosta would be able to use his initiative in promoting the Clean Air Act as a platform to run for office again, and whether it would help him. According to Dr. Acosta, in his district, poverty remains high. The main issues are really poverty and jobs. People do not care as much about the environment, as they do about issues like new schools.

1.9. Traffic and Air Quality in Europe ***Menno Keuken (TNO-MEP, the Netherlands)***

Europe has institutional barriers to implementing sustainability in its cities, although the issues are less complex than many of those faced in developing countries. In the EU, passenger cars have increased, but vans and buses are not as dominant. Growth in the number of vehicles has been between 3% and 5%, with faster growth expected in Eastern European countries.

In most countries, gasoline is the dominant fuel source, accounting for about 80% of the market. Most of the remaining 20% is diesel. A few countries use LPG. The Netherlands, for example, used to provide subsidies for LPG cars. However, this program was terminated when emissions from new vehicles, even diesel, approached those from LPG. LPG accounts for about 3% of fuel use in Italy and 1% in Belgium.

NOx emissions from mobile sources in the EU increased from 1980 to 1992, then began to decrease after 1992. Emissions are projected to continue decreasing through 2020. Much of the improvement since 1992 is due to the introduction of catalytic converters and fuel injected engines. Emissions from passenger cars and heavy-duty vehicles are large. However, diesel emissions have been dramatically reduced and are now almost the same as those for LPG in Europe. The contribution of NOx emissions from trucks is still high relative to their proportion in the vehicle fleet.

By 1999, overall emissions had declined dramatically, including VOC and PM, because of catalytic converters, direct injection of fuel to engines, and improved fuel quality. This decline is therefore mainly a result of technological change, and occurred despite the increase in the population of vehicles in Europe. Nevertheless, because of extensive traffic in urban areas and limited dispersion, there is still a problem of air quality. Passenger cars dominate VOC emissions. Trucks are less of a problem for VOCs. PM emissions have had a less dramatic decline than NOx. Catalytic converters are not as effective for dealing with PM.

We expect that after 2005, with the introduction of Euro IV emission standards, there will be an even larger reduction in these emissions. But we may be a bit too optimistic about this decline, particularly in PM, because the estimates are based on optimistic and idealized driving cycle conditions. Currently there is a lot of congestion in urban areas and highways, so we may not be very close to the “ideal” drive cycle.

CO₂ emissions from road traffic in the EU have not decreased, and are projected to increase in the future. Passenger cars are the largest contributors to the problem. The discussion of sustainability is now centered on CO₂ emissions. Air quality is not as much of an issue for policy makers; congestion is now the problem that concerns them. Noise is also becoming an issue, and legislation after 2007 will further address noise in urban areas, which is mainly caused by traffic.

In 1995, for a number of health-related pollutants, the percentage of urban population exposed to air quality levels was above compliance with EU standards. For example, exposure to high levels of PM₁₀ was 90%. By 2010, the exposed population is expected to decrease to 70%. A percentage of the population will still be exposed to NO_x, benzene, ozone, SO₂ and CO in 2010, giving problems with compliance. This is especially true for the population that lives close to heavily trafficked roads.

The policy framework for air pollution and emissions standards is the Clean Air for Europe (CAFE) program. There is also a research and development program. The policy promotes a mix of measures, including national emissions ceilings and EU air quality directives. But it is clear that technology measures are not adequate to provide overall compliance with air quality standards in 2010. Additional measures are required to deal with noise, health and climate change. Even if standards are complied with, there is still a problem with the volume of traffic. Economic measures, such as road pricing, road taxes, and parking fees, are not very popular. Spatial planning, including limiting parking, providing public transport, and influencing the location of residences and offices, is effective but is a long-term process. Traffic management, which is short-term and location-specific, is a good “hot spot” approach but requires a lot of control. The transition to sustainable transport needs to be based upon technology (hydrogen fuel cell, intelligent vehicles and roads) combined with integrated spatial planning and improved public transport.

Discussion

A question was raised about why VOC emissions will decline over time. According to Dr. Keuken, drops in VOC emissions are basically due to direct injection engines, which limit the evaporation of fuel into the atmosphere. There was also a question about what seems to be very optimistic forecasts of NO_x emissions. Dr. Keuken responded that NO_x emissions will go down, but only from private cars. Heavy-duty vehicles emissions will grow. Trucks in Europe have not been effectively integrated into the technology improvement program, but from 2005 onwards there will be more stringent emissions standards for trucks as well as cars.

A participant asked whether ozone forecasts, which are sensitive to meteorological conditions, have been revised in light of last summer’s heat waves. According to Dr. Keuken, this data was from a study done before last summer. However, there is now a new study that shows that background concentrations of ozone are increasing. The analysis accounted for higher temperature years, and it is clear that climate change will have a negative impact on ozone reduction. The view in the report presented here was too optimistic.

If the standards are not reached, are there contingencies in the legislation? Dr. Keuken explained that the standards are agreed to in Brussels but that it is up to local authorities to take measures to meet them. If the standards are not met, the localities can be fined. As a result of this local responsibility, there is more focus on traffic management, because these are some of the only instruments that can be implemented by local authorities to improve air quality. Unfortunately, local governments normally do not have the needed information about their options to improve air quality, because they lack data on the contribution of local traffic to air quality.

A comment was made about the danger of turning the standards into gods and that there may be other more worthwhile actions that deserve investment. De-carbonization is a huge challenge. These issues will take a long time to sort out. To stick to standards religiously might end up creating more resentment if you try to use road pricing simply to drive traffic down rather than to bring about a better traffic system. There is a danger of breaking down the consensus. Dr. Keuken responded that this research showed that technology-based measures were successful in decreasing emissions despite traffic growth, but this will not be enough to guarantee better air quality in the future. To deal with future congestion, CO₂, noise pollution, and space limitations, local authorities are putting more emphasis on traffic management. However, it is possible that they may detract attention from other measures that could be useful.

1.10. Urban Pollution in Italy: A 30 Year Experience ***Ivo Allegrini (National Research Council, Italy)***

This presentation will highlight the experiences with air pollution management in Rome over the past 30 years. Rome has had air quality problems for most of its history. For example, in the time of the Roman Empire, food cooking in the streets was a major source of emissions.

Rome is 22 km in diameter, with 2.7 million inhabitants (3.2 million during working days), 1.75 million cars, 650,000 motorcycles (most of which have two-stroke engines), and three airports. We need to consider several aspects of the problem, including urban development, mobility, protection of cultural heritage, public health, and protection of vegetation and natural areas.

Rome has a warm climate with high solar radiation, conditions that readily induce photochemical pollution. Metropolitan climatic conditions are such that there is weak atmospheric mixing during winter months and during the summer nights. Sea and land breezes in the summer reduce the frequency of high pollution incidents.

SO₂ dropped to extremely low values since 1993. CO has also declined following the introduction of catalytic converters. Benzene has decreased due to the Air Quality Act, and levels are now close to 5 micrograms per cubic meter, which is the European standard. Ozone increased until 1998, but then between 1998 and 2003 remained relatively stable, with a slight decrease. NO₂ declined a bit in the 1990s, and then stabilized, remaining above the Euro standards. Laws in Italy only require the measurement of total particulate matter, therefore, it wasn't until 1999 that reliable measurements of PM₁₀ were taken, which is still above the European standard of 40 micrograms per cubic meter.

Rome is surrounded by mountains, except in the West where there is an outlet towards the sea. Pollutants stagnate as they are trapped in the valley. The pollution problem is not limited to the central area of the city. Traffic seems to have little to do with PM₁₀ concentrations as measured at background stations. These background stations are a good indicator of exposure

of the population to pollutants. The PM problem is the same all over Italy, where the levels in many cities (for example, those in the Emilia Romagna region) are above the PM10 standards.

Italy must step up its effort with abatement programs whose aim is to achieve results comparable to those of the Northern Member States, where atmospheric conditions are in general less likely to induce air pollution episodes. In Italy, atmospheric stability causes an increase in the pollution concentrations. In order to avoid fines from Brussels for violation of EU standards, there is a pollution reduction plan for Rome. The urban area has been divided into three zones: the center zone (ZTL) and two other zones separated by the railway ring and beltway ring (23 km in diameter). General vehicle restrictions are applied, including, for example, increases in parking fares, obligations for annual vehicle inspections, and restriction of circulation according to even-odd plate numbers. Programmed restrictions to private cars (even-odd plates) apply every Wednesday. Fares for on-street parking will be raised to 1 euro per hour. Further restrictions in severe atmospheric stability will be enacted according to pollution alarm action plans. In terms of restrictions in the central zone, cars will not be allowed from 6:30 to 18:00 with certain exceptions to avoid hurting tourism and commerce, and to permit residents of the area to enter. Rail Ring restrictions will include a phase-out of diesel cars with non-Euro II standards, and the banning of all diesel Euro I and older models. Also, non-catalyzed gasoline cars before Euro I will not be allowed, and two-stroke motorbikes will also be phased-out soon.

Finally, there are additional topics for further consideration. A general consensus on air pollution management does not exist. Taxes are already high. Gasoline costs up to \$5 per gallon. Property taxes on cars are high. Insurance and highway expenses are high. Therefore, if the taxpayer is pressed more, then there is a strong need for consensus before a measure can be implemented. This consensus starts by classifying restrictions as effective or non-effective. Practical evaluation of individual measures is required. Cost-benefit analysis is necessary, because resources are not abundant. Better knowledge on physical and chemical processes is required to determine the chemistry of pollutants. Better analysis of private and public mobility, and economic and social implications must also be considered.

Session 2: Cleaning Up Vehicles and Educating Drivers

2.1. Motor Vehicle Pollution Control: Lessons Learned Over The Past Thirty Years ***Michael Walsh (US)***

Over the past thirty years, great progress has been achieved in motor vehicle pollution control. Global motor vehicle emissions are lower by 67% for non-methane HC, 56% for CO, 18% for NO_x, 43% for methane, and 9.2% for CO₂, and slightly higher for N₂O compared to what they would have been *in the absence of controls*. Yet, serious problems remain. There is strong growth in vehicle numbers, particularly in the developing world. A large percentage of this growth is in two- and three-wheeled vehicles. In megacities, you find a mix of vehicles, cars, motorcycles, and NMT modes all competing for road space.

The pollutants of concern are CO, ozone, particles, and, increasingly, toxics such as diesel particles, benzene, chromium, and asbestos. Two other growing concerns are regional haze, and, of course, global climate change. There is increasing evidence of the health impacts of air pollution. For example, we are now seeing that pollution can trigger asthma attacks. Health impacts range from asthma attacks and bronchitis to cancer and death. Hospitalization has a close correlation with PM10 and PM2.5. Developmental effects are linked to lead and

manganese. For every 10 micrograms per cubic meter, you can see a major impact on all causes of death. The impact that traffic emission can have on nearby schools is also clear. A Dutch study has linked proximity to truck traffic with lung function. Unfortunately, the poor are generally the most heavily impacted by air pollution.

A comprehensive program needs to be introduced to address these problems. It requires clean vehicle technology, clean fuels, appropriate maintenance, and transportation and land use planning. Vehicle emissions standards are working to drive down HC and NO_x emissions. For light duty vehicles, the emissions standards have evolved from Euro I, allowing 0.97 g/km NO_x emissions, to Euro IV and Japanese standards allowing for less than 0.1 g/km of NO_x. The tightest standards are SULEV, which require less than 0.05 g/km. There have been major parallel reductions in the sulfur requirements as well.

In California, zero emission vehicles (ZEV) regulations allow for three paths to provide for more flexibility: The Near-Zero Conventional Vehicles (Path 1), Clean Hybrids (Path 2), and eventually the Battery Electric Hydrogen Fuel Cell (Path 3). Projections show a significant penetration of hybrids in the market, and the eventual appearance of ZEV starting around 2010.

More attention is now being paid to heavy-duty vehicles, which not only have higher emissions, but also have a driving cycle that emits higher levels of pollution during operation. In Mexico City, it seems that many heavy-duty vehicles are overloaded. However, heavy-duty vehicle emissions standards are evolving. By 2005, Japan and Euro V will require 2 g of NO_x per kWh. Another problem with heavy-duty vehicles is that the existing fleet will likely remain functional for decades and cannot be ignored. One of the technologies of growing interest for the existing fleet is the retrofit of oxidation catalysts with particulate traps. In Hong Kong, for example, 40,000 diesel vehicles were retrofit with oxidation catalysts. Studies in California on fleet trucks have shown that these traps are robust.

It is also important to reduce sulfur levels. Sulfur competes with the other gases being eliminated on the catalyst surface, and can end up coating the catalyst and reducing its effectiveness. Almost all of the vehicle control technologies are impacted by the effects of sulfur, but NO_x adsorbers are the most sensitive to extreme sulfur inhibition. However, the good news is that low-sulfur fuel is spreading across the world. Germany stands out because of its use of tax incentives to accelerate the adoption of ultra low sulfur (10 ppm) fuel.

One of the key issues is the cost effectiveness of regulation. From the 1980s until now, the measures have been remarkably consistent. In California, for example, control strategies have an average cost of \$1 per pound for removal of ozone precursors, for options ranging from LEV to the 2007 HDDE. The only exception was costly reformulated gasoline.

Appropriate maintenance and a good I/M program may be difficult but the alternative is too expensive. All of the technologies benefit from good maintenance. The requirement that vehicle maintenance includes maintenance for lower emissions is primarily a cultural issue. For a successful I/M program, there are several requirements: very strict enforcement, public awareness, good inspector training, and separation of testing and repair. Government enforcement and auditing is also very important.

Climate change is another important factor. Anthropogenic emissions have a discernible effect on the climate. CO₂ accumulations in the past 150 years are substantial. Ozone is also a potent greenhouse gas, and background ozone is increasing. In urban areas, higher temperatures also aggravate the ozone problem, as we have seen in Los Angeles, which has

had its 10 warmest years on record within the past 15. It is hard to say what the outcomes of climate change will be for all cities, but with some cities getting warmer, ozone will be more difficult to control. There is also a growing body of evidence that diesel soot is also a quite potent, while short-lived, greenhouse gas.

We have not turned the corner on CO₂ anywhere in the world, and most cities have a high capacity for further growth in the vehicle population. Currently, the most populated countries (such as China, India, Indonesia and Brazil) have the lowest number of vehicles per capita. If cities follow the Los Angeles model and spread out, there will be a greater need for vehicles, and the model will be self-reinforcing. The correlation between GDP per capita and vehicles per capita is very strong, and will continue to be so when left to the market without strong policy interventions.

The International Council on Clean Transportation has developed 43 principles. Some of these policy fundamentals include the following:

- Clean vehicle strategies should consider both air quality needs and energy needs in parallel.
- Clean vehicle strategies should pursue inherently clean vehicles and fuels.
- Clearly defined roles for the national, provincial and municipal government benefit everyone.
- New vehicle standards should be fuel neutral.
- Countries that are developing a new vehicle industry should base their efforts on new technology to avoid becoming a dumping ground for old standards. 12 companies in the world make 75% of the world's vehicles, and they all know how to make the lowest emitting vehicles.
- It is not necessary to follow the old sequence; the technology exists for us to leapfrog.
- Vehicles and fuels are a package.
- Low pollution and efficiency are compatible, not conflicting, goals.

Discussion

Dr. Mario Molina noted that the auto industries are part of the dilemma: higher income leads to higher motorization. Here in Mexico, making and selling cars is an important part of the economy. However, we have to think of car ownership as different from car use. Dr. Walsh responded that, for this reason, we need systems such as BRT, which provide attractive alternatives to automobile use. A faster and more comfortable ride to work is a more attractive option. If public transit is not attractive, it will not work.

In response to a question about NO_x emissions and fuel efficiency, Dr. Walsh explained that there are tradeoffs between NO_x and particle emissions and fuel efficiency in a conventional diesel engine. When the EPA tightened NO_x standards, it was shown in the lab that vehicles were complying. But, in the auto industry, there was a corresponding revolution in the electronics of heavy-duty vehicles. Someone realized that if you change the chip so that it knows when you are running the test, it is possible to cheat. This discovery led to the largest enforcement action in the history of the EPA. In terms of the compromise between NO_x and fuel efficiency, one solution is post-treatment: retaining fuel efficiency, but cleaning up the NO_x emissions coming out of the tailpipe.

Dr. Ivo Allegrini noted that there is a clear correlation between growth in income and number of vehicles, but asked about the link between income and vehicle kilometers traveled, or the number of hours that each car is used. According to Dr. Walsh, the number of km per vehicle traveled has also tended to increase with income, but, as suggested by Dr. Mario Molina, we have to use policy measures to break this link between vehicle ownership and vehicle

kilometers traveled. Dr. Dario Hidalgo added that another important aspect of breaking this link is promoting non-motorized transport, where the only emissions are sweat.

2.2. Mexican Perspective on Fuel and Technology ***Nicolás Rodríguez (PEMEX)***

In this presentation, we will look at average fuel quality and fuel quality trends in Mexico, including a proposal for the introduction of Ultra Low Sulfur Fuel (ULSF), and the investment requirements needed to introduce ULSF in Mexico.

Compared to US and European gasoline, the percentages of aromatics and olefins in Mexican fuel are similar on average, but higher outside of the metropolitan areas. For the metropolitan zone, PEMEX Magna compares well with US fuels, except for the sulfur content, which is 398 ppm, compared to 250 ppm for conventional fuel in the US. Mexican diesel is high in cetane and sulfur, and presents a challenge. For diesel fuel the sulfur level is 370 ppm, compared to 331 ppm in the US and 150 ppm in Europe.

The Mexican Ministry of the Environment (SEMARNAT), the Ministry of Energy (SENER) and PEMEX drafted an agreement last year to introduce ULSF. Sulfur levels for PEMEX Premium will be brought down to an average of 30 ppm by 2006, with 250 ppm by 2004 and 2005. For PEMEX Magna in the metropolitan areas, 30 ppm will be introduced starting in 2008.

The “technology road map” needed to achieve ULSF dictates that the technical and economic processes required to introduce ultra-low sulfur fuel be established on a refinery-by-refinery basis. Specific technology standards will be set for each refinery, and each will be allowed to set a different scheme of processing depending on individual cost and technological need.

What are the investment requirements to move to higher quality fuels? First, Norm 086 regarding the sulfur levels of gasoline and diesel and Norm 085 for the recovery of sulfur during the desulfurization process must be satisfied. All of these investments will be considered to find the most profitable profile. Introduction of ULSF will require 3.3 billion dollars of investment. SENER and SEMARNAT are looking for the approval of the Treasury (Hacienda) to make this investment; otherwise, ULSF will not be introduced according to the proposed schedule.

Regardless of the new sulfur limits for PEMEX Premium established this year, we are waiting for the new price to be approved by the Treasury. In addition, PEMEX Diesel with 300 ppm maximum is offered in the metropolitan areas.

2.3. Impacts of Speed and Driver Behavior ***Menno Keuken (TNO-MEP, the Netherlands)***

This presentation will discuss a case study of a highway in the Netherlands, with a volume of 130,000 vehicles daily, 5-10% of which are heavy-duty trucks. This highway had important environmental impacts related to noise and air pollution, with levels exceeding EU standards, and was generating adverse health impacts within 100 m of the highway. Active local citizens groups wanted something to be done. There were three options to deal with the problem: (1) reduction of traffic volume, (2) reduction of specific types of traffic, e.g., trucks, and (3) improvement of traffic dynamics (e.g., avoiding stop and go) by ensuring that vehicles were moving smoothly on the highway using 80 km/hour speed trajectory control. This third measure was chosen as the most technologically and economically feasible option of the three.

Emissions factors depend on speed. If traffic is flowing between 20 to 50 km/hr, then NO_x emissions are approximately 0.3 to 0.5 grams per km. At speeds between 50 and 90 km/hr, emissions are at their lowest point, and above 90 km/hr they get higher again. Therefore, optimum emissions occur when traffic is flowing between 50 and 90 km/hr. The question was how to get the dynamics of the traffic within this speed range.

On a 3-km stretch, a maximum speed of 80 km/hr was established for both autos and trucks. Normally, cars move at 120 km/hr and trucks 80 km/hr. As cars enter this zone, cameras photograph the license plate and measure the speed. If a car goes over this 80 km speed limit, the driver is sent a large fine by mail. Noise reduction was addressed using a noise screen along this stretch of highway.

The initial capital investment in cameras and speed detectors was 1.5 M Euros, and annual maintenance totals 0.5 M. However, 7 M Euros per year are received in revenue from the 250,000 speeding fines collected annually. Therefore, the benefits of this project greatly outweigh its cost. At the beginning of the project, approximately 3,000 people were fined each day. The number has now fallen to 1,000 per day.

The key question is whether this was effective in reducing emissions and noise impacts. During the experiment, measurements were taken at the site and downwind. A major drop in the average concentrations occurred 50 meters downwind from the highway. NO levels dropped significantly 50 meters downwind, while 200 meters from the site the reductions achieved were not as significant. However, NO₂ was substantially improved as far as 200 meters downwind. The improvement in PM₁₀ 50 meters downwind was quite large.

The overall conclusion is that mobility improved from this measure, with less congestion as people drove at more even speeds. In addition, there were air quality improvements of 5 -10% of NO₂ and PM₁₀ up to 100m. Noise was also reduced, especially at night when cars used to speed through the area.

Discussion

Dr. Ralph Gakenheimer raised a question about how they were able to keep cars from falling below the “optimal” speed range. According to Dr. Keuken, much of the congestion was pushed upstream, since this was a local measure designed to help a local air pollution problem. Therefore, it was not considered in the analysis.

Dr. Sussman asked if there was any prior publicity to give people a warning. Dr Keuken responded that there was publicity and people were interviewed about the program. Initially, there were a lot of complaints, but they disappeared as people saw the mobility benefits.

Regarding the earlier question, it was noted by a participant that pushing congestion elsewhere is not necessarily good, and there cannot be a good cost-benefit analysis without considering the impact on time savings. Dr. Keuken added that many of the truck drivers interviewed said that due to the smoother driving, they had fewer stops and starts, and therefore less tension on their trucks, promoting safer driving. The gain in timesavings along the 3-km stretch was only 10 seconds, which isn't that much.

Dr. Longhurst added that since poorer people tend to live near the highways, there are social justice issues here as well. Dr. Anderson also noted that this type of measure could reduce

traffic, since congestion is caused by variance in speeds, so evening out the speeds is an interesting traffic experiment.

Finally, in response to a question about where the 7 M Euros in revenue goes, Dr. Keuken responded that it is considered general government revenue that goes to no particular use. The government did not expect so much money to come in from this project.

2.4. US Inspection and Maintenance Programs ***Robert Slott (MIT, USA)***

Most of this information comes from a report prepared for the State of Wisconsin, published in June 2002 (*Literature and Best Practices Scan: Vehicle Inspection and Maintenance (I/M) Programs*, Project Number 0092-02-09). In reviewing the I/M programs in 31 states, the study found that 12 states have test only, 15 have test and repair, and 4 have combined programs. Of these programs, 16 tested for NO_x, 7 included diesels, 10 used IM240, 9 used ASM, and all planned to include OBDII (On-Board Diagnostic) inspections on a pass/fail basis.

In addition to the comparison of testing practices, the study found that there is I/M research ongoing on low-income repair assistance in California, finding liquid leakers in Arizona and California, and remote sensing clean screening in Missouri and Colorado. Many programs are interested in the possibility of remote sensing to identify high emitters.

OBDII is a high-tech system being used for inspection in many states, but there is a need for motorist education and some potential for cheating. OBDIII equipment includes the Vehicle Identification Number (VIN), and a Security Number, and the time since codes were cleared.

For heavy-duty diesel PM emissions, there are two standard tests for smoke: SAE 1667, and Snap Idle, which is cheap, but easy to cheat and thus needs very good quality control and assessment. Also, Snap Idle results often do not correlate with on-road PM emissions. There is no state currently testing for heavy-duty diesel NO_x emissions because the dynamometers are too expensive.

The recommendations made to the state of Wisconsin from this review of best practices were: i) look for liquid leakers (a program with potentially large benefits); ii) wait to see what happens in other states with diesel testing (currently unreliable and expensive), and with remote sensing for high emitter identification (high false-pass and false-fail rates); iii) adoption of OBDII, with inspections done in alternative, low cost, customer friendly, and convenient ways.

2.5. In-use Emissions Testing in Mexico ***John Rogers (Trafalgar, Mexico)***

Emissions testing in Mexico City began with a voluntary inspection program in 1982. Annual emissions inspections were made obligatory in 1998 for vehicles dated 1982 and earlier. Obligatory testing for all vehicles began in 1992, and in 1993, the first multi-lane “macro-centers” were opened. In that same year, dynamometer tests were introduced for intensive-usage vehicles. Later, when problems were found in the system, the test and repair centers were closed in 1996.

Test and repair is very convenient for vehicle owners; however, 50% of the vehicles obtained their approval certificate fraudulently. Garages discovered that they could begin charging for repairs, which were not made, and fraudulently passing vehicles without being detected. The

public saw this as a highly faulty emissions control program. Public perception is very important. The program must be seen by the public as effective, objective, transparent, and control gross polluters. Therefore, the inspection should use good test procedures, and be enforced, supervised, and audited. False passes damage public acceptance.

Use of test-only inspection stations allows for good technical and administrative controls. Dynamometers were essential to reduce cheating, since it is easy to cause a false pass on static tests. Dynamometers are also the only way to test for NOx. A two-speed test was used because the focus was on heavy polluters, and the test was able to catch them.

New Verificentro stations have improved user friendliness, with simple details such as an improved color scheme. However, social memory is long. A recent survey by the Reforma newspaper asked if anyone ever asked for money for the respondent's vehicle to pass the test; 50% said yes. Even though the program is now more cheat-proof, people still remember the time when the program was corrupted. One good indicator of the program effectiveness is how much it costs to get a false pass.

Recent changes include the use of digital video via the Internet and near real-time data transmission. The government is strengthening computer-based remote auditing and the legal framework to avoid corruption. However, better calibration controls are still needed.

Recommended lines of action include developing a dynamometer-based diesel test procedure and dynamometer tests for AWD and ATC vehicles, considering adding motorcycles to the regimen, and adding OBDII inspections. There is a need to strengthen real-time remote auditing and real-time data on the Internet for transparency. Strong QA/QC and frequent evaluations of program effectiveness are essential for proper administration. Right now, the data is on the Internet, but with a long time lag. Strong QA/QC is required, because there is competition between different Verificentros. Probably the biggest change needed is to have a unified government-owned software program, which would operate on all of the Verificentros. This will eliminate a lot of the variability.

2.6. Traffic Air Pollution Control ***Francesca Costabile (National Research Council, Italy)***

This presentation will describe air pollution monitoring systems and applications of Intelligent Transportation Systems (ITS) for air pollution control in three cities: Beijing, Milan and Suzhou.

Beijing has a total area of 16,800 km² including 1,040 km² of planned urban area and 500 km² of built area, with approximately 13 million inhabitants and about 2 million vehicles, half of which are extremely old. Tailpipe emissions far exceed the Euro I standard, despite its introduction in China. In 2002, Beijing met the national daily air quality standard 55% of the time.

The project described here was to apply ITS to address traffic-related air pollution problem in Beijing. The action scheme requires a data center, which acquires and manages the information on traffic flows, air quality, and public transport operations. Using a simulation model for traffic flows and pollution levels, the data center produces various scenarios for traffic management plans, including whether or not to impose traffic restrictions.

The system receives data from air monitoring stations, and in cases of high levels of pollution, asks the Municipal Traffic Management Bureau to authorize traffic restrictions for polluting vehicles. Under these restrictions, traffic-monitoring stations (TMS) prevent polluting vehicles

from entering the restricted areas. The data center also asks for the public transport management subsystem (PTMS) to provide extra buses to compensate for traffic restrictions.

Turning to the case of ITS in Milan, the system is centered on a data center, which receives information from traffic monitoring systems, the air quality monitoring system, and the public transportation management system. The Milan system integrates 160 digital traffic counters to count and classify the vehicles entering and leaving the city, 316 centralized traffic lights to measure the traffic dynamics, 40 Limited Access Zones to control the vehicle access credentials, 25 violation detection systems, 17 variable message signs, and 20 video-cameras for video-surveillance. The system allows for the collection of a wide range of data, including vehicle counts and speeds, time-gap, queue estimation, automatic crash detection, and travel time estimates based on a dynamic origin-destination matrix. The video processing also allows for features such as license plate recognition in restricted access areas, and automatic enforcement of speeding and red-light-running, with video evidence of a car's license plate number and the surrounding location.

Suzhou is a city near Shanghai and with 2.7 million people. Its ITS system is based on an air quality monitoring system which measures the concentrations of emissions in space and time, focusing on SO₂, NO₂ and PM10. The monitoring network structure uses 9 fixed monitoring stations, 1 conventional mobile station, a fleet of innovative mobile stations, 20 saturation monitoring stations, and a data center.

Professional capacity building is another important part of this program. The city of Suzhou uses the data of air pollution monitoring for land-use planning. It has produced a pollution concentration map to help guide urban planning and city changes. Major pollution sources and hot spots are also identified. All of these projects are in the context of the Sino-Italian Cooperation Program for Environmental Protection.

In conclusion, ITS systems require air quality monitoring systems able to observe minimal variations in emissions and concentrations. The effects of local meteorology are extremely important. The best environmental information is derived from a proper combination of high-tech and low-tech monitoring devices. Low-tech (yet accurate) devices may be extensively used in developing countries.

Discussion

Mr. Samaniego asked how they were planning to “manage” the people. What happens if they cannot arrive to work in the emissions free zone, or if they are unable to return home? Dr. Costabile replied that the system is able to provide extra buses, and also manages parking spaces for cars and for buses. Alternative trip modes and public information are available. Dr. Ivo Allegrini added that the power of this system is to collect all kinds of data on traffic and air pollution – data that can be used and dispersed among different agencies. For example, car accidents can be detected and acted upon more quickly.

Friday, January 23, 2004

Session 3: Managing Demand: Economic Instruments

3.1. Pricing, Planning and New Technology: Are they alternatives?

Christopher Foster (RAC Foundation for Motoring, UK)

The focus of this talk is on the objectives of congestion pricing and how to implement the program. Cheaper instruments can produce the same objectives. Pricing objectives include:

1. To alter behavior to reduce congestion. This is what we're most interested in.
2. To raise money. But when that becomes the overall objective, you get the wrong answer. Politicians will want to push up the price to raise money, and settle for sub-optimal results in terms of the behavioral changes you wished to obtain.
3. To give signals for investment and development. But you can also get signals of divestment and contraction. By imputing values of time, lives saved, and road maintenance, you can work out financial rates of return for the road and compare them with other projects. Life becomes simpler for calculating rates of return for roads. Environmental costs and benefits can be brought in as well. Then the equilibrium size of the network can be worked out.
4. To compensate losers. By generating money, you have funds to buy off the opposition. This is as important a part of the design of any road-pricing scheme as anything else.

Objectives 2 and 3 are most important in the private sector, while objectives 1 and 4 are more important in the public sector. While all four should be looked into, they can clash.

Sir Christopher was introduced to road pricing as a member of the Smeed Committee on Road Pricing in 1962, together with Alan Walters, Michael Beasley and Gabriel Roth, considered the evangelists of road pricing. A major issue was how to implement the program technologically.

Various problems came up in the discussion. First, in the inter-urban toll road the marginal cost is lower than the average cost. Second, what is the respective role of planning and pricing in cities? Third, should one price be used to reflect current demand and supply? If you are trying to influence people's behavior then you need to have instantaneous, correct prices. Finally, what are the social costs? Congestion is the most important cost in transportation, relative to environmental costs; there are other social costs to consider such as road safety. All of these issues have to be taken together.

Why has it taken 40 years to arrive at the London road-pricing scheme? One reason was the slow development of technology, but was this a response or a cause? The main reason was that better management of existing roads through traffic engineering bought 40 years. These programs cannot continue to manage congestion indefinitely, is there much more time left? There was also the problem of the catchment area and of how to deal with the occasional user. Singapore didn't have this type of issue. It is easier to deal with an island. In London you have the problem of carving out areas where you'll have a pricing system.

Beliefs often interfere with proper implementation. These beliefs include the idea that one can invest one's way out of the problem by building more roads, or by public transport (without pricing to divert traffic). Another is that traffic can be diverted or deterred without investment (which only makes congestion worse). Another belief is that one can plan one's way out of the problem without demand management, which is very slow. Lastly, there is the belief that the problem can be solved through new forms of transport. But in all of these things, the biggest

barrier to be overcome is political resistance. Before the program was put in place, there were huge uncertainties about the technologies and about behavioral reactions. There was also the common belief that pricing is a private sector activity, not what government should be doing. There is also frequently a preference for controls without considering the side effects. For example, parking policies can lead to non-optimal side effects while land-use changes are often very slow or difficult to enforce. There are also concerns about the poor. There is public misunderstanding in the polls.

How acceptable is road charging? It had to be proven to the UK Prime Minister that this would be a popular measure. A number of polls were taken. A survey was conducted (NOP Automotive Survey, March 2002), which asked the following questions:

“In the future would you be willing to pay tolls to drive in city centers?” Results showed:

- By geographical region: UK 43% yes and 55% no. Scotland 36% yes and 62% no. London 39% yes and 61% no. The further away from London, the more likely to accept tolls.
- By age: the older they were (65 years old and over), the more willing they were to accept it (47% said yes). The opposite is true for younger people (out of 17 to 24 year olds surveyed, 69% said no).
- By social class: Social class AB 58% yes and 40% no. Social class C2 38% yes and 62% no. The higher income groups were more willing to accept the measure.

“How acceptable would road tolls be to you if there were equivalent reductions in fuel duty?” 18% said it would be unacceptable while 76% say it would be acceptable.

“How acceptable would road tolls be to you if roads improved to guarantee better journey times?” This is important not because of the improved travel time, but because of the improved travel time reliability. 71% said it would be acceptable and 22% unacceptable.

“How acceptable would road tolls be to you as part of a package of better roads, public transport and traffic management?” 71% replied acceptable and 23% unacceptable.

“Which is the top priority for spending the money generated from tolls?” The public responded as follows: road maintenance 19%; better roads (widening and bypasses) 32%; public services 12%; and public transport 34%. This reflected an understanding that if road use is limited other options must be available. There was less support for spending the revenues on road building than was anticipated.

General poll findings were that 60% felt it would be fairer if motorists paid taxes according to the amount of time they drive in congestion rather than paying a tax on fuel and tax discs. Only 22% argued that tax on petrol is a better way of restraining traffic than charging a toll on congested roads, but this isn't true.

Furthermore, 69% disagree with fuel tax rising by a given annual percentage. 58% think that if charges are introduced for using congested roads there should be concessions for those with low incomes. 52% think that the use of satellites to monitor the location of cars is an infringement of personal liberty. That is probably what finished off the Hong Kong scheme. There are concerns about the private or public misuse of the personal data.

Six months after the implementation, more than 50% of the London residents supported or tended to support the scheme, compared to around 30% who opposed or tended to oppose it. A full copy of the “Congestion Charging: 6 Months On” study can be found at: http://www.tfl.gov.uk/tfl/cc_intro.shtml.

How does one overcome resistance? There has to be as much public discussion as possible. There needs to be dissemination of information from the existing programs, now that the London example exists. Knowledge of elasticities of demand and of substitution (modal and other) needs to be built. Also, modeling for the national network needs to be done including several scenarios: the “do nothing” scenario, an “allowing for congestion” scenario, and a “for congestion charges” scenario. Also, one needs to model the effects of improved bus and other public transport, altered traffic engineering, new investment to redirect traffic flows, and land-use changes that might help relieve congestion.

The document explained what combinations of increased capacity and motoring charges in UK would avoid an increase in congestion. It also included what combination of annual increase in motoring charges and capacity expansion would be required to control congestion. Pricing is an essential part of the system.

In terms of planning for congestion charges, success depends on having reasonable approximations of the elasticities, and on the availability of substitutes, with careful consideration of what those options are. Buses are almost always the cheapest option. . Even in London you might need less transport-intensive land use solutions. You could probably get everything you want with buses. The subway might not be necessary.

The slowest to warm up to the road pricing idea were commercial centers in London because they were concerned that activity would decline. But the general impression is that commerce has not lost out. Before the pricing set in there were arrangements made. People organized themselves in different ways, minibuses appeared, and some businesses moved to another location. People will adjust if they are given enough warning.

Economics has different roles in tackling congestion and improving the environment. Pricing and regulation are often a constraining influence. It is foolish to rely too much on the pricing scheme when the new technologies haven't arrived. To try to instantly price before the technology is there is not sensible. It is also not sensible to rush science and have the danger of getting it wrong. Scenarios and targeting within a well-defined model structure are needed at the national and local levels. It is necessary to use economic criteria.

The best way to improve the environment is with fuel and vehicle technology. Introducing technology is key, and the process is already moving fast. Competition between manufacturers is vital. In a globalized economy, there are pluses and minuses with new technology. As cleaner fuels are introduced there is something to be said for giving people discounts to adopt them, but this shouldn't be done for too long because then price will be below economic production for too long.

Economic criteria should be used to find out the pros and cons of new technologies, fuels and traffic reductions. The general context is more important than the actual prices.

Many other solutions have drawbacks that emerge over time. There are environmental improvements from pricing that also have to do with technology. If you have information about pricing this can also help you figure out how much to invest in infrastructure.

Sir Christopher does believe that the time has come for pricing to be considered to solve the major problem of congestion. All of the other mechanisms to deal with congestion cannot get you all of the way, and can only buy time. Pricing does make it easier to calculate what your investments should be in traffic improvement.

Discussion

Dr. Gakenheimer commented that in Latin American cities, congestion pricing might be easier to enforce than “no driving days” program. Congestion pricing is a more stable scheme than finding substitutes for one day a week. The “no driving day” imposes a difficult decision for the household locator. Paying a given amount of money is a more stable form of expectation than the consideration that a household has to give to its travel decisions on the no drive day. He asked Sir Christopher for his view on managing the situation of the poor in congestion pricing and also about reported sales declines in downtown London.

Sir Christopher agreed that car-free days are very disruptive for car owners: suddenly they have to do something terribly important and can't get around easily to do it. The Beijing scheme is even more disruptive. A congestion pricing scheme would be much more stable, and people want predictability. The secret to overcoming the issue of the poor is to give them a bus service that they can use rather than money or rebates. *Colectivos* in Mexico City are a problem but they are also carrying a great number of people. If people are not going to use their car then certain amounts of *colectivos* going in all sorts of directions is what you expect to find. Having more reliable *colectivos*, instead of eliminating them entirely, is important.

Regarding sales decline, Sir Christopher mentioned that it is very difficult to disentangle the effects of the economic downturn and the pricing scheme.

Dr. Sussman inquired if people were asked in the surveys if they would want the revenue to be used to reduce fuel taxes. Sir Christopher replied that there wasn't much discussion about this because it had already been decided that the revenue would be used for public transportation.

A question was raised if they had modeled or looked for any rebound effects, that is, after a while, people get used to the congestion charges and may go back to using their car. It may eventually turn out to be more convenient to pay and use the car. Sir Christopher said that this hasn't happened yet, but it wouldn't be the end of the world if it did. If the bus services are good enough this may not happen. Short-term trips are more likely to be made by a bus. If this rebound were to happen, there would be a further price increase.

Another question was whether or not the developing world is ready for congestion pricing, in Sir Christopher's opinion. Congestion pricing happened in a highly orderly society unlike many of those in the third world (Cairo, for example). Is this applicable now or do we have to wait until we have a more mature infrastructure in developing countries? Sir Christopher said he doesn't know, but the more he learns about Latin American cities, the more he thinks there may be a role for congestion pricing.

Another comment was with respect to social injustice. The congestion-pricing scheme separates people by income. Some can pay and benefit immensely, there is another group that should have some sort of waivers. Diplomats and officials are also exempt. The result is that up to 50% of people get a better quality of life than the rest of the population, generating a big

injustice. Are there any alternatives? For example, a once a week waiver could decrease congestion and give equal opportunity to all.

In Sir Christopher's opinion, that kind of exception scheme would be less efficient. You have to find good transport substitutes for the losers so that you don't need a huge reduction in congestion. Congestion on the margin changes in a disproportionate way.

In response to a question about the impact on London businesses in the zone, Sir Christopher responded that there were some changes, but it is hard to disentangle the effects of congestion pricing from the effects of reduced tourism and the economic downturn. Anecdotally, he described a company whose sales at a store outside the ring increased, while their store inside the ring saw decreased sales.

Dr. Allegrini commented that he is strongly against road pricing. He is not convinced that there are environmental benefits. What will the public say when there are no environmental benefits after one year? To this Sir Christopher said that the public isn't looking for environment benefits, they are looking for congestion benefits.

Dr. Slott raised concerns about Latin America. It is important to study how and whether the money is collected, to reduce the incentive to cheat. Vehicle databases are also very unreliable. One would need to have a cash collection scheme, something like electronic toll collection, satellite monitoring or an EZ pass. These all have privacy implications.

Sir Christopher said that in London there have been cheaters as well. But you can cope with this within the margin through public information and education. People need to understand that they are cheating themselves. Do people really want to be spending so much time in traffic? This message has to be used to persuade the public. Dr. Gakenheimer pointed out that this doesn't have to be high-tech solution. In Singapore they simply had people buy daily passes and put them on their windshields.

Dr. Richard Mills made a comment regarding environment issues. A national extension of the scheme is seen by the environmentalists as the best way to get environmental benefits.

3.2. Central London Congestion Charging ***David Hutchinson (Greater London Authority, UK)***

Dr. David Hutchinson works for the Mayor, through the Greater London Authority (GLA), not for Transport for London. GLA has responsibility for metropolitan police, fire responders, and economic development planning. He is primarily responsible for environmental policy, but had input into the design of the congestion-pricing scheme. Transport for London is responsible for managing the main road network, the bus network, and the Underground. In addition, 33 separate municipalities manage the local secondary road network and are responsible for local air quality management. When Ken Livingston was running for Mayor of London in 2000, it was clear that an important part of his platform was to introduce congestion pricing.

In the creation of the Greater London Authority, a study (ROPEALL) advocated road user charging in London. It conducted a detailed analysis, considering air rails as well as classes of vehicles, and road uses. The study was available prior to the drafting of the general act the mayor put in his election manifesto.

The population of Greater London, the largest urban area in Europe, is just over 7 million, and is growing. There are 1 million workers traveling to the heart of London every day. London suffers the worst traffic congestion in the UK, with average traffic speeds of 15 km/hr. About 250,000 vehicles operate in central London and make 450,000 movements. Drivers typically spend half their time in queues. There is an estimated delay of 2.3 minutes per kilometer driven within central London and average traffic speeds are 8 km/hour. Congestion was increasing, costing people and business time and money. There was a general acceptance that something had to be done.

The Mayor was required to produce strategies for the long-term development of London. Therefore, congestion charging was part of a wider strategy, which was integrated with public transport, parking and loading enforcement. The number one priority was tackling congestion. There was extensive public consultation that took place over 18 months. Public transport improvements were undertaken in advance, and there were improvements in associated traffic management. They also made a commitment to monitoring schemes to analyze the before and after effects of the program. There was a lot of background and a lot of thought put into the plan. About 300 extra buses were put into the fleet prior to the start of congestion pricing.

How does the congestion charging scheme work? A small area of 22 km² is subject to the pricing in central London. It amounts to 1.2% of greater London. The area was chosen because it is characterized as the central business district (CBD), the major financial and shopping district. The population is only about 130,000. This area was also surrounded by perimeter roads that could reasonably act as its boundaries.

Payment is for an individual vehicle registration. There is a flat charge of £5, Monday through Friday, 7:00 AM to 6:30 PM, for all vehicles. Payment is by post, telephone, Internet, SMS, self-service machines, retail outlets, and some petrol stations. Payment is available up until midnight, but the charge rises to £10 if paid after 10 PM. It can be paid weekly, monthly, or annually. The times were set through extensive public consultation, after it was discovered that theaters would be affected negatively if the charge was in place until 7:00 PM.

Enforcement is possible by keeping track of the vehicles coming in. Vehicles are identified via their front license plate using fixed and mobile cameras. The cameras are linked to automatic number plate recognition technology. There are 203 fixed camera enforcement sites and 64 traffic monitor sites. All camera sites have dual cable systems for redundancy, making monitoring fail-safe. One camera (an ANPR) takes a monochrome image while another takes a color contextual image. If there is a record of payment, the image is deleted. If no record of payment is made by midnight, an £80 penalty charge is sent to the registered keeper of the vehicle. Vehicles of persistent evaders are clamped and/or removed.

Key exemptions and discounts are available for motorbikes and mopeds, military vehicles, emergency services, taxis and licensed minicabs, disabled persons (6,000 average per day), buses, coaches and minibuses, certain alternative fuel vehicles (the only explicitly environmental measure in the scheme), breakdown and recovery vehicles, and certain health service workers. There is also a 90% discount for residents of the zone. There are 26,000 residents in the zone, and 16,000 vehicles were registered for the resident discount.

The projected impacts were a reduction in traffic inside the charging zone of 10-15% and 2-3% in inner London. The scheme was predicted to cut traffic delays by 20 to 30% inside the charging zone and 5 to 10% outside of it, and to help bus operators, improve journey times, and enhance reliability. Net revenues were pegged at £130 million per year.

Revenues in the early years (short-term) were earmarked for the bus network (including night services), network accessibility, safety and security, as well as for benefits for pedestrians and cyclists at interchanges. Revenues were also planned for accelerating road and bridge maintenance. There would be transport funding for local authorities. In the long-term, investment was planned for expanding the underground and rail capacity, providing new services across and around London, constructing new river crossings of the River Thames, improving access to London's town centers, implementing train or segregated bus schemes, and making selected improvements to London's road network.

Public transport improvements were done in conjunction with pricing. There were substantial enhancements to bus capacity (new routes, frequent increases on existing routes, and introduction of larger buses). A new 24-hour service was put in place. Bus fares were frozen. There was better enforcement of bus lanes. Better information and security were provided. There were also some improvements to underground and rail.

To monitor impacts, a comprehensive 5-year monitoring program was put in place. It was to monitor traffic patterns and conditions, public transportation operation and passenger levels, social impacts (including those on vulnerable groups), business and economic effects, and environmental impacts (air quality in particular). Case study results were scheduled to be published every year. The first Annual Report was published on June 3, 2003.

Early successes included a 20% reduction in traffic entering the zone. Many expected chaos around the perimeter, particularly on the first day of introduction. Sample traffic decreased by 16% within the zone. Sample traffic speeds within the zone increased by 10-15%. There was also no increase in traffic on the Inner Ring Road. There were no significant changes in the traffic levels outside the zone. Around 100,000 payments were received each day. Most payments were made through retail outlets (37%), 25% were made via the web, 18% were made through SMS, and 20% were made through the call center (of which 6% using IVR).

Public transport was able to handle displaced car users, and bus patronage increased by 14% in the peak hour. Furthermore, bus delays due to traffic congestion dropped, and bus speeds increased, as did bus reliability measured in excess of wait time (in minutes). Bus delays due to traffic congestion decreased both in the charging zone and in the inner ring road. Last year, about 2.7% of kilometers were not operated in the charging zone and 3% were not operated in the inner ring road due to delays; this year those numbers declined to about 1.3% and 1.6% respectively. Last year, bus speeds were about 11 km/h in the charging zone and 12 km/h in the inner ring road; this year they were 12 and 14 km/h respectively. Excess waiting time was about 2 minutes last year in both the charging zone and inner ring road; it is about 1.5 this year.

The scheme was introduced on Monday, February 17, 2003, due to lower average traffic during that week. There were about 60,000 fewer car journeys, indicating that 23% of journeys were diverted from area. There was a 16% reduction within the charging zone. From the total diverted, 15-16% of those journeys shifted to public transport. Average traffic speed in the zone was raised from 14.2 to 16.7 km per hour. Travel delay (compared with free flow) had been 2.3 minutes per km, but dropped to 1.7 minutes per km; this drop represented the lowest delay recorded since traffic data gathering began in the mid-1980s (and represents a 26% improvement). Traffic on the inner ring road was not affected.

The key issues that we had overcome included transferring theory into practice in 33 months, presenting congestion charging to the public, creating the organizational arrangements,

managing a complex project, improving public transport, managing traffic around the charging zone, and providing public information.

Revenue was, in a way, a victim of the success of the scheme. There are 100,000 payments per day. Revenue projections were made on a basis of a 20% reduction in traffic, while the actual reduction was 28%. There were also more exempt vehicles (those for the disabled or using alternative fuels) than expected. There is also evidence that businesses are looking at their operations and improving efficiency, particularly in terms of delivery. The result was fewer commercial vehicles, again reducing the revenue gathered. There was also higher evasion than had been anticipated; there was some criticism of the company handling that operation.

There is now discussion of extending congestion pricing into a wider area in London. There is a debate on whether there should be two separate zones or one larger zone. London assembly suggested that it would be better to have two areas so that a resident in the western extension who wants to go to the main center should pay the full fee instead of the discount. All of this is up for discussion.

In terms of London-wide pollution monitoring, there was no discernable effect on air quality, but no effect was anticipated. This is traffic and congestion management, not an air quality scheme. We have probably seen improvements in air quality at the level of individual streets.

Discussion

Dr. Allegrini asked if the use of parking charges, as in Rome, would not be a simpler scheme than congestion pricing. Dr. Hutchinson replied that a parking scheme does not deal with parking spaces within commercial buildings, which cannot be charged. These commercial buildings have large numbers of parking places in their basements. There has been a lot of discussion about introducing legislation allowing enforcement of parking fees on public roads but it has never been close to materializing. A parking scheme would also not deal with through traffic which never parks. Dr. Gakenheimer added that parking ownership is highly disaggregated, with many establishments offering free parking to employees and patrons.

In response to a question about the criteria for the choice of size of the congestion-pricing zone, Dr. Hutchinson said that there was talk about an extension of the area. This criterion was the availability of ring roads to clearly define the boundary. If you go much further than the ring then there is no clearly defined division, and you have to go a long way to find a diversion route. It would be possible to extend the area in some places but would require much more traffic management and changes in the road system, and implementation would have been very slow. This would have meant that it would not have been implemented within Mayor Livingston's first term, which was his political priority.

Dr. Molina mentioned that it seems clear that we cannot just transplant this to a Latin American city. In order to implement congestion pricing, important changes would have to take place. There seem to be two issues: the first one is the required infrastructure, vehicle registration, etc.; the second is the equity and fairness issue. If people oppose paying any fees to use roads because they believe that the roads are public and hence that they have the right to use them at no cost and at any time, then everyone ends up losing. There is, however, a way for everybody to win, by appropriately pricing the use of congested roads. How the government goes about working out the details and returning the income to the losers remains to be worked out, but this concept is well established. We can see this in the context of the tragedy of the commons. Is there something cultural, that we aren't ready for in some parts of the world, or is it simply that

the concept is misunderstood? Was there any sense in London of this fairness issue? The answer to this question was that there was a lot of discussion at the early stages. Improved bus services were one aspect. Night bus services were directly aimed for low income people, who most often work in shifts.

Dr. Hutchinson was also asked to elaborate on exemptions and any pressure that different groups might have exerted to become exempt. He explained that many groups came up with a good reason to be exempt, but not everyone was in the same situation as, say, an emergency ambulance. A participant noted that four highways will be constructed in Santiago and an issue was how to work on four different concessions while operating them. Many people do not pay the tolls and operation is complicated.

3.3. Designing Pollution Markets with Imperfectly Observed Emissions *Juan Pablo Montero (Universidad Católica de Chile, Santiago)*

This presentation discussed the advantages of pollution permit markets over traditional standard regulations when the regulator has incomplete information on firms' emissions and costs of production and abatement (e.g., air pollution in large cities). Because the regulator only observes each firm's abatement technology but neither its emissions nor its output, there are cases in which standards can lead to lower emissions and, hence, welfare dominate permits. If permits can be optimally combined with standards, however, in many cases this hybrid policy converges to the permits-alone policy but (almost) never to the standards-alone policy.

How do you design pollution markets with imperfectly observed emissions? The motivation behind this question is that policymakers are paying more attention to pollution markets (tradable permits) as an alternative to the traditional command and control approach of setting emissions and technologies. A notable example is the 1990 US acid rain program that implemented a nationwide market for electric utilities' sulfur dioxide (SO₂) emissions. In general, permit programs have been implemented for large stationary sources (e.g., power plants, refineries) that have been required to install costly continuous monitoring equipment. Is it possible to use permits to control air pollution in large cities such as Santiago de Chile or Mexico City that have numerous small (mobile and stationary) polluting sources? Or is it better to stick to standards given that continuous monitoring is not feasible? In the 1990s, the acid rain program was very successful, but it was easy because there were few fixed sources. This presentation discusses whether a similar system would be useful for vehicles.

Why does it matter that there is imperfect monitoring? When emissions are closely monitored permits can achieve the same emissions goals as standards, but at a much lower cost. If, however, the regulator can only monitor a source's abatement technology or emissions rate but cannot monitor utilization of the abatement technology (which translates into the firm's output), then actual emissions will be uncertain under either policy instrument. Under which instrument (permits or standards) are emissions likely to be higher? Some observers think that using permits can result in higher emissions because they provide firms with more flexibility to choose abatement, and hence, output. The regulator faces an instrument choice problem: permits reduce abatement and production costs but may lead to higher emissions than standards.

To address such a question Dr. Montero first developed a theoretical model with the following elements: there is a large number of firms, each producing output and pollution; there is a regulator with imperfect information regarding each firm's abatement and production costs; the abatement technology or emissions rate can be observed but not the output or any other direct

measure of emissions. Using the same monitoring requirements, the regulator controls emissions by either imposing a uniform emissions rate standard or allocating permits in an optimal manner (that maximizes social welfare). The permit design is based on an approximation of how much output will be generated (or how much the abatement technology will be used).

The results show that the use of permits leads to lower emissions than the use of standards, when the cost structure of the group of affected firms presents the following characteristics: firms with higher output are more likely to do more abatement (i.e., if there is a positive correlation between abatement costs and production costs) because costs increase with output; this is a correlation effect. Also, firms that are doing more abatement are at the same time increasing their output relative to other firms (i.e., there is a positive interaction between abatement and production); this is an interaction effect. If both the correlation and the interaction effects are positive, permits are always superior to standards in terms of their benefits to all of society (they maximize social welfare). This is because in that case, more of emissions will be reduced with the use of permits, than with the use of standards. If, on the other hand, one of these effects is negative, the superiority of permits over standards is no longer clear.

If one of the effects is negative, then there may not be as much abatement: there may be a negative interaction between abatement and production. This could happen because permits could create “perverse” incentives for firms to shift from cleaner to dirtier, increasing emissions. Firms that abate may decrease their output. Or firms that are producing at full capacity may be abating less. This means that the amount of “clean” output produced by all of the combined firms will be less than in the case of standards.

Would a hybrid policy, which combines permits with a standard in an optimal manner, work? By construction a hybrid policy cannot be dominated by either single-instrument policy, in terms of how much it can reduce emissions. Interestingly, there are cases when the hybrid policy renders the same emissions reductions as the permits-alone policy (for example, when there are no correlation and interaction effects). It is very unlikely that the hybrid policy ever achieves the same emissions reductions as the standards-alone policy.

Have permits ever been used under conditions such that monitoring the use of abatement technologies is difficult? In 1992, permits were implemented in Santiago to control total suspended particles (TSP) from about 600 stationary sources. Permits were grandfathered to existing sources. The aggregate reduction requirement was 40%. It was assumed that firms produced at 100% of their production capacity (although they may have produced at less than their capacity).

Was this a good idea? Using data on emissions rate and utilization, Dr. Montero recovered the cost structure of the group of sources affected by the TSP program. He found there is no interaction effect and a slightly negative correlation effect; meaning that when production costs increase, abatement costs decrease. Emissions were lower than if the firms had been subjected to a standards policy. Only 8% of gains from lower emissions were offset by a slight increase in emissions, as compared to what would have happened under a standards policy. A hybrid policy would add virtually no benefit in this case, relative to the standards.

Control of air pollution in large cities must rely on imperfect emissions monitoring. Is it economically sound to implement a permits policy with the same monitoring requirements as a standards policy? The theoretical and empirical analyses shown here suggest that permits should be used either alone or in optimal combination with standards.

Discussion

Dr. Montero was asked about the difference in terminology for permits. Permits have been used in many contexts in the US, including the SO_x program mentioned earlier and a NO_x scheme in Los Angeles. There was a big problem allocating the initial permits. In the US legal system, “permits” and “allowances” are not equivalent. Dr. Montero explained that he used the word permit as defined in the economic literature. But, permits are called allowances in the US legal system.

A permit-trading scheme for small sources was discussed. Having owners trade permits at their annual emissions verification would be problematic. Instead of doing this, one option is to buy and sell permits when one buys a new vehicle, for example, using them to cover vehicles with higher emissions. The owner of a new vehicle will not need as many permits and can sell them to the owner of an older, more polluting vehicle.

Dr. Ivo Allegrini noted that Italy has a program with emission standards and permits. Dr. Montero mentioned that Chile is planning a system where people would pay for the emissions of their car. Their car model would determine how much they pay. There were additional comments that emission standards are not popular because those less able to pay will be hurt most. On the other hand, permits are a good way of limiting emissions, because their use encourages people to look for less costly alternatives to achieve emissions reductions.

Session 4: Planning and Implementation Constraints

4.1. Planning Transportation Perspectives, São Paulo Metropolitan Area *Arnaldo Pereira (São Paulo Metropolitan Bus Authority, Brazil)*

The São Paulo metropolitan area has 18.3 million inhabitants and an estimated 3.6 million vehicles. It accounts for 16% of the national GDP because it is the largest industrial center. The São Paulo metropolitan area has 39 municipalities, as well as three other metropolitan areas within a 100-km radius. In the future there will be five other major metropolitan areas in the same radius. This means that we should consider inter-metropolitan transportation as well.

The Metropolitan network has a 60-km metro line, 270 km of commuter trains, and 33 km of bus corridor (with 4,000 buses and 300 intercity lines). The 39 municipal-operated bus systems provide 55% of the supply of public transit services, while the metropolitan-operated Metro provides 19%, metropolitan trains 8%, and intercity buses 18% of public transit in São Paulo.

Modal split evolution has been such that individual transport has gone up from 32% in 1967 to 53% in 2002, while public transport has decreased from 68% in 1967 to 47% in 2002. The highway system is not large. The age of the fleet is also a problem. About 1/3 of the fleet is cars that are more than 10 years old (31.8%), 6-10 year old cars represent 32.6%, 5 year old cars are 8.3%, and 4 year old cars are 5.4%. There are issues with the control and inspection of vehicles.

There are also critical institutional issues. São Paulo is not the federal capital, as is the case with Mexico City and Santiago. It is far away from the federal government, which doesn't really take urban problems into account anyway. There are problems with obtaining funds. The

Constitution of 1988 gave significant power to the municipalities, and the fragmentation makes it difficult to implement new policies.

There has been an “attack” of informal transportation, with municipal buses losing significant ridership (approximately 30%). This started because of unemployment - providing informal transportation is a job for the disadvantaged. Rail and intercity bus demand dropped slightly but remained more or less the same. This is because the metropolitan train was renewed and the metro network was increased.

It is not enough to provide transportation. It is necessary to gain public acceptance. According to an annual survey of public services, the Metro ranks high in public acceptance, while buses rank lower. Even people who do not use the service rank buses poorly. The São Paulo population likes the Metro and doesn't like the bus services, which are seen as a mode of transportation for the poor only. Surveys also identified the main issues people are worried about as public security and congestion. Pollution is not on the top of the list.

In the winter of 1996/7 there was a severe air pollution crisis, during which the government restricted 20% of the car fleet from 7 AM to 8 PM. In 1998 this became more of a traffic congestion tool, restricting 20% of the private car fleet during peak hours, 7 to 10 AM and 5 to 8 PM. Opinion surveys show that people assimilate the restrictions because they understand the need for them. Air pollution is no longer at the top of the priority list.

In 1998, an integrated transportation plan was developed in response to changes in the city, a lack of urban policies, and a lack of public transport. There was a major lack of urban planning, and the last urban plan for São Paulo was made in 1968. As part of the plan, an Origin-Destination survey was carried out, with 130,000 interviews and 30,000 households. MVA-Start was used for simulation of future conditions. Before that EMME/2 was used for local simulations and straight analysis.

One of the innovations of the 2020 PITV was intensive participation by municipalities, transport and traffic operators, NGO's and consultants. There are tools in place that allow for updating and adjusting the plan every 4 to 5 years, and looking at planning as a process. Strategies cover the mass transit network, medium capacity transportation networks, and the metropolitan road network.

Different proposals were analyzed for the municipal and medium-capacity road networks. New management strategies, such as update of traffic signals, parking restrictions, and freight operations restrictions, were also analyzed. Pricing and fare payment strategies, such as metropolitan-level transit fares and demand management, are also important. Pricing strategies, such as integrated and non-integrated fares, were tested.

Each strategy was analyzed and compared to the “do-nothing” alternative. If nothing is done, congestion will increase 30% and CO emissions will increase by 45% in the next 20 years. Indicators for the evaluation of the strategies included structural and social accessibility for the low income population, average speed for trips taken by low income groups, CO emissions in the expanded downtown area, economic return on investment, rate of general mobility and the modal split.

Restrictions on car access and parking in the central area are also planned. The current transportation infrastructure is limited, and without a large bus or metro network, it is difficult to

control people's access. A large network of minibuses with special services was proposed in order to provide accessibility to people going downtown.

A study by the Economic Research Foundation of São Paulo State University explored investment alternatives. The basic premise is the internal transfer of resources from private to public transportation. This is because private transport doesn't pay for the infrastructure it uses. Alternatives include fuel taxes, urban tolls and car property taxes. Of these alternatives, only the car property tax currently exists. These alternatives differ according to the amount they charge, whether they charge car use, and their operational and political issues. However since the plan was written in 1998, the federal government approved a new fuel tax. Discussions are currently underway about how to allocate these funds to road construction and urban public transport.

A study analyzed the policy alternatives and pros and cons of each one. It recommended adoption of a car property tax to fund the investment. But things changed. The Federal Congress approved a new fuel tax. Part of the funds will be dedicated to roads and the hope is to get 20% of these funds for urban transportation projects. The plan is used by the state government as a directive of investment and action. The transportation plan itself is not enough. Land use, environment, and transport plans are needed together in the entire metropolitan area. The planning tools are not well developed. The Federal government is providing new urban policies which will hopefully be implemented in the entire city. The institutional issues must also be overcome. Finally, we have to bring a marketing approach to the public transportation system.

Authorities and society must overcome the institutional issue. This involves 39 mayors meeting and agreeing. It isn't possible to increase public transport without a marketing approach. It is necessary to understand people, political behavior, stakeholders, social needs, expectations and opinions.

4.2. Technical Tool to Evaluate the Effectiveness of Control Measures *Ivo Allegrini (Air Pollution Institute, Italian National Research Council, Italy)*

A tool exists to quickly determine whether a new policy will be effective. The basis of this tool is that concentration equals mass divided by volume.

- Mass depends upon emissions fluxes, physical and chemical transformations and deposits.
- Volume depends on advection (horizontal air mass movements due to winds) and convection (vertical movements due to heating of lower air masses).
- Concentration variations for a pollutant i depend on emissions fluxes, deposition losses, surface chemical formation processes, chemical removal processes, stability of the surface layer, atmospheric mixing and transport processes.

For low reactivity primary pollutants, chemical transformation terms are negligible and simplify the equations. It is important to identify pollutant species for which the term is not time dependent. For example, radon has a constant emissions rate and low reactivity. Therefore, the measuring equipment was altered to measure radon for use as a tracer to monitor the meteorology of Rome.

During the day, the lower atmospheric layers are well mixed. Radon emitted from the ground is diluted and its air concentration is almost constant. At night, the mixing of the lower atmospheric layers is reduced. The dilution of Radon is hampered and its air concentration increases. In Rome at night, there is high stability and high radon concentrations. In the afternoon, the atmosphere is unstable.

During warm months natural radioactivity shows a well-defined and modulated temporal pattern of nocturnal stability and convective mixing during the day. During cold months high-pressure periods are sporadic and advection often occurs. Diurnal mixing is weak and of limited duration.

A very simple model is expressed with a sinusoidal function where atmospheric stability decreases in the day and increases at night, and where traffic is zero at night and heavier during the day. If this initial model is combined with another sinusoidal function, there are 2 maxima during the day, one in the morning (6 to 7 AM) and one in the afternoon (6 to 7 PM). Those two maxima are not related to rush hour but instead come about because of the combination of atmospheric stability and traffic during these periods.

In the summer, when morning traffic increases, the lower atmosphere is already well-mixed; night time stability occurs when the traffic has already decreased. In summer the atmospheric concentration is lower because the atmosphere is unstable during rush hour. In the winter, when the morning traffic increases the mixing layer is still undeveloped; evening stability occurs when the traffic flow is still high. In winter the atmosphere is stable, leading to significant pollution. When natural radioactivity is modulated so is the carbon monoxide structure.

The Atmospheric Stability Index (ASI) is calculated on the basis of measured natural radioactivity values and of their time derivatives during significant periods of the day. Primary pollution events are closely dependent on the mixing conditions of the lower atmospheric layers, well described by the ASI.

Looking at atmospheric stability over one year period, we see that there is a good correlation between benzene and the atmospheric stability index ($r=0.886$). A one-to-one ratio is not anticipated because the ASI only takes into account one of the two driving forces that determine pollutant concentrations, meteorology, which is the real driving force. The statistical variation is only there because of different emissions rates. Stratification of the sample was also performed by grouping weekdays and Saturdays and Sundays by meteorological conditions.

In August, the benzene air concentration was lower than predicted by mixing properties alone because the emission flux was distinctly lower than during the rest of the year. For example, the atmospheric benzene concentration in Rome shows an important decrease because of traffic limitations that have been imposed for the last three years. This technique stratifies the data into groups based on occurrence of atmospheric pollution: very high, high to medium, low and very low. If in the presence of similar atmospheric conditions we observe a decrease of benzene air concentrations, then we can conclude that this is due to a real decrease in the emissions fluxes inside of the urban area.

In conclusion, natural radioactivity is a valuable tool for the interpretation of atmospheric pollution. The ASI allows the characterization of the period under study in terms of meteorological predisposition to a primary pollution event. The ASI makes it possible for authorities to evaluate, on a scientific basis, the results of possible strategies or real actions undertaken to reduce urban pollution. The ASI makes it possible to carry out a sound comparison of pollutant concentration trends over the years.

4.3. Planning and Implementation Constraints: The Case of the BRT project in Mexico *Manuel López (Gobierno del Distrito Federal, Mexico)*

The objective of bus rapid transit (BRT) is to improve transit in the city. The BRT is a system of buses running along exclusive lanes in a corridor. Two systems are being planned. One in the Federal District (DF; south of the city), the other in the State of Mexico (EM).

Two plans already include this project: the PITV and Proaire. The BRT concept is part of a broader goal of giving preference to public transportation in the city. There is a technical committee that includes several ministries. The project began with a metropolitan approach, with involvement by the State of Mexico, but today the EM is no longer working on the project.

The first phase is already funded by international foundations including the GEF, the Japanese government, the German trust fund, and the Hewlett and Shell Foundations. Some \$16 million dollars were obtained from foundations. The World Bank also gave some support, but it asked for a technical committee, where it could participate. The technical committee has five executive members – two from the State of Mexico, and one each from the DF, SEMARNAT, and World Resources Institute, as well as a large number of permanent guests.

The initial project was for 200 km, all in the DF, with 5 corridors. These corridors were selected based on physical feasibility (lanes), complimentary with the Metro, operational feasibility (intersections, RTP vehicles, STE vehicles), anticipated demand, capability to negotiate with the current operators (existing buses), and potential for development around the alignment. From this analysis, Insurgentes and Eje 8 Sur were selected. The subcontracted design for Insurgentes created a corridor between Indios Verdes and Ciudad Universitaria. The Eje 8 Sur corridor goes from Metro Mixcoac to Santa Marta.

A Project Implementation Unit was established and more than 60 permanent stakeholders were involved in the planning. These stakeholders were divided into workgroups on legal, technical, social, urban, environmental, institutional, negotiation and financial issues. They then developed a roadmap (flow chart) to track progress on the various issues and activities that are needed in order to arrive at the final implementation of the corridor.

For Insurgentes Avenue, consultant services were selected through a bidding process. The conceptual design is for 21 km, from Indios Verdes to Ciudad Universitaria, with 300,000 trips per day and 7,500 passengers per hour each direction during peak travel on 120 articulated buses. The corridor will have 2 terminals and 37 stations. The Committee is also working to certify the emissions reductions for carbon emissions trading. Eje 8 Sur will run 23 km from Metro Mixcoac to Santa Martha, with 11,500 passengers per hour each direction during peak travel, with 150 articulated buses, intersecting 5 Metro stations. There is a high expectation for new added demand. The design will be concluded by the end of March, as will the methodology for the baseline emissions. External experts will also write a review report. Budget approval is expected by March, with construction expected to start in May, and operation by October. Other corridors will be developed in 2005.

Challenges include institutional coordination, and intermodal transfers using a prepaid transportation payment card. There is a need for a Metropolitan vision, but little is being done. Even though the EM is planning a BRT corridor, there has not been one meeting between the two groups recently.

There is a need for a new Origin-Destination survey in the MCMA. The permanence of the projects is another issue. Also, the BRT lines can become Metro lines if the demand increases substantially.

4.4. Bogotá, Colombia Experience ***Jorge Acevedo (Universidad de los Andes, Bogotá)***

Bogotá today has a population of 7 million, and is growing by 2.2% annually. There are about 1 million private vehicles, which grew at 2.5% annually between 1998-2000, and at 5.5 % annually since 2001. There are about 35,000 buses, minibuses and *colectivos*, most of which are old (average age over 14 years) and 10,000 of which are illegal. There are about 70,000 taxis of which some 15,000 are illegal.

There are roughly 18 million total trips per day of which 14 million are motorized. About 4.5 million trips are conducted in private vehicles or taxis (32%) while about 9.5 million are conducted using public transport (68%). Of these, the first phase of TransMilenio serves 800,000 (730,000 formerly public and 70,000 formerly private trips).

There are about 35,000 public transport drivers and more than 35,000 public transport vehicle owners. These are organized around 65 “public transport companies” that “affiliate” the vehicles to let them serve the company’s licensed routes. Affiliation requires both a down payment and monthly payments.

Bogotá’s demand management policies include the “Pico y Placa,” program, which restricts vehicles operation based on the digit of the vehicle license plate. For private transport, 40% is restricted daily, Monday through Friday, from 7-9 AM and 5-7 PM. For public transport (taxis included), 20% is restricted daily, Monday through Saturday, throughout the day. There are now more than 200 km of bicycle paths. Finally, there is TransMilenio, which has achieved a major change in the way the public perceives the transit system. Bogotá is very proud of it, even though it cost five times the cost of the earlier system (\$1 million per kilometer for the earlier system, versus \$5 million for TransMilenio).

The earlier BRT system was created with confined corridors for buses, and focused on the most heavily used corridor in the system with 25,000 passengers per hour in each direction. The system was designed to use the central lanes. It achieved very good results. Bus speed and reliability improved enormously. Even the mobility of the rest of the traffic was improved. The next Mayor extended the system further, and it became more reliable. Nonetheless, that system was not well used. It was still considered low quality by the general public, especially because of its poor design and use of old, polluting buses.

There is still a challenge with respect to public transportation. Ongoing policy decrees should focus on a few problem areas. First, bus companies must lease vehicles from owners. Second, companies must operate their fleet, collect fares, contract drivers, and maintain vehicles. Electronic vehicle licensing allows on-road detection and retention of illegal vehicles. Part of the fare goes to a fund to purchase old vehicles and destroy them.

Discussion

A participant commented that public perception is important. In Mexico City the Metro is perceived as second rate. It is important to note the difference between bus lanes and a bus

system. The bus system depends upon a systems approach that was not present in the first attempt.

4.5. Santiago de Chile Experience

Pedro Oyola (Comisión Nacional del Medio Ambiente, Santiago)

In 1997 the Santiago Metropolitan Region was declared saturated with TSP, PM₁₀, CO, and O₃, and was identified as latent for NO₂. An Atmospheric Decontamination and Prevention Program for the Metropolitan Region was initiated. An intensive program to reduce the impact of mobile sources, and, in particular, from public transportation, was started. An important collaboration between CONAMA and the universities was initiated to improve capacity building.

The costs of pollution abatement are substantial but the benefits greatly outweigh these costs. Emissions reductions of 2.755 tons per year of PM and 14.732 tones of NO_x cost about US\$127 million. But the benefits are approximately \$260 million dollars per year. The avoided costs to health are higher for diesel-powered vehicles. In millions of dollars per year, avoided health costs for light gasoline vehicles are 10.959, for light LPG they are 15.812, for light CNG vehicles they are 18.798 and for light diesel the cost is 103.960.

Reductions of PM took place between 1997 and 2003. PM₁₀, as measured by the ICAF index, declined in many regions of Santiago. For example, in Pudahuel it went down 43%, in Cerrillos it declined by 35% and in La Paz it declined by 44%. Anthropogenic PM₁₀ emissions sources are follows: 48% mobile sources, 33% fixed sources, and 19% area sources. Mobile sources consisted of buses (21%), trucks (13%), and light vehicles (14%). Fixed sources included combustion (12%), processed (14%), and homes (7%). Area sources included firewood, farmland and sewage.

In large cities, vehicle emissions are usually the most important. In small cities, there may be sources specific (and limited) to the area that is significant (smelters, home heating, biomass burning, etc.) Fixed sources are easiest to control while mobile sources are harder to control. Local emissions may mislead the interpretation of the results. Monitoring site representativeness is needed. Topography may determine the concentration of pollutants; in certain areas the wind pattern controls and limits the spatial extent of pollutants.

Cluster analysis of the data among the stations is used to obtain groups with similar temporal behavior. Each group of stations has similar PM₁₀ and ozone. The groups are independent of the season. Topography of the city is probably responsible for the configuration of the group.

We think one of the main benefits of Transantiago will be reduction in PM 2.5. We created a special pollution-monitoring network focused in Pudahuel, the most polluted area in the metropolitan area. Ventilation is a big problem in Santiago. The movements of pollutants from the southern part of the city to Pudahuel were mapped. The effects of exclusive lanes for buses and reversible roads (which change in direction depending on the time of day) can be modeled.

A copper smelter is located in the south of the city (Caletones). We used its outputs (copper, molybdenum, sulfur) as tracers. We found that most of pollution at Pudahuel was not produced in that area. Black carbon is also a good tracer. Emissions double during the night, and are transported from downtown to Pudahuel, where there are no local emissions.

Topography may determine the concentration of pollutants in certain areas. Cluster analysis was done to divide the city in parts and obtain groups with similar temporal pollution behavior for

high pollution episodes. The majority occurs late at night. There is some variation in the trend of the occurrence of atmospheric episodes. There are two types of episodes: early episodes due to a lack of wind (local phenomena) and late episodes due to high-pressure systems coming from the equator (a larger-scale phenomenon).

Movement of pollutants from downtown to the west was observed, as was coagulation, where particles become bigger. In Transantiago, low polluting buses are given an extra bonus in the road bidding process. Biomass is one of the main sources of pollution in Pudahuel. Biomass and diesel engines are both future targets. More information can be found at: <http://fisica.usach.cl/uv/archivos> and <http://www.conama.cl/rm/realtime>

4.6. *Low Emissions Zones* ***David Hutchinson (Greater London Authority, UK)***

The Greater London Authority Act requires the Mayor to prepare strategies for transport, economic development, biodiversity, air quality, culture, spatial development, municipal waste management, ambient noise, and energy. There is a hierarchy of strategies. At the highest level are the EU directives, then the National Air Quality Strategy, then the mayor's Air Quality Strategy for London and, finally, local air quality management. The Air Quality Strategy for England, Scotland, Wales and Northern Ireland addresses fine particles, nitrogen dioxide, sulfur dioxide, carbon monoxide, lead, benzene, 1,3-butadiene, ozone and polyaromatic hydrocarbons. Road transport is the main source of NO_x and fine particles. Regulated industrial processes are the second main source of fine particles. Gas use in commercial and residential buildings is the main source of NO_x.

Since air quality remains a problem in London, different measures need to be analyzed. One measure that was analyzed, and will be discussed here is Low Emissions Zones (LEZ) -- a zone from which vehicles that fail to meet a specified emission standard (such as Euro II) are excluded. A feasibility study was undertaken by a consultant for the Greater London Authority, the Association of London Government, Transport for London, London Boroughs, the Department for Transport, the Department for Environment, Food & Rural Affairs, the National Society for Clean Air, and the Energy Saving Trust. A copy of the completed report from July 2003 can be found at: <http://www.london-lez.org>.

A range of LEZ options for areas, vehicles, start dates, emissions criteria, operations and enforcement were considered. The program had to be large enough to create enough of an emissions impact.

Lorries are responsible for a large share of NO_x and PM₁₀. If you look at emissions per km traveled, articulated lorries, buses and coaches are the high emitters. If a LEZ is established, it should start with a scheme that targets lorries and London buses and coaches, as these vehicles have disproportionately high emissions per vehicle. Lorries account for a significant portion of particles and NO_x emissions. As they pollute much more per vehicle than cars, it is more cost-effective to focus on them.

The study recommends that lorries and buses meet Euro 2 standards using particle traps in 2007, and that the criterion be tightened to Euro 3 with particle traps in 2010. A NO_x reduction retrofit scheme should also be considered for 2010. The initial scheme could develop over time into a rolling scheme, combining Euro standards and age-based criteria. If vans are to be included in the Low Emission Zone scheme, the study recommends that they meet an age-

based criterion. This should be a rolling ten-year-old age limit. A similar age-based standard is also recommended for taxis, both for licensed and private hire vehicles.

One of the problems that affected the whole project was estimating the total number of vehicles in London. There is registration data but vehicles can be used anywhere. Therefore, there is a range of estimates between 3.7 to 4.9 million cars, and between 60,000 to 150,000 lorries. Poor information on the actual numbers introduces a lot of error into the cost and benefit estimates. According to the study, dealing with the large operators would not be difficult, but smaller operators, or operators of specialized vehicles, would have more difficulty because of their longer vehicle lifetimes. Large truck and bus operators would have fewer problems adapting to the new standards than small-scale companies. The cost to vehicle operators is likely to be significantly higher than the costs of setting up and operating a London LEZ. The exact costs would depend on operator behavior in response to the zone. Existing Government grants could offset some of these costs, but the numbers of vehicles affected by a LEZ in London would far exceed the existing grant levels.

If a LEZ were introduced, what would be the outcome? It became apparent that it would not be possible to achieve as large an impact on air quality as was hoped. Relative to the baseline case, reductions in NO_x emissions from lorries and buses would decrease by 1.5% in 2007, and by 2.7% in 2010. NO_x emissions for lorries, buses, vans and taxis would go down by 3.8% in 2010. For PM₁₀ the reductions would be 9%, 19% and 23% respectively.

But as large parts of the city approach compliance, these small reductions could cause a high increase in the number of compliant areas. However, this legal compliance may not be sufficient to justify the program. Relative to the baseline case, reductions in the area exceeding targets for NO_x were 4.7% for lorries and buses in 2007, 12% for lorries and buses in 2010 and 18.9% for lorries, buses, vans and taxis. Relative to the baseline case, none of the areas would be brought into compliance for PM in 2007, but by 2007, 32.6% of the area would be improved for lorries and buses and 42.9% by 2010 for lorries, buses, vans and taxis.

Even the most severe Low Emission Zone would not, on its own, result in London meeting all the air quality targets. The progress towards the air quality targets also has to be seen against a natural background of improving air quality. The study has found that a feasible London LEZ would have modest benefits in improving overall emission levels and absolute air quality concentrations. One of the reasons the city has looked specifically at the LEZ is because it is one of the few areas where local authorities have authority.

The next steps are, first, for the Mayor and London Boroughs to make a joint decision on whether to implement the zone. Second, a public consultation process must begin over the preferred scheme design, and agreement over any proposed modifications must be reached. Third, Transport for London (TfL), London Buses, and the Public Carriage Office (responsible for bus regulation and taxi licensing) must agree on the approach. Next, the format of the TRO and any associated Bill or Regulations to decriminalize offences (if applicable) must be established. A definition of the national certification system between the federal Department for Transport (DfT) and its agencies must be agreed on. Finally, the funding and division of responsibilities must be agreed to.

Information on the LEZ study can be found at: <http://www.london-lez.org>.

4.7. Action Planning for Air Quality Improvements: Comparative Perspectives - UK
James Longhurst (Air Quality Research Group, University of the West of England)

What is air quality management (AQM)? It is easy to say, but difficult to implement. Formally, it is the application of a systematic approach to the control of air quality issues in which all the factors determining air quality are considered in an integrated, proportionate and cost-effective manner based upon sound science and by reference to health-effects based air quality criteria. Improvements can be made, as has occurred in London. Air quality problems have been an inescapable partner of economic development. Our social, political and economic responses to air pollution have often lagged behind our awareness and understanding of the impact of pollution. Still there is a struggle to balance public expectations of personal mobility and accessibility with clean air. It is also difficult for political institutions to deal with the information required to address air pollution problem.

The UK operates within the EU frameworks. The EU problems are no different from those in the UK. For the UK there are several problems. There is improved fuel efficiency, introduction of catalytic converters, and improved vehicle technologies, but national policies are struggling to address air quality consequences of growth in vehicle numbers and increases in mileage per vehicle. Registrations rose from 17.4 million to 26.7 million between 1986 and 2000. About 82% of journeys (by mileage) are made by car. By the early 80's there was evidence of the link between pollution and health problems in the country. The Environmental Act of 1995 was introduced, and was based on very detailed knowledge of health risks caused by air pollution.

In Europe, the Ambient Air Quality Assessment & Management Directive 96/62/EC is a framework under which the EU agrees on limit values (Daughter Directives). European directives are transposed into Member State legislation. Limit values are legally binding. Specific locations are designated for action. There is an Action Plan at the national level.

Problems for Europe include the fact that urban traffic congestion costs are in excess of €100 billion euros each year (and are likely to double over next 10 years). Also, local and trans-boundary pollution and subsequent health impacts impose similar costs. Urban transport contributes about 14% of all CO₂ generated in Europe. This information can be found in "Scoping Proposal 2003: University of Leeds, University of York, and University of Westminster, U.W.E., Bristol, TRL Ltd."

The UK Air Quality Regime includes primary legislation (the 1995 Environment Act), the National Air Quality Strategy, health-based air quality objectives, periodic scientific review and assessment, local implementation by local authorities, identification of air quality management areas, and action plans in locations where objectives are not going to be met.

Air Quality Management Areas (AQMA) are zones where special measures can be implemented. In the UK, 25% of local authorities have trouble meeting the air quality objectives and are therefore designated as AQMAs, which are required to have Action Plans in place to meet the health-based air quality norms. The major problems are NO₂, PM₁₀, and SO₂. Predicted exceedences of the National Air Quality objectives are 91% for NO₂, 45% for PM₁₀, and 6% for SO₂. Surprisingly, both major urban areas and other, less typical areas, such as small market towns, rural hotspots, and motorway corridors, exceed the standard. These smaller areas have a very different spatial dynamic between emissions, concentrations and exposures. Emission sources are 95% from traffic, 9% from industrial, and 1% from domestic and some shipping sources. More effective communication, collaboration and consultation between and within tiers of government and with stakeholders have emerged.

The UK experience has taught us that elements of the process seemed to work well, including assistance to the municipalities and the technical and institutional capability established to deal with air quality (including training provision and support, guidance, internet support, and a high-quality monitoring network). This is probably the most important take home message. However, there is not enough integration with wider policies and plans at the national, regional, and local levels. Also, the timescales of AQM planning and transport planning (5-year cycles), and land use planning (10 to 12 years) are very different. Local Agenda 21, or sustainability plans, can take even longer.

Air Quality Action Planning is how each AQMA will meet air quality objectives. Once declared an AQMA, they have to consider options, looking at AQ improvements, cost-effectiveness, non-AQ impacts, and perceptions and practicalities. Once the AQMA has prioritized options, it moves to the implementation phase.

Action planning is difficult to move along political, cultural and social borders. Local authorities not declared an AQMA can still, in a non-statutory way, develop an AQM action plan to keep their emissions down. Action planning needs to clarify the overall extent of AQM exceedences and declare AQMA(s). Action planning must undertake further review of air quality within the AQMA(s), and must also consider specific criteria, such as air quality improvements actually required, source apportionment, early consideration of potential options and their cost-effectiveness, and the practicalities of implementing different options. There is also a need for evaluating and monitoring the effectiveness of the plan.

Currently, air quality is considered a material planning consideration. Therefore, air quality issues are addressed at the beginning of the planning process. There are also other planning frameworks, which often make integration and coherence difficult.

Building on some of the comments about sustainability, if we are truly to think about sustainability, we cannot shift environmental problems in time or place. Local authorities cannot influence engine efficiency or fuels. Transportation management measures should not be underestimated, but will best be considered within the local context.

It is also challenging to have integrated planning, including economic development. Sometimes these plans are regional rather than local. Industry regulators, trunk road operators, and health authorities all need to be involved. Local authorities are usually struggling with transportation problems. Some of the local actions taking place include residential zones of 20 mph to give people back the streets using vehicle access restrictions. There are also many local communication strategies. We often miss opportunities like this one. There is a huge amount of work to do here. We usually fail to communicate our strategies to the public.

The exposure-based approach of the UK is transferable to other countries and non-European cities. One aspect that is clearly transferable is the health-based objective and risk-based approach. Also, capacity-building exercises should be of use in other contexts.

Session 5: Conclusions

5.1. Key Messages from the joint seminar

Dr. Mills used this occasion to distill some key headline areas, and areas for long-term investigation. The following is a set of key messages detailing the impact of vehicles on air and environmental quality:

1. Forecast growth in vehicle numbers poses enormous challenges, which will need cooperative action at global, regional and urban scales.
2. With the increase in population and vehicles, it is important to maintain public roads as a public space, with all that that implies. We also need to separate ownership and use of vehicles.
3. Technology is not enough. It has achieved enormous improvement in vehicle emissions performance, but is offset by growth in vehicles numbers. If over the coming years, the ingenuity that has gone into vehicle technology can go into ITS, then we can continue to deliver with technology and make gains with congestion. Improvements of air quality must look to integrate assessments, which consider all abatement options including technology. Technology will be important, but we also need management and behavioral changes.
4. Changes to systems of governance have significantly failed to keep pace with the expansion of mega-cities. Political leadership is needed to cut through overlapping and conflicting jurisdictions and short-time horizons.
5. The scale of population movement and urban growth may in many cases already have ruled out the “compact city”, but ways need to be found to retrieve its important features.
6. Experiences in some cities (like Bogotá and Santiago) show that radical and integrated packages of transport measures, based upon management of road space and an enhanced role for high quality bus and rapid transport systems can deliver efficiency and equity and be economically, environmentally and socially sustainable. But this is not possible without strong political leadership.
7. Transport and air quality must be better integrated at the policy level. The important thing is that even when other sources, from garbage burning to industrial process, are included, transport emissions are a growing problem, and anticipatory action is important. In Europe, there is a very organized, rigid system of mandatory targets to deliver particular health outcomes, which are legally binding, regardless of the local circumstances. So at one extreme, we have extremely chaotic systems, and the other extreme, we have systems that may be almost too rigid to be cost effective or adaptive.

Open Discussion

Dr. Gakenheimer pointed out the importance of forecasting vehicle kilometers traveled as opposed to ownership. With increasing incomes, the trip rate is growing more rapidly than motorization. It is not just in the developing world that governments have not been able to keep up with this phenomenon. He also agreed that governments have not kept up with changes in cities; governance is not adequately equipped to deal with these changes so institutional

change is more necessary than simple updating. It is true the compact city will never be recovered but it is important to consider the rapid decentralization of cities. It will be an increasingly important goal to contain decentralization -- if the government does not take an active role then decentralization will be exacerbated.

Dr. Sussman noted that an integrated package of policy options is important, but should be expanded to include land use planning and health policy. There is also a need to train professionals to think in interdisciplinary, integrated, and cross-cutting ways. There is also a sense that understanding the geographic scale of these issues is important, looking at the metropolitan-based region. Air pollution problems and global economic competition, all take place at the metropolitan or regional scale, so we should think of transportation at the regional scale. ITS permits management and control of transportation systems at the broad, regional scale in a way that wasn't available before.

Congressman Acosta wanted to underscore that we should emphasize existing environmental and energy policies. Capability and capacity building is in direct relation to having an integrated policy framework.

There were additional comments about the importance of the prioritization of public over private transportation and addressing the problem of informal systems. The private sector needs to be incorporated into the planning process, because the public sector does not have the resources (financial or managerial) to handle some of these projects on their own.

We should note the importance of data collection and the value of having continuity of data. It would be a step forward if this document to the World Clean Air Congress could help some governments in Latin America and Asia to capture the need for data collection. Many countries prefer to spend money on other things instead of really knowing what is going on over a continuum of time, so whatever helps get this message across will be very useful.

Sir Christopher Foster asked about how to achieve results. If you have early successes and have overcome things that are easy, then the more challenging steps that remain are difficult for political reasons. There is a lack of understanding of what is going on. If you want to get people to move you have to emphasize both health and other impacts. Also, if things get steadily worse then you will need economic instruments. This understanding will make these issues seem all the more important.

Dr. Allegrini made another comment that the system could be used to understand reasons for trip making. In Milan, some 45% of trips are for work. It is difficult to create a network of good transportation to address this issue, so we need to understand the reasons that people need this. Young people get married and move out to the suburbs, because that is where they can afford to live, but then they need to buy a car to go to work. This is a social problem that is important to understand in terms of the motivations behind the increase in the number of cars.

Dr. Allegrini also pointed out that there are three legs to air quality and transportation, one leg is standards, the second leg includes the action plans we have heard about today, the third leg is information to the public.

A comment was made regarding social injustices. Many solutions still require that people use cars to survive. No matter what solutions we find to reduce pollution and congestion, we need to see the social injustices that are resulting from this problem. They are much bigger in the developing world, where there is a much wider gap between the rich and the poor.

Congressman Acosta made a comment relating private and public buses to the tragedy of the commons. He said there is a need for public and private partnerships, but that the issue remains of defining “who owns what.”

Dr. Slott mentioned the necessity of gathering information and testing and retesting hypotheses. It is easy for paradigms to be invented, hypotheses to be assumed, and for solutions to be dreamt up. A critical review of paradigms and hypotheses is worthwhile, and it is critical for researchers to test these, instead of taking them for granted.

Sir Christopher also made a comment about the commons, saying that roads aren't like commons serving villagers and cattle. In some sense the public interest of the road sometimes requires that the use of the roads be prioritized. This calls for some sort of rationing or pricing measure. The idea that roads are free for everybody has to be countered strongly.

When you privatize provision of a road, you are normally able to charge a price different from the price charged in the public sector. But we need to get public control over the prices and tolls so that the system is used in a more rational way.

It is important to stress the participation of the private sector in the solutions. We think of problems and solutions that are ever more expensive and very often the public sector doesn't have enough resources to undertake them.

5.2. Closing Remarks ***Mario Molina (MIT)***

Dr. Mario Molina provided a few additional thoughts. He agreed with the key points outlined here. This workshop has provided an excellent forum for the international participants to exchange information, and to learn from each other's successes and failures. There should be no excuse for repeating mistakes that have already been experienced elsewhere. Furthermore, we have to analyze what has worked well elsewhere. It was interesting to learn that in the UK capacity building of institutions is essential, just as it is essential in Latin American cities.

One of the challenges that keep coming up is the availability of financial resources. Can we afford to have clean cities? We can use the experiences from the various cities that we heard at the workshop. We know that Bogotá is not particularly rich, but they now have the TransMilenio. How did they do it? Why did it happen only now? We have known about Curitiba's BRT system for a long time. Why did it take so long to implement elsewhere? We heard that in large measure, the Bogotá success story is due to the leadership of Mayor Peñalosa. Political leadership was a very important component of many success stories. Maybe we should figure out what is behind that leadership, and whether we can start important programs now rather than just wait for the right person to show up.

To bottom line is that we must learn from each other in dealing with environmental problems. Furthermore, as we heard repeatedly in this meeting, it is necessary to work with the local people; every locality is different and requires its own unique mix of strategies. We may not be able to make use of all the advice that comes from Europe or US, but maybe some of it is applicable.

When we deal with those problems that appear intractable often we are really dealing with poverty. We have to recognize our limitations and we have to be realistic. We cannot solve

world poverty, but we must take this into account when we manage air quality and transportation. For example, indoor air quality is another serious health problem in many places. While we should be aware of its existence, addressing this issue may not be appropriate for this group. The strength of this group is to focus on air quality and transportation without losing sight of the other problems. We would like to be able to communicate to politicians, particularly in our developing world, that although there is a variety of problems that need to be addressed that may be more urgent than transportation and air pollution, that is not an excuse to ignore the other problems at all. There are important investments that can be done to benefit all of society.

Dr. Molina closed the seminar by thanking Drs. Richard Mills and Luisa Molina for putting this workshop together. He also thanked Alvaro, Rebecca and Julia for their help and note-taking. Finally, he thanked all participants for attending, especially those coming from long distances.