

URBAN TRANSPORTATION AND AIR QUALITY

In 1993, the TAC Urban Transportation Council published a Briefing entitled *A NEW VISION FOR URBAN TRANSPORTATION*. This Briefing proposes a 30-year generic vision for Canadian urban areas that can be tailored to fit to local conditions. The vision is supported by 13 decision-making principles that point the way to a more desirable future¹. (Superscript numbers refer to endnotes on Page 8.) The vision calls for significant change from past practices in respect to land use, the role of private automobiles, and transportation funding.

Since the publication of *A NEW VISION FOR URBAN TRANSPORTATION*, TAC has developed several Briefings that elaborate this document's specific recommendations. This Briefing addresses, in part, the twelfth of the decision-making principles: "Ensure that urban transportation decisions protect and enhance the environment". Urban transportation and its impacts on air quality are issues that transcend political boundaries and require public and private cooperation to secure significant improvement.

AIR QUALITY IS A MAJOR URBAN ISSUE...

Introduction

During the last 50 years, Canada's urban areas have grown considerably in population and, even more, in size. Employment opportunities, immigration, and economic development have all contributed to an increased concentration of activity in urban areas. Now, 80% of Canadians work and live in communities with a population of more than 10,000 people.

The growth in urban areas has numerous social, economic and environmental benefits, but it is not without problems, one of which is poor air quality. Unlike other urban problems such as vehicle collisions, noise and traffic congestion, the impacts of poor air quality are often difficult to grasp. Yet, as in the case of these other issues, poor air quality has significant social, economic, and environmental impacts.

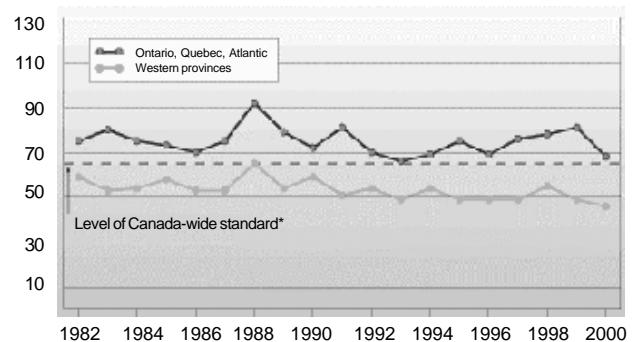
The Need for a Briefing

When air quality becomes a matter for public discussion, the role of transportation is inevitably raised. Some types of urban transportation are seen as worsening the problem while others are identified as more positive. In addition to raising the awareness and understanding of air quality issues, this Briefing looks at urban transporta-

tion through an 'air quality lens' and suggests ways to reduce or eliminate components that lead to poor air quality.

Elected officials at all orders of government as well as representatives of business and non-government organizations can bring about change by incorporating air-quality considerations in their decision-making processes.

Ground-level ozone (Average peak concentration at monitoring stations in Canada, in parts per million)



Source: Environment Canada, Canada's National Environmental Indicators Series 2003 - Urban Air Quality

AIR POLLUTION HAS A DIRECT EFFECT ON THE HEALTH OF CANADIANS...

Effects of Air Quality

The effects of air emissions are well documented. They include climate change, air pollution, and smog, with resulting acid rain, loss of agricultural productivity, reduced visibility, and human health effects. Air quality has been a concern in urban areas for more than a century. The impacts of air pollution on human health include eye, nose, and throat irritation, reduced lung capacity, aggravation of respiratory diseases, cancer, and premature death.

The impacts of air emissions vary significantly by the type of pollutant. At the broad level, air emissions are generally classified into two categories. One includes emissions that have **globally acting impacts**. The most important of these cause global warming and other changes in climate and are often referred to as **Greenhouse Gas Emissions** (GHGs). The other category of emissions includes those that have **locally acting impacts**, notably poor urban air quality. Emissions contributing to poor air quality are often referred to as **Criteria Air Contaminants** (CACs). They include Total Particulate Matter (TPM), Particulate Matter with a diameter less than 10 microns (PM_{10}), Particulate Matter with a diameter less than 2.5 microns ($PM_{2.5}$), Carbon Monoxide (CO), Nitrogen Oxides (NO_x), Sulphur Oxides SO_x , and Volatile Organic Compounds (VOCs).

“The are strong links between air pollution and health problems, especially for the elderly, children and for those with respiratory and cardiac problems. A large number of studies, including some from the Government of Canada, the Ontario Medical Association and the Toronto Public Health Department show that air pollution can lead to premature death, increased hospital admissions, more emergency room visits and higher rates of absenteeism.”

Source: Environment Canada Website www.ec.gc.ca/air

In recent years, **particulate matter** has received increased attention because of its severe and lasting impacts on human health, particularly in children and the elderly. Fine particulates ($PM_{2.5}$) in tailpipe emissions contribute to breathing problems and lung damage while larger particulates (PM_{10}), generated from road dust and tire wear, are responsible for reduced visibility, degradation of materials, and impacts to vegetation.

The focus of this Briefing is on air emissions as they pertain to urban air quality. The issues of global warming and the reduction of GHGs have been addressed in previous TAC briefings (see A PRIMER ON URBAN TRANSPORTATION AND GLOBAL CLIMATE CHANGE, May 1998), and in numerous reports prepared as part of Canada's National Climate Change Process.

Major Impacts on Human Health and the Environment of Common Pollutants Associated with Vehicle Use

Emissions	Health impacts	Environmental impacts
Nitrogen oxides (NO_x) include nitric oxide (NO) and nitrogen dioxide (NO_2), which is formed from the oxidation of NO.	<ul style="list-style-type: none"> NO_2 is a lung irritant at high concentrations, may lead to depression of the immune system, with children and the elderly being at risk. 	<ul style="list-style-type: none"> NO_2 reacts with water to form nitric acid (HNO_3), an element of acid rain. NO_2 contributes to the formation of ground-level ozone, is associated with suppressed vegetation growth and contributes to the corrosion of metals and degradation of various materials.
Carbon monoxide (CO) is a gas produced by the incomplete combustion of organic materials.	<ul style="list-style-type: none"> Reduces the ability of the blood to carry oxygen. 	<ul style="list-style-type: none"> CO may contribute to the formation of ground-level ozone.
Volatile Organic compounds (VOCs) are a chemically diverse group of compounds that have at least one carbon atom.	<ul style="list-style-type: none"> Many individual VOCs (e.g., benzene) are known to have or are suspected of having human health effects ranging from carcinogenicity to neurotoxicity. 	<ul style="list-style-type: none"> Contributes to the formation of ground-level ozone.
Ozone (O_3) is formed from the reaction of NO_x , VOCs, and sunlight.	<ul style="list-style-type: none"> Associated with changes in lung function, decreased immune function, and possibly the development of chronic lung disease. 	<ul style="list-style-type: none"> Reduces agricultural productivity and the growth rate of trees.
Particulate Matter (PM_{10}) is produced from road dust and tire wear.	<ul style="list-style-type: none"> Associated with Increased respiratory infections, reduced breathing capacity, and potentially cancer. 	<ul style="list-style-type: none"> PM deposition on vegetation reduces photosynthesis; it also contributes to degradation of materials and reduced visibility.
Fine Particulate Matter ($PM_{2.5}$) is produced from direct tailpipe emissions as well as the reaction of various pollutants in the atmosphere.	<ul style="list-style-type: none"> Can cause breathing and respiratory symptoms, irritation, inflammation and damage to the lungs and premature deaths. 	<ul style="list-style-type: none"> Not yet well investigated, but likely to be found to cause health impacts in several species and the same environmental impacts as PM_{10}.

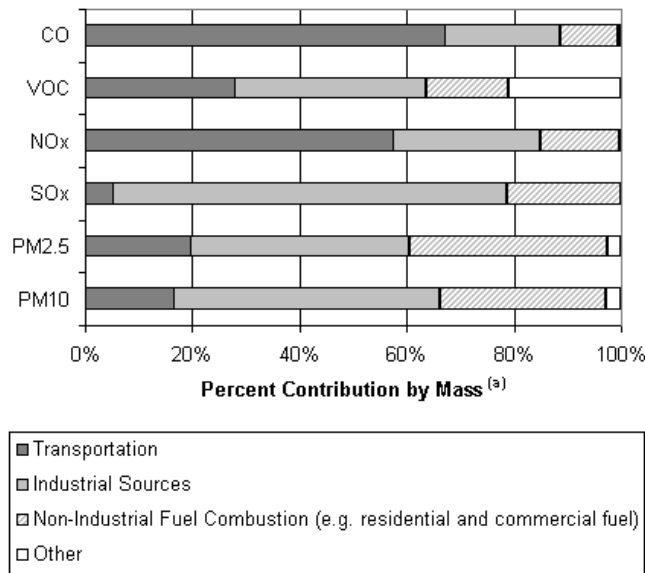
Source: Adapted from Environment Canada Fact Sheet 93-1 and Environment Canada Clean Air website http://www.ec.gc.ca/air/introduction_e.html

TRANSPORTATION IS A MAJOR CONTRIBUTOR TO POOR AIR QUALITY...

Transportation and Air Quality

There are many factors that contribute to air pollution in urban areas including electricity generation, industrial processes, building heating systems, and transportation. The burning of fossil fuels in motor vehicles is among the most significant contributors to air pollution. Transportation is the largest contributor to emissions of carbon monoxide and nitrogen oxides (NO_x) and a major contributor to Volatile Organic Compounds (VOCs). In sunlight, NO_x and VOCs react to form ground-level ozone, the main component of smog. Transportation also produces particulate matter, a component of smog and a cause of respiratory and breathing problems.

Contribution of Transportation to Air Emissions (1995)



(a) Relative to all sources excluding open sources (e.g., prescribed burning, dust from paved/unpaved roads)

Source: Environment Canada, Background - On-Road Vehicle and Engine Emission Regulations, http://www.ec.gc.ca/Press/2003/030102_b_e.htm

Most air emissions from transportation are attributable to the operation of road vehicles including private vehicles (cars and light trucks/SUVs/minivans) and commercial vehicles. In 1995, light duty vehicles, including SUVs, were responsible for approximately 75% of the total transport emissions of carbon monoxide². Heavy duty trucks were responsible for 30% of the emissions of nitrogen oxides. U.S. studies indicate that 70-80 percent of the cancer risk from air pollution is due to particulate emissions from diesel engines³.

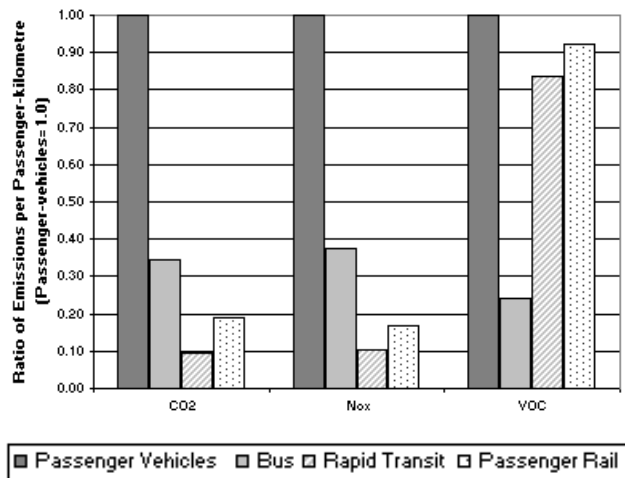
“Automobiles produce approximately half the pollutants that combine to form ground-level ozone, the main ingredient in smog. In summer, smog can damage vegetation and have adverse effects on human health.”

Source: Environment Canada

Contribution by Mode

When measured in terms of emissions per passenger-kilometre, a measure that allows comparisons across modes, passenger cars emit nearly three times as much CO₂ and NO_x as a standard urban bus assuming typical load factors. Even at load factors as low as six passengers per bus, a bus consumes less fuel and produces fewer emissions per passenger-kilometre than a car carrying a single occupant⁴. Transit options that rely on electrical power generation produce even less emissions—such as subways, light rail vehicles, trolley buses and streetcars. (Estimation of the net impact of these emissions requires consideration as to whether the electricity is produced by burning fossil fuels or from cleaner sources such as hydro or wind power.)

Comparison of Air Emissions by Passenger Mode



Source: Environment Canada, *Making Transportation Sustainable, A Case Study of the Quebec City-Windsor Corridor*, March 2002.

For freight modes, there are conflicting opinions as to which modes produce the least amount of emissions for a given amount of work. The conflicting opinions arise mostly because trucks and trains rate differently for different types of emission and because the two modes function differently. Trains tend to move heavier bulk goods

over longer distances. Trucks tend to move lighter goods over shorter distances. Truck use is increasing rapidly, and this in itself is contributing to increases in air emissions.

Progress and Outlook

A encouraging area with respect to air quality and emissions is the role technology has played in reducing the emissions intensity of both passenger and freight vehicles. Among the most significant changes have been the introduction of catalytic converters and the elimination of lead from gasoline. The impacts of these changes on overall air emissions have been offset by large increases in travel activity. As the table opposite shows, in the last decade average emissions factors (i.e., grams of emissions per vehicle-kilometre) for heavy trucks have declined by 33-47% for the indicated pollutants, but the amount of travel by heavy trucks has increased by 35%, mostly off-setting the improvements in emissions rates.

Another offsetting factor is the increased use of light trucks, mini-vans, and sport-utility vehicles (SUVs) for passenger travel. Between 1990 and 2001, the number of light trucks in use increased by 70% while the number of cars dropped by 1%⁵. According to data developed for the U.S. Environmental Protection Agency (EPA), a light truck or SUV produces 30% more NO_x emissions per kilometre than a typical passenger car⁶. Until recently, vehicles classified as light trucks, which include minivans and SUVs, have been subject to less stringent emission standards than passenger cars.

Further improvements in vehicle emission standards are imminent. On January 2, 2003, the Government of Canada announced new regulations governing emission standards for 2004 and later for on-road vehicles and engines. They are significantly more stringent than previous standards. These emission standards are closely tied to those of the EPA and are often referred to as the Tier II standards.

They will govern passenger vehicles, including pick-up trucks, minivans, and sport utility vehicles, as well as trucks of all sizes. Environment Canada estimates that in 2020 the new regulations will reduce emissions of NO_x, PM, CO, and VOCs by 73%, 64 %, 23 %, and 14%, respectively, compared with what would be emitted if current standards were maintained⁷. However, total emission reductions due to improved standards will be negated by increased vehicle use.

Thus, the anticipated improvements should not lead policy-makers to conclude that changes in behaviour are not required. Moreover, the World Health Organization reports that "recent developments in our understanding of the effects of air pollutants on health suggest that, at least for particulate matter and ground-level ozone, all levels of exposure above zero are associated with effects on health"⁸.

Change in Vehicle Emission Rates and Activity (2000 compared with 1990)

Vehicle Class	Percent change in emissions per vehicle-kilometre ^(a)			Percent change in vehicle-kilometres ^(b)
	Hydrocarbons (HC)	Exhaust carbon monoxide (CO)	Exhaust nitrogen oxide (NO _x)	
Passenger cars (excl. SUVs) (Gasoline)	-30%	-22%	-24%	- 12%
Light Trucks/ SUVs/minivans (Gasoline)	-39%	-31%	-24%	+ 51%
Heavy Trucks (Diesel)	-33%	-16%	-47%	+ 35%

^(a) Based on US average fleet data, which is similar to average fleet data in Canada. Source: US EPA

^(b) Based on data from Natural Resources Canada, Office of Energy Efficiency, 2002

ALL MODES OF TRANSPORTATION MUST BE PART OF THE SOLUTION TO AIR QUALITY PROBLEMS...

A Journey Towards Improved Air Quality

Urban transportation moves goods and people for a multitude of purposes that improve quality of life, but at a cost in air quality. As noted earlier, improvements in engine design and emissions control have been offset by a steady increase in the number of vehicles on the road and the distances they are driven. New communities are being constructed with more emphasis on automobile

use than on transit. In many cases, employment centres are developed away from traditional town or city centres, losing the opportunity for living within walking/cycling distance from work and social/cultural activities.

All sectors of urban life must contribute if a sizable reduction in air pollution is to be achieved. In most urban areas, transportation is the major source of emissions. Moreover, it is the sector that can be most easily seen



making a contribution to the situation, whether it appears to be a positive or negative.

Improvements in the transportation sector must address vehicle and fuel technologies as well as transportation activity and behaviour. The problems cannot be solved using a single approach. It's important to address all aspects of the transportation system, including supporting infrastructure. For example, the use of longer-lasting asphalt and concrete pavements means fewer delays due to road construction. The result is less congestion, and avoidance of some of the much higher levels of emissions associated with stop-and-start traffic.

Private Automobiles

Much attention has been directed toward reducing the impacts of the automobile. Manufacturers of cars and trucks have made numerous technological changes directed towards improving fuel efficiency and reducing emissions. However, the technological advances have been offset by increases in the number of vehicles and resulting increases in traffic, as well as the trend towards use of larger and more powerful vehicles such as SUVs.

Improvements in the passenger-vehicle sector must start with the adoption of stringent vehicle emission regulations nation-wide, including those that will affect SUVs. It is also desirable to have similar, if not identical, standards and practices for in use vehicles in all jurisdictions. For example, only a few provinces have implemented emissions-testing programs. Other options include incentives to influence vehicle purchase choices, such as 'feebates' whereby less efficient vehicles attract higher purchase taxes or annual licence fees with corresponding rebates in respect of more efficient vehicles.

Improvements are also likely to be made through increased use of new vehicle-propulsion technologies and fuels that offer the potential to reduce air emissions substantially. These technologies include hybrid vehicles, battery-electric vehicles, fuel-cell vehicles and vehicles running on alternative fuels including ethanol, natural gas, clean diesel, and biodiesel⁹.

In addition to technology improvements, there are many other well-documented strategies for reducing emissions from passenger vehicles. Examples are:

- ◆ economic instruments, including fuel taxation and road pricing;
- ◆ changes in urban structure including the promotion of more compact mixed-use developments that make walking, cycling, and transit more feasible;
- ◆ transportation demand management (TDM) programs including high-occupancy vehicle lanes and rideshare initiatives;

- ◆ transportation supply management programs, including options that reduce congestion and related emissions (provided they limit induced travel); and
- ◆ consumer-education and awareness programs.

Many of these types of initiatives were outlined in TAC's URBAN TRANSPORTATION VISION in 1993. They remain relevant today.

Public Transit

Public transit utilizing bus, streetcar, light-rail or subway technologies has the ability to carry passengers much more efficiently than private automobiles, resulting in significantly reduced air emissions.

Canadians living in major urban areas usually have access to public transit. Transit system operators endeavour to structure service around the needs and the desires of users, but in many cases an array of conflicting needs works against full use of transit. Several factors make private automobiles a desirable choice for many travelers. They include low-cost or free parking at work sites and dispersed trip patterns resulting from urban sprawl and uncoordinated land-use planning. The Canadian Urban Transit Association and other organizations continually advance the use of transit as part of a sustainable urban community. They urge that transit be seen as an investment in a community rather than a cost to society.

Increasing transit ridership is a key decision-making principle elaborated in A NEW VISION FOR URBAN TRANSPORTATION. The principle points to the provision of "higher quality transit service to increase its attractiveness relative to the private auto". Implementing the principle poses many challenges. The implementation could be achieved in part by changing existing communities and planning new communities, both in ways that reduce dependence on the private automobile.

Transit continues to be under-funded in most urban areas. Rather than investing in transit ridership growth, most transit agencies are struggling to maintain existing infrastructure and service levels¹⁰. Few agencies have the ability to experiment with new forms of service that could increase transit ridership.

A recent survey of transit agencies by the Canadian Urban Transit Association (CUTA) identified a need for approximately \$21 billion in transit equipment and infrastructure during the five-year period 2004-2008. About half of this total amount was for projects that were planned and budgeted. The remainder was for projects that would require new funding from other sources.

Source: CUTA Transit Infrastructure Needs Survey 2004-2008, Canadian Urban Transit Association, February, 2004.

As the relationship between health and air quality receives more attention and becomes better understood, increased use of public transit must be seen as a cost-effective way to reduce vehicle emissions. Substantial investment is required to encourage more people to use the various means of public transit, thereby increasing the overall efficiency of the transportation system. The investment would provide for such incentives as:

- ◆ reduced transit fares;
- ◆ substantially increased service levels, combined with the implementation of innovative service-delivery mechanisms and cleaner transit technologies; and,
- ◆ implementation of measures to increase the efficiency of transit services, including bus lanes and exclusive rights-of-way for transit.

These must be supported by promotion of more transit-supportive land use. This can involve limits on expansion of urban boundaries, increases in development densities, mixing of uses, and focusing of development on nodes and corridors that are easily served by transit.

Non-Motorized Transportation

Non-motorized forms of transportation such as walking, cycling and roller-blading produce virtually zero air emissions. Just as public transit is an integral part of solving urban air quality problems, so too are these modes. In addition to helping to reduce air emissions, walking and cycling improve health and fitness and reduce the need for costly road improvements. There are obvious concerns about exercising in conditions of poor air quality. However, the benefits of the exercise likely outweigh the risks of increased exposure to air pollution, provided caution is used in areas of high pollution and on days when air quality is poor¹¹.

Trip-avoidance or trip-substitution solutions such as teleconferencing and telecommuting are other effective strat-

egies for reducing motorized transportation and related air-quality impacts.

Freight Transportation

Urban areas by definition are gathering places for commerce and the transport facilities needed to move goods to and from business locations. Current goods-movement patterns, whether for long haul or local delivery, rely heavily on trucks, adding to air emissions. A NEW VISION FOR URBAN TRANSPORTATION addressed the movement of goods, acknowledging that "many inefficiencies exist". These inefficiencies can be reduced with the added benefit of reduced air emissions. Promising options, to name a few, include:

- ◆ better planning for goods movement at all stages of urban planning and land development;
- ◆ improved vehicle utilization through better matching of vehicles to size and type of delivery, and through reducing the number of trips when trucks are empty or lightly loaded;
- ◆ consolidation of delivery services to and from congested areas; and,
- ◆ greater use of intermodal freight (i.e., utilizing rail or marine modes) where it can be made cost-and time-efficient through improved infrastructure.

Many of these changes would require suppliers and customers to accept new ways of doing business.

Leadership in reducing the trucking industry's emissions could best come from national and provincial associations of trucking firms working to educate their members and the general public. Such efforts should be helped by government initiatives including improved data collection and dissemination and support for education programs.

ACTIONS ARE REQUIRED AT ALL LEVELS...

A Strategy for Change

Canada cannot grow as it has in the past and still expect to improve air quality. Achieving better air quality will require sustained action at the national, provincial, and local levels. These actions will have to include **education**, **incentives**, and **regulations**, in that order, to ensure continuous improvement in air quality.

Practitioners in urban transportation and those in responsible positions in industry and government must take responsibility for bringing about change.

National Level

Alone and in cooperation with provincial governments, the federal government monitors urban air quality across Canada. It also develops and supports programs to research and monitor air quality concerns. As well, the federal government acts to increase awareness of air quality issues through education, and to foster actions at the individual and community levels required to reduce transportation's contribution to air quality problems. National and regional transport associations can play a strong role in supporting education and awareness programs by disseminating information to their members.

Moreover, the federal government has a key role to play in ensuring incentives are in place to improve air quality through changes to vehicle and fuel technologies as well as changes in transport behaviour. Such incentives could include:

- ◆ grants and tax exemptions for the development of advanced-technology vehicles and cleaner fuels;
- ◆ incentives for increased transit use, such as allowing employees to receive tax-free employer-provided transit benefits;
- ◆ increased funding for public transit and other more sustainable modes of transport to enable these modes to compete with private automobiles in terms of coverage, convenience, and cost (securing transit funding through dedicated federal fuel taxes is an idea that has received much attention from the transportation community in recent years; other user fees can also generate revenue, as demonstrated in British Columbia and Quebec);
- ◆ incentives for more efficient goods movement, including funding for new infrastructure to facilitate intermodal freight and logistics approaches that increase operating efficiency.

Finally, the federal government needs to adopt and enforce regulations that apply progressively more stringent emission standards to on-road vehicles. Efforts to coordinate regulations with the U.S. are continuing.

Provincial Level

Several things could be done by provincial governments to help reduce transport's contribution to poor air quality. Actions are required in the areas of:

- ◆ governance and funding of urban transport;
- ◆ improved infrastructure, including selection of pavement and materials to minimize fuel consumption and emissions;
- ◆ vehicle registration and licensing;
- ◆ taxation or incentive based approaches; and,
- ◆ emissions testing/monitoring and regulation of emissions by vehicles in use.

Provincial governments can play a key role in determining how and which land-use policies are set through legislation that regulates municipal actions.

Encouraging mode shifts to transit is one of the most important ways provincial governments could help to improve air quality. Programs that enable urban areas to use dedicated provincial fuel taxes to provide stable fund-

ing for urban transit could help ensure that transit is enhanced and expanded to attract new riders and maintain existing riders. Such programs are in place in Vancouver, Edmonton, Calgary, and Montreal. Increasing transit use has the further benefit of freeing up road capacity for goods movement.

Provincial governments are responsible for vehicle registration and licensing. Through this role, it is possible to regulate vehicle emissions through emissions-testing programs and on-road smog patrols. This is already done in some provinces. Removing 'gross' polluters from the road helps to assure the public that progress is being made. As well, vehicle registration charges could be more directly related to fuel efficiency or to emissions, or both, with the most polluting vehicles attracting the highest vehicle registration fees.

Dedicated fuel tax programs for transportation, including transit, have been implemented in Vancouver, Edmonton, Calgary, and Montreal.

Source: TAC Briefing, INNOVATIONS FOR FINANCING URBAN TRANSPORTATION, June 2002.

Ontario's emissions testing program - Drive Clean – has been credited with reducing smog-causing emissions from vehicles by 15.2 per cent.

Source: Ontario Ministry of Environment News Release, August 7, 2002

Local and Regional Level

Municipal governments play a critical role in bringing about improved air quality in urban communities. There are many tools they can deploy to improve education, provide incentives, and regulate factors that influence air quality. These include:

- ◆ fostering programs that encourage the use of non-motorized travel, such as bicycle-user groups, TDM programs, provision of bike lanes, etc.;
- ◆ developing long-range transport and land-use plans that promote more compact, mixed-use, and transit-supportive land-use patterns;
- ◆ supporting the long-range plans with complementary zoning regulations, including those that provide for reduced parking of automobiles;
- ◆ making sure transit is attractive compared to private automobiles by providing adequate transit infrastruc-

ture and service levels combined with convenient routing, safe and clean equipment, reliable scheduling, and competitive fares;

- ◆ using or requiring the use of construction materials and road maintenance practices that minimize air emissions;
- ◆ setting examples for others by adopting a 'green fleet' concept when purchasing new vehicles and in maintenance programs.

Conclusion

Improved air quality is a health issue that needs to be addressed from national, provincial and local viewpoints. Transportation of goods and people is vital to Canadians' high quality of life. Reducing the negative impacts of motor vehicle emissions must be part of the mission of a responsible transport community.

Most air pollution in Canada occurs in urban regions. It is there too that there are the greatest opportunities to make significant forward steps to reduce air pollution. To do so requires education, incentives, and regulation.

ENDNOTES

- ¹ The New Vision for Urban Transportation identified 13 decision making principles as follows:
 1. Plan for increased densities and more mixed land use
 2. Promote walking as the preferred mode for person trips
 3. Increase opportunities for cycling as an optional mode of travel
 4. Provide higher quality transit service to increase its attractiveness relative to the private auto
 5. Create an environment in which automobiles can play a more balanced role
 6. Plan parking supply and price to be in balance with walking, cycling, transit and auto priorities
 7. Improve the efficiency of the urban goods distribution system
 8. Promote inter-modal and inter-line connections
 9. Promote new technologies which improve urban mobility and help protect the environment
 10. Optimize the use of existing transportation systems to move people and goods
 11. Design and operate transportation systems which can be used by the physically challenged
 12. Ensure that urban transportation decisions protect and enhance the environment
 13. Create better ways to pay for future urban transportation systems
- ² Environment Canada, 1995 Criteria Air Contaminant Emissions for Canada, December 1999.
- ³ American Lung Association and Environmental Defence, Closing the Diesel Divide, Protecting Public Health From Diesel Air Pollution, 2003.
- ⁴ Assuming fuel consumption of 11 litres per 100 kilometres for cars and 60 L/100km for buses. It is recognized that relative performance with respect to individual pollutants would vary because of differences in fuel type and emissions control systems.
- ⁵ Natural Resources Canada, Office of Energy Efficiency, Energy Database <http://www.oee.nrcan.gc.ca/neud/dpa/home.cfm>
- ⁶ US EPA, National Transportation Statistics, Table 4-38, Estimated National Average Vehicle Emissions Rates by Vehicle Type and Fuel, <http://www.bts.gov/publications/nts/2002/index.html>
- ⁷ Environment Canada, On-Road Vehicle And Engine Emission Regulations, http://www.ec.gc.ca/Press/2003/030102_b_e.htm.
- ⁸ World Health Organization, Air Quality Guidelines, 1999, Chapter 3. <http://www.who.int/peh/air/Airqualitygd.htm>
- ⁹ For an overview of current and emerging vehicle technologies, see Transport Canada, Advanced Vehicles Program, 2001-2002 Annual Report, Road Safety and Motor Vehicle Registration Directorate, January 2003. <http://www.tc.gc.ca/roadsafety/atvpgm/menu.htm>
- ¹⁰ Transport Canada, Urban Transit in Canada – Taking Stock, 2001
- ¹¹ Health Canada, Clean Air Champions - "Getting Active For Cleaner Air" - Education Resource Kit http://www.hc-sc.gc.ca/hecs-sesc/air_quality/publications/clean_air_champions/health_impacts.htm

Useful Websites:

A New Vision for Urban Transportation, Transportation Association of Canada, May 1993 – <http://www.tac-atc.ca/english/pdf/urban.pdf>

A Primer on Urban Transportation and Global Climate Change, Transportation Association of Canada, May 1998 – <http://www.tac-atc.ca/english/pdf/global.pdf>

Environment Canada – Clean Air Introduction – www.ec.gc.ca/air

On-road vehicle and engine Emission Regulations, Environment Canada – http://www.ec.gc.ca/Press/2003/030102_b_e.htm

Auto Emissions – An Overview, US EPA – <http://www.epa.gov/otaq/05-autos.htm>

Exhaustion: A Guide to Transportation Emissions, Environment Canada – <http://www.ec.gc.ca/emission/toce.html>

Canada's National Environmental Indicator Series 2003 – Urban Air Quality – http://www.ec.gc.ca/soer-ree/English/Indicator_series/default.cfm

Toronto Smog Summit – http://www.city.toronto.on.ca/cleanairpartnership/smog_summit.htm

Greater Vancouver Regional District Air Quality – <http://www.gvrd.bc.ca/air/quality.htm>

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While TAC and the authors endeavoured to ensure that all information in this briefing is accurate and up to date, they assume no responsibility for errors and omissions.

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